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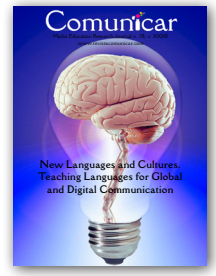

Sustaining Regional Equality and Interdisciplinary integration of Arts and Sciences through Creativity Research in STEAM Education Systems

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ABSTRACT
STEAM education system is largely being incorporated within different countries to develop creativity and problem-solving skills among the students. This study has also focused on sustaining regional equality and interdisciplinary integration of arts and sciences via creativity research in STEAM education systems. For this study, the qualitative data was collected from 12 science teachers working in different Chinese high schools. Thematic analysis was used for analyzing the collected interview transcripts. Four important themes were formulated which include (a) STEAM Education System, (b) Creativity in STEAM Education System, (c) STEAM Education System Issues and (d) Recommendations for STEAM Education System. The results obtained from this study showed that STEAM education system helps in encouraging student engagement, following interdisciplinary integration of arts and sciences. However, regional inequality in China prevents effective accessibility and quality of STEAM education in rural regions of the country, emphasizing the development and implementation of effective educational and regional policies. This study has also provided different practical and theoretical implications within the context of STEAM education systems.

KEYWORDS
Regional Equality, Interdisciplinary Integration, Arts, Sciences, STEAM Education, Creativity.

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1. Introduction

Globalization has influenced education sector in terms of aligning together innovative and interdisciplinary approaches, demanding governments and higher education institutions to incorporate them in their governance. This was evident in the educational goals outlined by world organizations such as the Organization of Economic Cooperation and Development (OECD) and The United Nations (UN) (OECD, 2018). Due to their adaptability to changes, STEM education emerged to include Science, Technology, Engineering and Mathematics for the need for higher-order thinking skills in education (Baharin et al., 2018; Rifandi & Rahmi, 2019). The evolution in education resulted in the development of pedagogies designed to engage all student in STEM fields. For the purpose of making STEM more inclusive and equality along with the promotion of creativity among students, the integration of arts was proposed, leading to the STEAM (Science, Technology, Engineering, Arts, Mathematics) education system (Aguilera & Ortiz-Revilla, 2021).

Despite the growing attention toward STEAM, there is still ambiguity about whether educational goals are being effectively accomplished. In China, there is a growing demand of innovative talent which has led to growing significance of interdisciplinary integration in education (Wang et al., 2018). While STEAM is regarded as an innovative approach in teaching and learning, questions regarding the effectiveness of STEAM remain where a few studies have attempted to evaluate its impact on academic performance (Hsiao & Su, 2021). However, the perception of teachers is less observed. Particularly, as highlighted by Li et al. (2022), limited attention has been given to high school teachers who are trying to implement interdisciplinary activities in their classrooms. A significant challenge remains is the need to cross disciplinary and foster interdisciplinary approach, leading to the need of additional resources and appropriate strategies (Matuk et al., 2022).

Modern-day classrooms have become diverse and multicultural which requires teachers to incorporate STEAM in education system that can aid students in gaining critical and creative thinking skills (de Vries, 2021). With diverse communities, Gavari-Starkie et al. (2022) discussed STEAM in rural areas and discussed that rural areas are likelier to suffer from the lack of interdisciplinary education which holds the potential to offer solutions to increasing social issues in the current times. Some studies have suggested that social and cross-cultural factors play a role in STEAM education.

Despite several studies having been carried out in recent times in the context of China (Gavari-Starkie et al., 2022; Li et al., 2022; Matuk et al., 2022), there is a gap observed in the STEAM framework when it comes to understanding how STEAM can be effectively utilized to promote regional equality, creativity and interdisciplinary integration in different regions of China. The integration of arts and science within STEAM education to meet effectively meet educational goals must be explored. One specific area of interest is the exploration of interdisciplinary integration, creativity and equality in education in STEAM activities. For this purpose, the current study aimed to answer the following research questions:

1. How does interdisciplinary integration of arts and science via creativity research influence STEAM education system?
2. How can regional equality be sustained within the context of STEAM education system?
3. What recommendations can be implemented to improve and sustain regional equality and interdisciplinary integration of arts and science through creativity in STEAM education systems?

By focusing on the integration of arts and science, the present study discovered the potential of STEAM education system and made a few practical recommendations that can facilitate stakeholders in bridging educational gaps and promote inclusivity. The following section covers the literature review followed by the research methodology. The research findings and discussion are then provided, leading to the conclusion and recommendations.

2. Literature Review

2.1. Defining STEAM

STEAM emerged from the blend of STEM with Arts resulting in a new approach toward learning (Peppler & Wohlwend, 2018). It is suggested that the interdisciplinary combination can yield in new insights, innovative perspectives and creativity that is not restricted to a single discipline. As discussed by Liao (2019), STEAM provides an effective system to prepare students to contribute to the global economy through innovative approach Regarded as a curriculum-based approach, STEAM attempts to foster students' creativity and encourage innovativeness (Liao, 2019). Within the research stream of STEAM, the interpretation of "A" has been associated with arts

education, where though Arts is seen as a non-STEM discipline, but with a problem-based learning approach (Perignat & Katz-Buonincontro, 2019). Studies have discussed the inclusion of visual and performing arts along with design processes in education (Liao, 2019) while a few others have focused on integration of environmental studies, liberal arts, humanities (Perignat & Katz-Buonincontro, 2019; Videla et al., 2021).

2.2. Creativity in STEAM

The concept of creativity within STEAM has immense importance as many researchers have claimed that STEAM education system is directly associated with creativity, supporting an environment of motivation and self-efficacy (Jia et al., 2021). Similarly, Cheng et al. (2022) discussed that students can gain creative thinking skills due to the implementation of STEAM subjects. Creativity is regarded as a crucial learning outcome as Yamada (2021) pinpointed the importance of developing mathematical, scientific and creative abilities among students, particularly to meet the growing demand of technology-driven skills. In line with this, Perignat and Katz-Buonincontro (2019) conferred that engagement in art leads to enhanced creativity and allows young people to develop skills that are beneficial for their progression in STEAM fields. On the other hand, some researchers argue that creativity is not only associated with the integration of arts and science in education as the impact of STEAM education system on students' outcome may also impacted by other socio-cultural factors (Tran et al., 2021). Adding to this debate, Sochacka et al. (2016) highlighted that critical thinking and creativity are complicated elements and cannot be simply viewed through the lens of integration of arts in education.

In the light of these arguments, therefore, creativity cannot be restricted to any one discipline and these high-order skills require the blend of disciplines, highlighting the need for a holistic approach to understanding and supporting creativity through the role of STEAM. With the combination of languages, arts, design, humanities and philosophy, critical thinking skill can be developed, equipping students to deal with complex challenges in the world (Khanom, 2023). In consistent with this view, Dumitru (2019) discussed that critical thinking allows educators to also excel in social, educational and technical activities. Thus, STEAM can enhance students' learning experience through instilling soft skills and social competencies, influencing their problem-solving abilities.

2.3. Interdisciplinary Integration

The concept of interdisciplinary STEAM is based on the bridging of several disciplines together to form a common theme while at the same time, each discipline remains distinct (Perignat & Katz-Buonincontro, 2019). While discussing the concept of interdisciplinary integration, researchers have relied on terms such as "infusion," "arts-integration," "merging," and "combining" arts and science (Perignat & Katz-Buonincontro, 2019). Jia et al. (2021) discussed STEAM education system by discussing the integration of all the five disciplines in a curriculum designed for engineering design. On the other hand, Ozkan and Umdu Topsakal (2021) evaluated the impact of STEAM by discussing the combination of arts and physics. Thus, it can be seen that interdisciplinary integration of arts and science can vary with full integration or partial integration with two or more disciplines.

A few conventional subjects related to fine arts were also integrated in this STEAM education system, justifying the inclusion of Arts stream. Cheng et al. (2022) proposed the integration and implementation of a learning module of six weeks where students learned about music and sound in different subjects. This aligns with the combination of physics, art, engineering, mathematics and music as STEAM activities. Similarly, Thuneberg et al. (2018) integrated mathematics and arts by implementing an informal math module with arts component based on an inquiry-based learning approach. STEAM activities such as provision of hands-on construction arts and building geometrical shapes were implemented for supporting creativity and self-sufficiency. Park and Cho (2022) took into consideration the combination of history as a humanities subject in STEAM education in the context of Korea, showing the relevance of integration of science and technological in historical context. Activities that were based on scientific and mathematical explanation of historical sites resulted in enhancing students' understanding of the history. The diverse approach of explanation and creativity provides a valuable approach and serves the objectives of various integrated disciplines.

2.4. Challenges and Disparities in Implementation of STEAM

The process of adoption of STEAM activities in educational institutions is not seamless as pointed out by researchers (Belbase et al., 2022; Boice et al., 2021) such as the varying needs of children and heterogeneity of classes (Camelia Delia et al., 2022). Challenges hampering the implementation of STEAM

also include inadequate resources and regional disparities that exist (Belbase et al., 2022; Gavari-Starkie et al., 2022). In the case of America, it was reported that students in rural areas are interested in STEM activities (Crain & Webber, 2021). Regional inequality was one of the factors influencing their educational pathway along with barriers such school characteristics. This was supported by the findings of Herro et al. (2019) as they discussed that students have varying degree of understanding and learning.

Additionally, Villa et al. (2021) reported that rural education is impacted with closure of schools in these areas. Gavari-Starkie et al. (2022) criticized that STEAM has not been extensively studied in the context of rural education which is suffering from a deficiency of resources, dearth of teachers and poor school performance. The design of a rural classroom is not the same as of an urban classroom with significant differences in teachers' abilities (Khairani, 2017). Teachers face issues such as lack of knowledge, supportive environment, training and resources to implement STEAM (Camelia Delia et al., 2022). In contrast, Yang (2020) argued that STEAM education is more ideal for rural settings as the problem-based and interdisciplinary approach can offer innovative approach to learning. STEAM education in the context of farming culture can promote equality and interaction among rural and urban Chinese students (Yang, 2020).

3. Research Methods

3.1. Research Approach

The present study employed a qualitative approach by using interview method to uncover the teachers' perception for STEAM education system, which in learning settings has been more frequently examined with qualitative research methods (Bertrand & Namukasa, 2020, 2023).

3.2. Study context and Sample

The study targeted high schools in China and focusing on science teachers from different schools and regions to ensure diverse representation as the study population. The sample included teachers from both rural and urban areas with the objective to explore regional differences in STEAM education, aligning with the research questions proposed in the study. Using purposive sampling, a total of 12 science teachers were interviewed.

3.3. Data Collection and Analysis

In line with the qualitative approach of the study, the data collection process comprised semi-structured interviews with a sample of 12 science teachers working in Chinese high schools. Each interview lasted for 50 to 60 minutes. The interview informants were informed about the objectives of the research to ensure voluntary participation. Furthermore, they were asked to complete an informed consent form, guaranteeing confidentiality and the right to withdraw from participation at any point. The structure of the interview questions was developed after thorough review of the relevant literature and covering key topics related to the research questions, such as interdisciplinary integration, regional quality, creativity, challenges and teaching methods. The interview questionnaire is attached in the Appendix. At the end of each interview, the researcher asked the teachers whether they wanted to share any additional thoughts or questions.

For the data analysis, the researcher followed the approach of thematic analysis as outlined by Terry et al. (2017), a method that is frequently adopted by researchers in qualitative analysis (Terry et al., 2017). This approach is associated with systematic generation of codes and themes, offering flexibility in analysis, and the identification of patterns and trends in qualitative data (Terry et al., 2017). The analysis was conducted using NVivo software. To minimize any bias in analysis and ensure richness of the analysis, a team of expert researchers was developed including a content expert and qualitative analyst. Using an open coding approach, the interviews were assessed to identify broad categories in the transcripts. The research team collaborated to identify the initial themes following an inductive generation of codes. The themes were then discussed, and codes were established. The themes in the study were supported by relevant quotes and a consensus was reached among the research term on the alignment of the final themes.

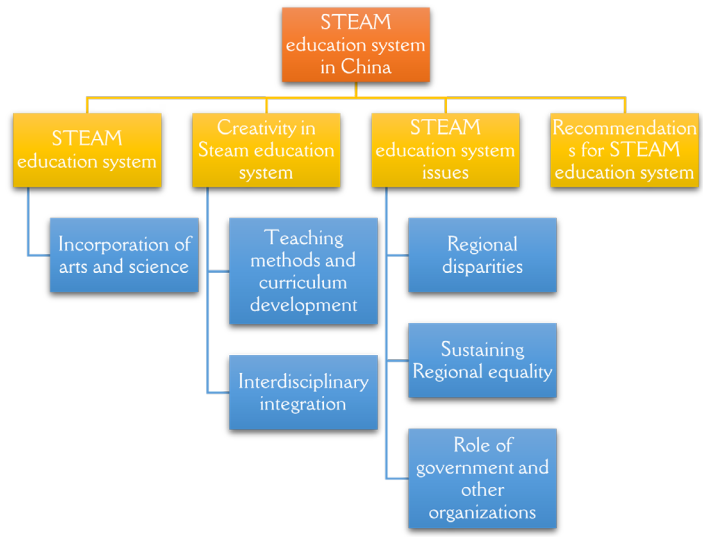
4. Results

In order to fulfil the objectives of this study, thematic analysis was utilized for identifying the underlying themes concerning the regional equality and interdisciplinary integration of arts and sciences via creativity

in STEAM education systems. After careful analysis of the collected data, different themes and sub-themes were formulated which are presented below and illustrated in Figure 1:

- Theme I: STEAM Education System
  - *Theme Ia: Incorporation of Arts and Science*
- Theme II: Creativity in STEAM Education System
  - *Theme IIa: Teaching Methods and Curriculum Development*
  - *Theme IIb: Interdisciplinary Integration*
- Theme III: STEAM Education System Issues
  - *Theme IIIa: Regional Disparities*
  - *Theme IIIb: Sustaining Regional Equality*
  - *Theme IIIc: Role of Government and Other Organizations*
- Theme IV: Recommendations for STEAM Education System

Figure 1: Mind Map-STEAM Education Systems in China.



• Theme I: STEAM Education System

Nine of the participants supported the role of STEAM education system in revolutionizing the overall education sector in China. According to them, STEAM is an educational model which helps in developing critical thinking as well as problem-solving skills among the students, which has become crucial for the children of 21st century. Five of the participants, emphasized the incorporation of STEAM education system to get the students ready for various humanity-related challenges. Within this regard, one of the participants stated:

"STEAM education encourages the students to take thoughtful risks and involve in experimental learning, incorporating collaboration, problem-solving and creativity. This model can help such students to become future leaders, learners, educators and innovators."

o *Theme Ia: Incorporation of Arts and Science*

According to eight of the participants, the incorporation of arts and sciences in STEAM helps the students to learn about the value of innovation, contemplation, creativity and communication. The arts help them to appreciate different cultures while the sciences teach them to implement different scientific methods to find the required solutions. It includes the development and testing of the developed hypotheses, analyzing the results and making important observations. In support of this argument, one of the participants quoted:

"The skills formulated via arts are largely required in the workforce to making creative solutions, whereas the scientific skills help in problem-solving."

- **Theme II: Creativity in STEAM Education System**

STEAM education integrates project-based activities, which motivate the students to utilize cross-discipline knowledge to resolve the identified issues. According to ten of the participants, this approach helps the students to implement their creative skills to identify the solutions within the context of real world. In this regard, the creativity research helps in developing efficient projects. Four of the participants also stated that STEAM activities are more engaging and interactive as compared to conventional learning environment. In response to STEAM education system's creativity, one of the participants said:

"The inquiry procedure within the STEAM education increases active involvement and curiosity of the students, facilitating them to develop creative products following disciplinary knowledge with the associated real-life implications."

- *Theme IIa: Teaching Methods and Curriculum Development*

The incorporation of STEAM education has also largely influenced the teaching methods and curriculum development. Six of the participants stated that they completely changed their teaching practices following the STEAM education model. They developed project-based curriculum, to promote student engagement. In support of this argument, one of the participants stated:

"I incorporated case study and other project-based activities in my curriculum to improve the creativity and problem-solving skills among the students."

- *Theme IIb: Interdisciplinary Integration*

Eleven of the participants believed that interdisciplinary integration of arts and science via creativity help the students in understanding real-world issues. They stated that creativity has a multifaceted nature, and it can be trained via cognitive, personal and other contextual factors. Therefore, the interdisciplinary integration of arts and science in STEAM education can also help in providing important training to students. Within this context one of the participants stated:

"Different techniques such as SCAMPER, random connection and flexibility can be incorporated to improve the creativity among students in STEAM education system. These techniques are also influenced by interdisciplinary integration of arts and sciences."

- **Theme III: STEAM Education System Issues**

According to the participants, different issues are faced within the context of implementation of an effective STEAM education system. Seven of the participants stated that the lack of essential resources, inefficient training and limited knowledge negatively impact the implementation of STEAM education systems. Within this context one of the participants stated:

"Different issues are faced within the context of STEAM education system such as unequal distribution of resources and knowledge."

- *Theme IIIa: Regional Disparities*

Seven of the participants believed that the socio-economic inequalities in different regions of China have also impacted the STEAM education systems. They stated that the rural regions are deprived of essential resources and skills, required for implementation of STEAM education system. In this regard, one of the participants stated:

"The rural regions are not provided with equal accessibility and quality within the context of STEAM education system, which prevents the students from these areas to develop important creativity and problem-solving skills."

- *Theme IIIb: Sustaining Regional Equality*

Ten of the participants emphasized sustaining regional equality within the context of STEAM education system. They believed that all students must be provided with equal opportunities to excel in their personal and professional life. This can also be effective in improving the social performance of the associated students, leading to significant outcomes. This argument was also advocated by one of the participants as he stated:

"The rural regions in China lack the availability of advanced technology and other important resources which are required for promoting STEAM education, therefore, it is crucial to ensure regional equality within this context."

- *Theme IIIc: Role of Government and Other Organizations*

In China, the autonomy of the higher education is limited due to control system, utilized by the national government. This system prevents scientific innovation, and a larger poverty gap also influences the access to STEAM education. Seven of the participants emphasized the role of government in improving the STEAM education systems in different regions in China, as one of them stated:

"In my opinion, the Chinese government is taking important measures to develop and promote effective policies concerning STEAM education. However, in this regard, the promotion of innovation and technology within the Steam education in different regions is also crucial."

- **Theme IV: Recommendations for STEAM Education System**

All participants emphasized sustaining of regional equality, creativity and interdisciplinary integration of arts and sciences, within the context of STEAM education systems in different regions of China. According to them, this approach can promote education equity within the country's different regions. In this regard, one of the participants stated:

"It is crucial to develop important educational and regional policies to promote regional equality within the context of STEAM education system."

Figures 2 and 3 show tree map and project map for this study.

Figure 2: Tree Map-STEAM Education System in China.

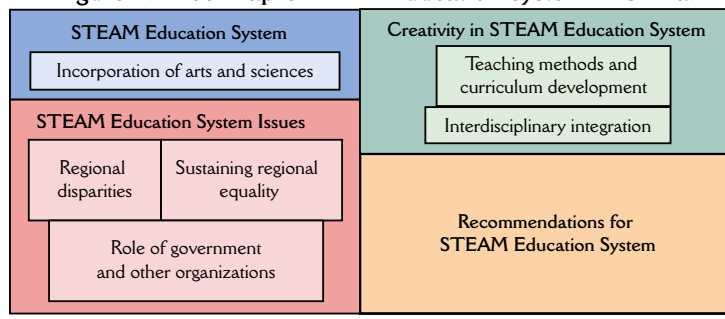
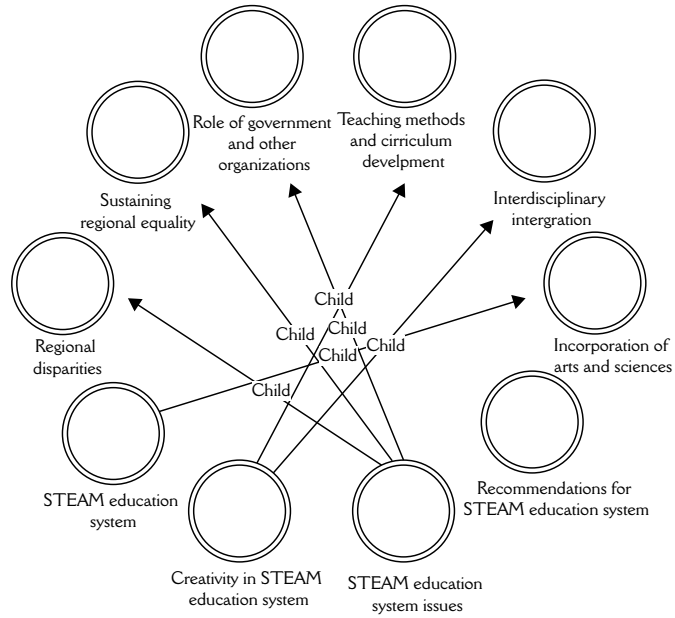


Figure 3: Project Map- STEAM Education System in China.



5. Discussion

This study aimed to explore the regional equality and interdisciplinary integration of arts and sciences in STEAM education systems in China. For this purpose, the qualitative data was collected from 12 science teachers in high schools of China and thematic analysis was done. Four important results were obtained from this study.

First, it was observed that the incorporation of STEAM education has effectively improved the overall education sector. According to the interview informants, STEAM education helps in improving the creativity and problem-solving skills among the students which makes them ready for the real world. STEAM education helps in promoting future leaders and innovators. Second, it was observed that the STEAM education system provided opportunities for the enhancement of creativity. It encourages the teachers to innovatively modify their teaching practices and curriculum to enhance student engagement. As a result, the project-based activities are largely incorporated in STEAM education system. Moreover, the interdisciplinary integration of arts and sciences also help in improving critical thinking skills among the students. Within this context, effective training of students is also considered to be effective in improving their learning performance and other related skills (Gu et al., 2023).

Third, the results show that different issues are faced in implementing an effective STEAM education system in China. In this regard, regional inequality is found to influence the quality and accessibility of STEAM education in rural regions of the country. The unequal socio-economic status in China, also influences the availability of required resources and knowledge within the context of STEAM education system. Therefore, the government plays an essential role in improving the implementation of STEAM education system in China by implementing important educational and regional policies. Finally, important recommendations were made by the participants to improve STEAM education system in China by sustaining regional equality, creativity and interdisciplinary integration of arts and sciences within the STEAM education system. They emphasized on promoting education equity (Zhan et al., 2022), to attain significant outcomes in this regard.

6. Conclusion

This study focuses on sustaining regional equality and interdisciplinary integration of arts and sciences through creativity research in STEAM education systems in China. The results obtained from this qualitative study shows that STEAM education helps in developing important creativity and problem-solving skills among the students due to utilization of interdisciplinary knowledge. However, regional inequality and socio-economic status are also focused to influence the accessibility and quality of STEAM education systems in different regions of China. In conclusion, it is crucial to sustain regional equality and creativity within the context of STEAM education system to develop important skills among the students, encouraging them to become future leaders.

7. Research Implications

7.1. Theoretical Implications

This study highlighted one of the major issues observed within the context of STEAM education system in China, the issue of regional inequality. It drew attention to regional inequality in the rural areas of China, where educational institutions often lack important resources and skills like creativity and problem-solving skills among the students. This issue was a matter of great concern in the implementation of STEAM education system in China. Moreover, this study would be beneficial in exploring the benefits of creativity within the context of STEAM education system which can help in modifying the teaching practices and curriculum. However, in the past studies, not much focus has been given on the association between regional inequality and accessibility to STEAM education system within the context of China, thus, the present study would be effective in overcoming this research gap. This study also added novelty by focusing on the interdisciplinary integration of arts and sciences via creativity research in STEAM education system, adding effectiveness to the current research.

7.2. Practical Implications

The empirical evidence obtained from this study can encourage different educational institutions to integrate STEAM education system. They can be motivated to incorporate more project-based activities and case studies within their curriculum to improve student engagement. This can also be effective in improving critical thinking skills among the students. Moreover, the government can also be encouraged to develop and implement efficient

STEAM education policies and other regional policies to promote education equity in both rural and urban regions. This approach will also be effective in improving the overall social development of the students.

8. Limitations and Future Research Directions

Different limitations were observed during this study. For instance, the sample size was very small for data collection, due to qualitative nature of the study. Second, this study only focused on the perceptions of science teachers concerning the STEAM education system and regional equality, due to easy accessibility of target audience. Similarly, this study focused only on the interdisciplinary integration of arts and sciences within the context of STEAM education due to research bias. Future research can incorporate quantitative method to collect data from a larger sample. Additionally, the future research can also focus on the perceptions of students regarding the topic under discussion. This can also encourage the discussion regarding different disciplines of STEAM education, including technology, engineering and mathematics.

Project Funding

1. Shanghai Graduate Education Reform Project: Improve the Aesthetic Education Quality of MFA Graduate Students by Relying on Social Public Cultural Resources, Project No.: 23XJG103.
2. High-level Local University Construction Project: MFA Graduate Tutor Special Training on "Cultivating Virtue and Talents", Project No.: 23XDS005.
3. Shanghai School Curriculum Ideological and Political Demonstration Course, Teaching Master:Graduate Education Project "Design Forms".
4. First-class course cultivation project of Shanghai University of Engineering Science:Performance Techniques, Project No.: k202207001.
5. Shanghai Philosophy and Social Science Planning General Project: Research on Public art Multidimensional Support for Shanghai Old Area Reconstruction and Community Ecosystem Reconstruction, Project No.: 2020BWY028.
6. Shanghai Philosophy and Social Sciences Planning Youth Project: A Study on the Evaluation and Design Optimization of Psychological Healing Effectiveness of Shanghai Public Art, Project No.: QNTD202109.
7. Youth Research Team Cultivation Program of Shanghai University of Engineering Science: Research on Public art and Smart Environment Space, Project No.: QNTD202109.
8. 2023 Shanghai University municipal key course "Expression Techniques", Project No.: s202311001.

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Appendix A
Interview Questions

1. In your opinion, how has STEAM education system influenced the educational sector in China?
2. What are the benefits of incorporation of arts and science within the context of STEAM education system?
3. In your opinion, how does creativity influence STEAM education systems? What is its role in influencing the teaching methods and curriculum development?
4. How does interdisciplinary integration of arts and science via creativity help the students in understanding real-world issues? Are they able to identify important solutions?
5. Can you highlight any issues which are faced in implementing an efficient STEAM education system in different regions of China?
6. In your experience, have you observed any disparities concerning the accessibility and quality of STEAM education system in different rural and urban regions of China?
7. Are these disparities being acknowledged, focusing on sustaining the regional equality within the context of STEAM education?
8. What measures and strategies are being implemented by the government or other organizations for overcoming this limitation in STEAM education system in order to promote regional equality?
9. Can you make any recommendations for sustaining regional equality, creativity and interdisciplinary integration of arts and sciences, within the context of STEAM education systems in different regions of China?