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Comparison of Four Universities on Both Sides of the Taiwan Strait Regarding the Cognitive Differences in the Transition from STEM to STEAM in Design Education

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Abstract: There have been many studies on the effectiveness of the STEAM model since its integration into design education, but further investigation is needed to determine whether teachers and students truly understand the meaning of STEAM. The aim of this study is to evaluate people's perceptions of the STEAM model in design education. Respondents from four universities on both sides of the Taiwan Strait participated in the study. Following expert evaluation and a number of tests, the revised questionnaire was used to survey the attitudes of respondents. The results indicate the following: (1) Respondents were more familiar with universities in their area and therefore rated them relatively highly. While this is reasonable, it suggests that respondents may lack a global perspective. (2) The proportion of arts courses is generally high, but further analysis is required to determine whether they in fact play a role in connecting to STEM. This study concluded that educators and researchers need to have a deep understanding of the essence and connotations of STEAM. Students must also consider how to acquire the knowledge and skills needed for 21st-century design through STEAM courses. Furthermore, the use of STEAM in design education needs to be continuously evaluated and improved.

Keywords: from STEM to STEAM; design education; cognition; four universities; cross-strait

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1. Introduction

From the Bauhaus to the Ulm School of Design, the principles of modern design have been established to have a lasting impact [1–9]. The philosophy of modern design emphasizes the importance of benefiting people over products, and human-centered design is prevalent in the design of products. Therefore, for "product", "design", and "evaluation", the focus is always on humans. These principles are also followed when evaluating products or designs [10]. Similarly, the above points apply to the development and application of the model of design education [11,12]. To achieve benign and sustainable development, it is important to continuously adjust the design education model to meet the needs of the times. As far as design education is concerned, the goal is to implement the essence of design, and to adjust how design responds to technological development and social change [13–15].

Although the core of design education is still influenced by the Bauhaus [16–18], it is worth considering how design education should develop in the future; moreover, the concept and mode of design education also need to be dynamically adjusted, so that the essence and spirit of design can be fully reflected [19]. Additionally, the revision and improvement of the design education model need to answer questions posed by industry. If there is a disconnect between teaching and the practical application of the knowledge and skills, it is difficult for design schools to train students to achieve the competencies they require as designers [20–23].

Design has changed a significant amount during the 21st century, which means that its educational model also needs to be continuously updated [24,25]. STEAM (science, technology, engineering, arts, and mathematics) was used as the theoretical framework of this study; along with questionnaires and analyses, this framework allowed us to examine the current state of STEAM in design education, as well as to understand the cognitive differences between respondents in terms of the STEAM attributes they valued [26].

Taiwan shares the same cultural background as the Chinese mainland, and its modern design is also influenced by the Bauhaus. Additionally, with the deepening of academic exchanges, Taiwan and the Chinese mainland also learn from each other in the field of design education. Previous research has given us the opportunity to understand the strengths, features, and implications of Taiwan and China's design education [27–31].

This article is part of a series of studies. A previously completed study, which is undergoing peer review, analyzed Taiwanese respondents' perceptions of the use of the STEAM model in design education. Thus, this article will conduct research from another angle, analyzing the different views on the same topic among respondents from four universities on both sides of the Taiwan Strait; additionally, it considers the possible reasons for these differences.

2. Theoretical Framework: A Transition from STEM to STEAM with the Support of Art as a Glue

The introduction and research on the basic concept, scope, and core concepts of STEM (science, technology, engineering, and mathematics) and STEAM have attracted much attention from the academic community, and successive published studies have provided strong theoretical support for this research [32–42]. It is unnecessary to rehearse these studies here; we review them only to provide clarification on a central issue, namely, that art has played a huge role in this transformation. If Bauhaus advocated "a new unity, between art and technology", then STEAM advocated the use of art to further unite the principles and methods of technology and science. The purpose of this research is to provide students, designers, and design educators with a means of creating creative products that are more aligned with the arts and humanities. Art will become a key element connecting the other four dimensions (i.e., S, T, E, and M), which will enhance the artistic and humanistic associations of creative products.

STEM is a broad term used to group together these diverse academic disciplines. This term is typically used to address education policies or curriculum choices. The acronym STEM was suggested by Rita Colwell, Ph.D., a bacteriologist who was the director of the NSF in the 1980s [43]. The framework of STEAM derived from STEM, adding the category of art to the original STEM, emphasizing that future students should develop their humanistic and artistic literacy (Humart = human + art) and interdisciplinary abilities. In short, the STEAM framework integrates art and humanity into "rationality and objectivity" [44], and uses art, culture, and humanity to connect to the rational STEM to form a strategy and mode of thinking (see Figure 1).

In summary, STEM focuses on the technical and methodological aspects, while STEAM is a strategy and concept strongly tied to the formation of an art-centered theoretical framework. Many studies also provide strong evidence [45–49]. Art plays a crucial role in connecting the other four attributes in STE(A)M, and becomes the core of this system. "Art" is a very broad concept, and this study argues that it also has cultural implications [50,51].

As discussed in the above, the STEAM model has been applied to education and training. For example, the formulation and application of STEAM education policies allow STEAM to be quickly promoted in teaching in related fields, and in turn examine the rationality and appropriateness of policies [38,52–54]. A large number of specific application examples, as well as critical thinking on the STEAM model, provide a solid foundation for selecting STEAM as the core theoretical framework in this study [28,55–64].

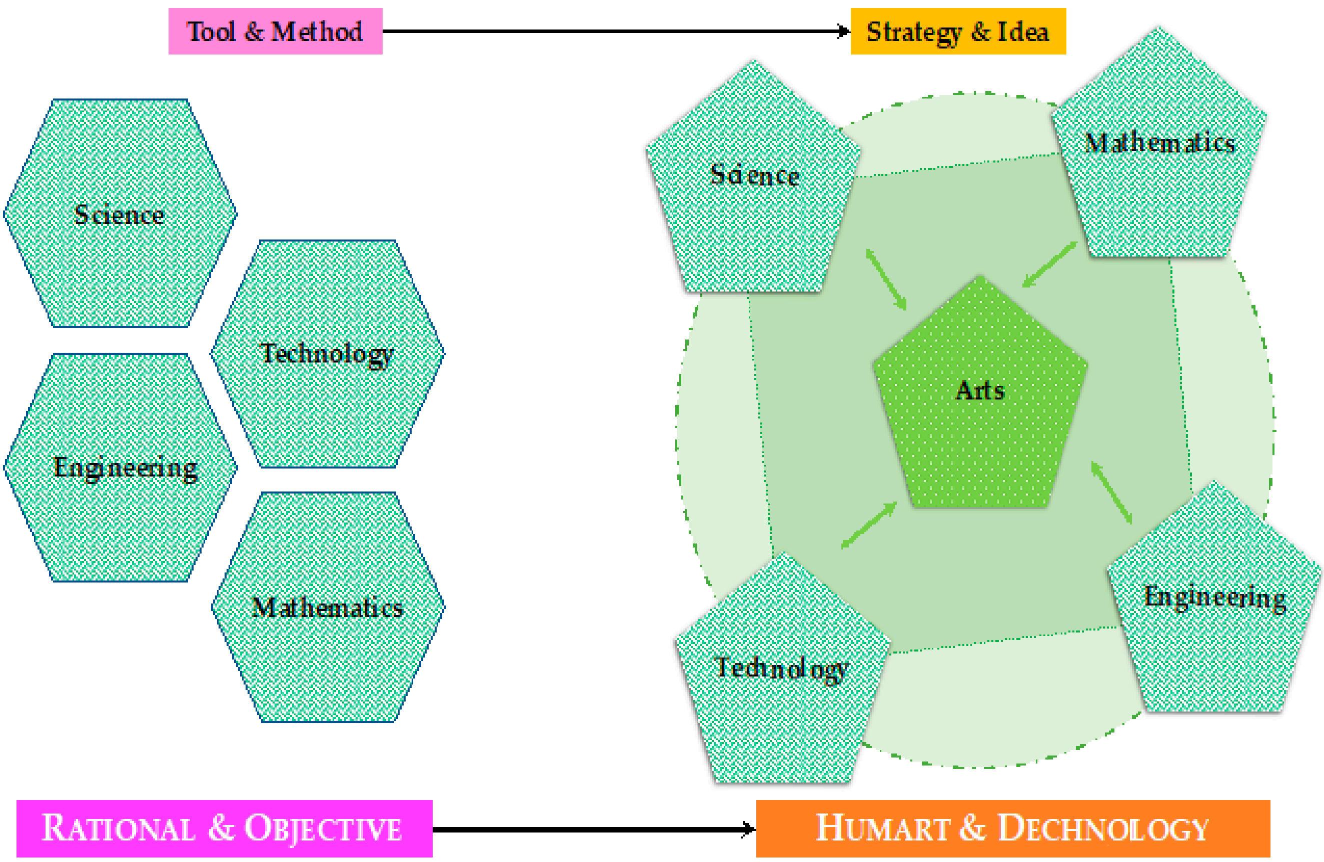

Figure 1. From STEM to STEAM: The fusion of Humart (human + art) and Dechnology (design + technology). (Source: this study).

Another reason for conducting this study as a pilot study is to find out how people differ in their perceptions of STEAM and the relationship between the STEAM model and design education. How is the impact being made? STEAM, which is seen as a new driver, is also essential to ensure that it works as it is intended and can be corrected at any time based on audience feedback [65,66].

3. Materials and Methods

3.1. Hypotheses

Considering that this study aims to examine the application of STEAM in design education, we selected respondents who are either teachers or students at different design schools. Thus, the research hypothesis is focused on the field of design education in universities. Based on the objectives of the study, as well as a literature review, this study proposes the following hypotheses:

Hypothesis 1 (H1). *Respondents who have no study abroad or exchange student experience, may only be familiar with the sample of their country or region, so they will give them a high rating;*

Hypothesis 2 (H2). *Two U.S. universities (RISD and MIT Media Lab) in the sample may be relatively unfamiliar to respondents if they have no experience studying abroad. In this case, the respondents' evaluation will be relatively low;*

Hypothesis 3 (H3). *Respondents from Taiwan are more familiar with STEAM, which leads them to rate the use of STEAM in six universities more highly.*

3.2. Procedures

This study involved the use of a questionnaire analysis to determine respondents' views on the use of STEAM in design education. In order to better focus on the sub-topics to be explored, the data obtained from the questionnaire were analyzed from different perspectives. Therefore, the data collected in the questionnaire were used multiple times, and may be cross-compared in different articles.

The study is divided into three parts (see Figure 2). In part I, a literature review is used to elucidate the difference between STEM and STEAM, and the relationship between STEAM and design education is explored. In part II, experts from the field of design were invited to conduct interviews, and design schools/laboratories from six universities were selected as samples. Once the questionnaire was designed, the researchers invited several experts in the field of design to review the questionnaire and tested it on a small scale. The questionnaire was revised based on comments provided by experts and interviewees. In part III, in addition to descriptive statistics, this study focuses on what is attributed to possible cognitive differences between respondents from four universities on both sides of the Taiwan Strait. Meanwhile, respondents' familiarity with the relevant university is regarded as self-variable, and the differences are analyzed after grouping, to better capture the cognitive differences between different categories of respondents.

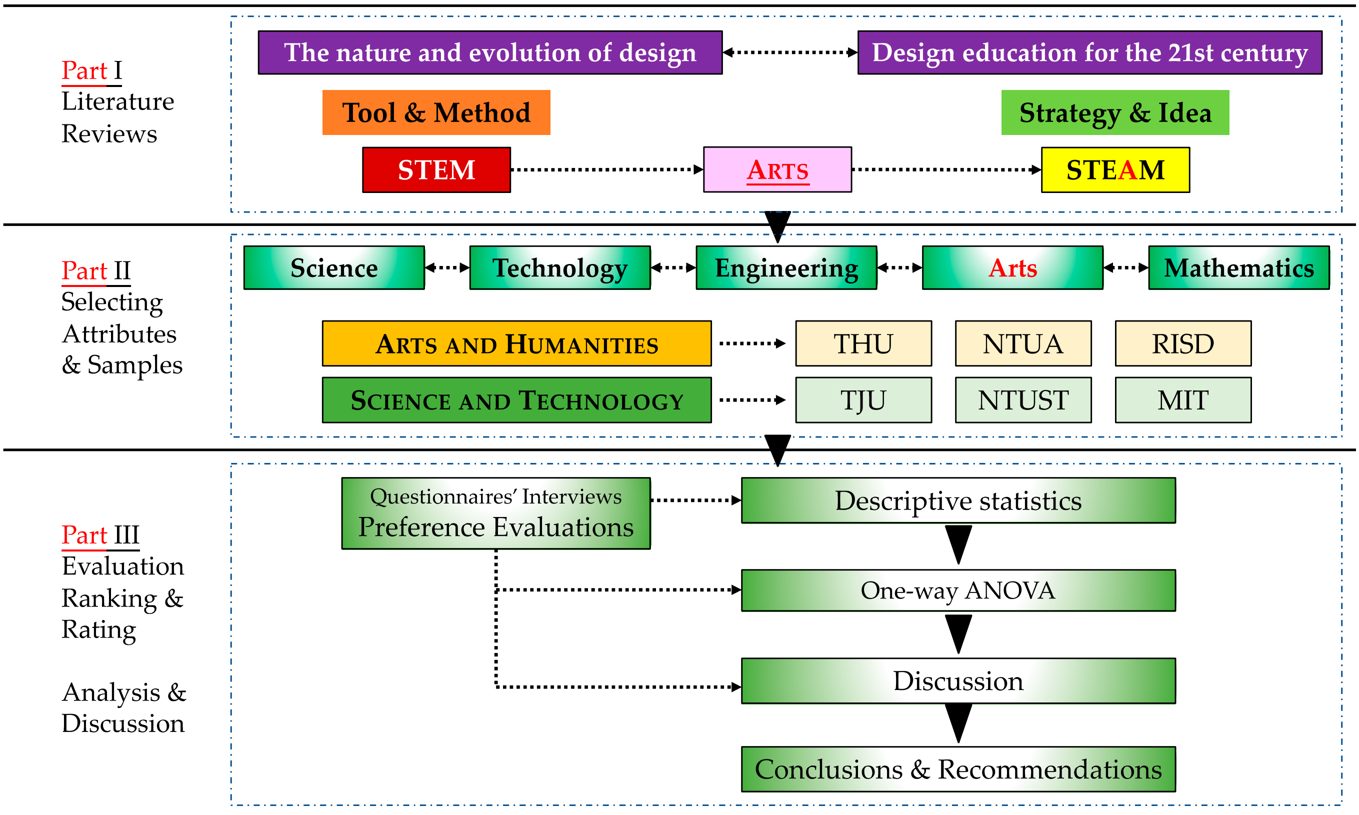

Figure 2. The procedures for deriving the effectiveness of the STEAM model that used in design education. (Source: this study).

3.3. Samples and Their Curriculum

In this study, researchers selected six universities with design colleges or laboratories as samples: (1) the Academy of Art & Design, Tsinghua University, (2) the College of Design and Innovation, Tongji University, (3) the College of Design, National Taiwan University of Arts, (4) the College of Design, National Taiwan University of Science and Technology, (5) the Rhode Island School of Design, and (6) the MIT Media Lab (see Table 1).

Table 1. Samples.

Category	Six Universities with a College or Laboratory of Design
Arts and Humanities	Academy of Art & Design, Tsinghua University (THU) College of Design, National Taiwan University of Arts (NTUA) Rhode Island School of Design (RISD)
Science and Technology	College of Design and Innovation, Tongji University (TJU) College of Design, National Taiwan University of Science and Technology (NTUST) MIT Media Lab (MIT)

Source: this study.

Our selection of these six universities for this study is based on the fact that three of them concentrate on the arts and humanities, and the other three focus on the field of science and technology. This division enables this study to better explore the use of the STEAM model and the current situation of design education in art or technical universities.

Additionally, to ensure the reliability of the sample, focus group interviews (FGIs) made up of several experts in the field of art and design identified the above six universities as a sample. These experts are from the National Taiwan University of Arts. The selection of samples generates a number of challenges. For instance, if the sample is too large, the questionnaire may be too complicated. We use university rankings released by both sides of the Taiwan Strait in recent years as a reference indicator; subsequently, experts identified samples from many universities based on their own experience.

The researchers searched the homepages of design schools at four universities and downloaded their course plans. Although curriculum plans may not be complete (e.g., their homepages do not updated curriculum information in a timely manner), this study believes that these curriculum plans still have reference value. The analysis of these data allows us to understand whether the curriculum planning of design schools in these universities refers to the STEAM model.

3.4. Questionnaire Design and Testing

The questionnaire was divided into two parts: the first part pertained to the respondents' basic information; in the second part, respondents were asked whether they were focused on STEAM at six universities, and then whether the target schools focused on the five dimensions of STEAM. A 5-point Likert scale was used for the responses, with scores ranging from 1 ("Very low") to 5 ("Very high") (see Table 2).

Table 2. The second part of the questionnaire.

Q1: Are you familiar with this university?		Very Low 1 2 3 4 5 Very High
Q2: Please assess whether this university attaches great importance to the use of STEAM in their design education?	**S**cience	Very Low 1 2 3 4 5 Very High
	Technology	Very Low 1 2 3 4 5 Very High
	Engineering	Very Low 1 2 3 4 5 Very High
	Arts	Very Low 1 2 3 4 5 Very High
	Mathematics	Very Low 1 2 3 4 5 Very High

Source: this study.

Regarding the first question, we hoped that respondents could make judgments based on their intuition, so no more explanation was given for this question. During the small-scale test, the respondents did not dispute it.

This article aimed to find out how views on STEAM differ among respondents from four universities on both sides of the Taiwan Strait. Therefore, two versions of the questionnaire were generated. The first version was filled in by respondents from the Taiwan area and the Chinese mainland who are not students or graduates of those four universities. The second version was available to teachers, students, or graduates from the four universities. We adjusted the options in age and education level to allow those who have not yet graduated from college to answer the questionnaire.

Following pre-testing and revision, the questionnaire was launched on 26 October 2022. Considering that some respondents may not be able to respond immediately, we extended the time for questionnaire collection appropriately. We checked the questionnaires one by one, focusing on whether there were any indiscriminate or incomplete questionnaires. Following checking, all questionnaires were deemed to be valid. SPSS 28.0 was used to further process and analyze the data.

4. Results and Discussion

4.1. Descriptive Statistics

The data related to the respondents are shown in Table 3:

- Respondents from the Taiwan area and the Chinese mainland (none of whom were teachers, students, or graduates of the four universities) used the first version of the questionnaire. A total of 128 respondents from Taiwan and 222 respondents from the Chinese mainland participated;
- Teachers, students, and graduates from four universities used the second version of the questionnaire. There were 115 and 60 respondents from the National Taiwan University of Arts (NTUA) and the National Taiwan University of Science and Technology (NTUST), respectively. There were 35 and 64 respondents from Tsinghua University (THU) in Beijing and Tongji University (TJU) in Shanghai, respectively.

Table 3. All respondents in the experiments.

Variables		Taiwan Area (n = 128)	NTUA (n = 115)	NTUST (n = 60)	Mainland China (n = 222)	THU (n = 35)	TJU (n = 64)
Gender	Female	47/36.7%	79/68.7%	14/23.3%	151/68.02%	9/25.71%	25/39.06%
	Male	81/63.3%	36/31.3%	46/76.7%	71/31.98%	26/74.29%	39/60.94%
Age [1]	18–22	/	29/25.2%	11/18.3%	85/38.29%	13/37.14%	21/32.18%
	23–35	/	18/15.7%	11/18.3%	111/50%	7/20%	34/53.13%
	26–35	18/14.1%	17/14.8%	4/6.7%	/	/	/
	36–45	31/24.2%	31/27%	12/20%	17/7.66%	11/31.43%	7/10.94%
	46–55	52/40.6%	17/14.8%	15/25%	5/2.25%	4/11.43%	/
	56–65	22/17.2%	3/2.6%	7/11.7%	4/1.8%	/	2/3.13%
	>65	5/3.9%	17/14.8%	4/6.7%	/	/	/
Education level	University Student	/	33/28.7%	8/13.3%	77/34.68%	12/34.29%	15/23.44%
	Graduated from University	9/7%	8/7%	18/30%	7/3.15%	4/11.43%	5/7.81%
	Masters	47/36.7%	42/36.5%	25/41.7%	128/57.66%	11/31.43%	39/60.94%
	Ph.D.	72/56.3%	32/27.8%	9/15%	10/4.5%	8/22.86%	5/7.81%
Do you know STEAM?	Yes	98/78.4%	74/64.3%	37/61.7%	119/53.6%	25/71.43%	35/54.69%
	No	27/21.6%	41/35.7%	23/38.3%	103/46.4%	10/28.57%	29/45.31%
Studying abroad? (More than 1 year)	Yes	40/31.3%	26/22.6%	8/13.3%	13/5.86%	9/25.71%	7/10.94%
	No	88/68.8%	89/77.4%	52/86.7%	209/94.14%	26/74.29%	57/89.06%
The country or region where you are studying abroad	United States, Canada	20/15.6%	14/12.2%	3/5%	2/0.9%	3/8.57%	/
	Europe	4/3.1%	6/5.2%	2/3.3%	4/1.8%	3/8.57%	3/4.69%
	Asia	12/9.4%	5/4.3%	2/3.3%	5/2.25%	3/8.57%	3/4.69%
	Australia, New Zealand	3/2.3%	1/0.9%	1/1.7%	/	/	/
	None	88/68.8%	89/77.4%	52/86.7%	209/94.14%	26/74.29%	57/89.06%
	Other	1/0.8%	1/0.9%	1/1.7%	2/0.9%	/	1/1.56%

[1] The age of the respondents varied between versions of the questionnaire. Therefore, regarding the age variable, the options are slightly different.

The familiarity of the respondents of the six universities is shown in Table 4. It is reasonable to assume that the respondents are familiar with universities in their countries or regions. However, even with samples from the respondents' country or region, a certain percentage of the respondents were unfamiliar with part or all of the sample. This may have affected their in-depth evaluation of the sample.

Table 4. The mean and std. deviation of the respondents' familiarity with six universities.

	THU	TJU	NTUA	NTUST	RISD	MIT
Taiwan Area (n = 128)	2.18 (1.111)	2.27 (1.245)	3.95 (1.229)	3.43 (1.215)	2.34 (1.220)	2.91 (1.160)
	NTUA > NTUST > MIT > RISD > TJU > THU					
NTUA (n = 115)	2.10 (1.18)	1.77 (1.035)	3.75 (1.22)	2.83 (1.237)	1.93 (1.19)	2.34 (1.263)
	NTUA > NTUST > MIT > THU > RISD > TJU					
NTUST (n = 60)	1.65 (1.039)	1.58 (1.062)	2.88 (1.474)	3.42 (1.476)	1.87 (1.255)	2.63 (1.507)
	NTUST > NTUA > MIT > RISD > THU > TJU					
	THU	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Mainland China (n = 222)	2.75 (1.120)	2.45 (1.171)	1.93 (1.143)	1.78 (1.075)	1.85 (1.130)	2.01 (1.186)
	THU > TJU > MIT > NTUA > RISD > NTUST					
THU (n = 35)	3.89 (1.105)	2.74 (1.120)	2.00 (1.163)	1.77 (0.942)	2.49 (1.197)	2.51 (1.095)
	THU > TJU > MIT > RISD > NTUA > NTUST					
TJU (n = 64)	3.05 (1.188)	3.02 (1.188)	2.20 (1.311)	1.98 (1.105)	2.05 (1.188)	2.50 (1.321)
	THU > TJU > MIT > NTUA > RISD > NTUST					

Note: samples that are most familiar to the respondents are marked in gray shading.

In the twenty-first century, students can learn about the current situations in renowned universities in other countries or regions by using the internet, and can also use open-source data to study online. However, this may not be sufficient to give students a comprehensive understanding of a university or of a specific department. However, these benefits are still out of reach for students in economically and socially underdeveloped areas. In fact, even in developed countries or regions, there are still many students who are unable to access the educational resources of other countries or regions due to economic constraints (e.g., some families cannot afford to pay for internet communication). Therefore, this study posits that the reasons for the emergence of the above phenomena are more complex than this one explanation allows. However, it is still necessary for students to take advantage of various opportunities and conditions to expand their international perspectives. In recent years, due to the COVID-19 pandemic, international communication has been restricted, but online communication has developed rapidly, and many universities or research institutions have overhauled their homepages and shared numerous resources. This provides great convenience for students, including teachers.

The respondents' assessments of whether these six universities focus on STEAM are shown in Table 5. The responses reflect the following trends:

- Respondents from the four universities may have been objective, rather than simply scoring intuitively. For example, they argued that MIT deserves the highest score in some attributes, which is consistent with the actual situation. This may be related to the prestige of MIT;
- Some of the respondents were not from the four universities mentioned above. However, these people rated the two universities in their home country relatively highly. For example, respondents from the Taiwan area (teachers, students, and graduates who are not from NTUA and NTUST) rated NTUA and NTUST relatively highly. This may be due to the respondent's intuitive reaction. For example, if respondents have not studied abroad or even used the internet to learn about other universities, they may have given relatively high ratings to universities in their country or region out of patriotic feelings. However, the situation reflected in the above assessment may also

be more consistent with the actual situation. Follow-up studies will further analyze whether this phenomenon is real and the reasons for its occurrence.

Table 5. The mean and std. deviation of the respondents' assessment of the STEAM model.

Taiwan Area (n = 128)	THU	TJU	NTUA	NTUST	RISD	MIT
Science	3.23 (1.233)	3.14 (1.085)	2.88 (0.988)	3.88 (0.944)	3.26 (0.941)	4.44 (0.903)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Technology	3.26 (1.186)	3.23 (1.103)	3.16 (1.007)	4.16 (0.903)	3.34 (0.891)	4.50 (0.939)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Engineering	3.16 (1.200)	3.15 (1.065)	2.58 (1.024)	3.97 (0.922)	3.26 (0.982)	4.38 (0.940)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Arts	3.69 (1.266)	3.51 (1.190)	4.57 (0.928)	3.36 (1.070)	3.88 (1.047)	3.62 (1.080)
	NTUA > RISD > THU > MIT > TJU > NTUST					
Mathematics	2.94 (1.228)	2.99 (1.112)	2.35 (0.977)	3.45 (0.971)	2.97 (0.922)	4.21 (0.993)
	MIT > NTUST > TJU > RISD > THU > NTUA					
NTUA (n = 115)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	3.27 (1.15)	3.01 (1.158)	2.79 (1.039)	3.65 (0.937)	3.13 (0.996)	4.21 (1.055)
	MIT > NTUST > THU > RISD > TJU > NTUA					
Technology	3.36 (1.069)	3.27 (1.187)	3.20 (1.061)	4.00 (0.927)	3.37 (1.037)	4.26 (1.027)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Engineering	3.22 (1.138)	3.14 (1.139)	2.80 (1.053)	3.77 (0.974)	3.08 (0.890)	4.19 (1.067)
	MIT > NTUST > THU > TJU > RISD > NTUA					
Arts	4.05 (1.083)	3.67 (1.212)	4.56 (0.797)	3.34 (1.075)	3.77 (1.071)	3.37 (1.151)
	NTUA > THU > RISD > TJU > MIT > NTUST					
Mathematics	3.10 (1.116)	3.01 (1.112)	2.42 (1.043)	3.41 (1.016)	3.06 (1.003)	4.10 (1.068)
	MIT > NTUST > THU > RISD > TJU > NTUA					
NTUST (n = 60)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	3.28 (1.166)	3.20 (1.117)	2.73 (1.071)	4.08 (0.979)	3.17 (0.977)	4.02 (1.066)
	NTUST > MIT > THU > TJU > RISD > NTUA					
Technology	3.53 (1.171)	3.23 (1.079)	3.05 (0.982)	4.20 (1.054)	3.28 (1.043)	4.13 (1.112)
	NTUST > MIT > THU > RISD > TJU > NTUA					
Engineering	3.20 (1.286)	3.23 (1.079)	2.98 (1.157)	4.12 (1.010)	3.35 (1.087)	4.10 (1.130)
	NTUST > MIT > RISD > TJU > THU > NTUA					
Arts	3.60 (1.153)	3.27 (1.133)	4.25 (1.068)	3.98 (1.033)	3.52 (1.112)	3.52 (1.097)
	NTUA > NTUST > THU > MIT > RISD > TJU					
Mathematics	3.13 (1.270)	3.10 (1.040)	2.73 (1.150)	3.73 (1.250)	3.17 (1.080)	3.93 (1.150)
	MIT > NTUST > RISD > THU > TJU > NTUA					
Mainland China (n = 222)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	2.58 (1.355)	2.32 (1.262)	2.02 (1.149)	2.02 (1.218)	1.89 (1.142)	2.32 (1.444)
	THU > MIT = TJU > NTUA = NTUST > RISD					
Technology	2.62 (1.379)	2.38 (1.336)	2.01 (1.165)	2.06 (1.252)	1.93 (1.200)	2.36 (1.485)
	THU > TJU > MIT > NTUST > NTUA > RISD					
Engineering	2.49 (1.338)	2.41 (1.378)	2.00 (1.146)	2.02 (1.224)	1.94 (1.189)	2.31 (1.457)
	THU > TJU > MIT > NTUST > NTUA > RISD					
Arts	3.32 (1.333)	2.81 (1.376)	2.35 (1.379)	2.07 (1.186)	2.28 (1.444)	2.24 (1.339)
	THU > TJU > NTUA > RISD > MIT > NTUST					
Mathematics	2.36 (1.340)	2.22 (1.270)	1.93 (1.113)	1.94 (1.134)	1.84 (1.114)	2.29 (1.471)
	THU > MIT > TJU > NTUST > NTUA > RISD					

Table 5. *Cont.*

THU (n = 35)	THU	TJU	NTUA	NTUST	RISD	MIT
Science	3.17 (1.224)	3.11 (1.255)	2.37 (1.060)	2.69 (1.255)	2.71 (1.274)	3.71 (1.487)
	MIT > THU > TJU > RISD > NTUST > NTUA					
Technology	3.54 (1.291)	3.29 (1.274)	2.34 (0.998)	2.77 (1.308)	2.97 (1.317)	3.91 (1.483)
	MIT > THU > TJU > RISD > NTUST > NTUA					
Engineering	3.37 (1.215)	3.23 (1.308)	2.43 (1.037)	2.51 (1.147)	2.94 (1.282)	3.66 (1.414)
	MIT > THU > TJU > RISD > NTUST > NTUA					
Arts	4.20 (0.933)	3.54 (1.314)	3.20 (1.410)	2.74 (1.245)	3.80 (1.410)	3.40 (1.288)
	THU > RISD > TJU > MIT > NTUA > NTUST					
Mathematics	2.89 (1.132)	2.86 (1.216)	2.23 (0.973)	2.49 (1.197)	2.69 (1.207)	3.57 (1.441)
	MIT > THU > TJU > RISD > NTUST > NTUA					
TJU (n = 64)	**THU**	**TJU**	**NTUA**	**NTUST**	**RISD**	**MIT**
Science	3.00 (1.272)	2.98 (1.327)	2.47 (1.284)	2.50 (1.392)	2.45 (1.272)	3.08 (1.546)
	MIT > THU > TJU > NTUST > NTUA > RISD					
Technology	3.11 (1.323)	3.12 (1.315)	2.42 (1.270)	2.48 (1.380)	2.56 (1.446)	3.08 (1.515)
	TJU > THU > MIT > RISD > NTUST > NTUA					
Engineering	3.00 (1.297)	2.98 (1.303)	2.53 (1.345)	2.45 (1.308)	2.41 (1.342)	3.03 (1.469)
	MIT > THU > TJU > NTUA > NTUST > RISD					
Arts	3.64 (1.200)	3.44 (1.332)	2.92 (1.473)	2.47 (1.259)	2.89 (1.565)	2.95 (1.506)
	THU > TJU > MIT > NTUA > RISD > NTUST					
Mathematics	2.91 (1.411)	2.72 (1.303)	2.28 (1.175)	2.42 (1.355)	2.36 (1.326)	2.95 (1.527)
	MIT > THU > TJU > NTUST > RISD > NTUA					

Note: samples that receive the highest ratings on different attributes of STEAM are marked in gray shading.

4.2. Differences in Respondents' Perceptions

One-way ANOVA was used to determine whether there was any cognitive difference among the respondents from the four universities, and the results are shown in Table 6. It can be seen that, with the exception of TJU, there were significant differences in the respondents' perceptions of the other five universities with different attributes.

Through in-depth analysis and interpretation of the data, the following characteristics can be found:

- Respondents from NTUA and NTUST rated both the cognitive differences in the attributes that were highly rated;
- The standard deviation of some attribute scores was large, indicating that perceptions of them varied widely between respondents.

4.3. The Sample's Curriculum and Its Relevance to STEAM

This study will further analyze the curricula of these four universities, enabling us understand the real situation of the STEAM model in use in these four universities (see Table 7). The following inferences can be drawn from the curricula of these four universities:

- With the exception of the Department of Architecture at NTUST, art courses have the highest proportion of different departments at these six universities. Typically, the department of architecture or the school of architecture is relatively independent. Although elements of art are also essential to architecture, they may not be prioritized;
- Some departments do not offer courses related to science or mathematics. Few departments retain a certain proportion of technology-related courses because they require technical support;
- Due to the different definitions of course categories in each country or region, and the fact that some courses may be interdisciplinary, there is a certain percentage of courses that cannot be included in any category in STEAM, and can only be temporarily replaced by "Other". The proportion of these courses is not very low.

Table 6. The differences between respondents from four universities.

Sample	Attribute	Source of Variation	*SS*	*df*	*MS*	*F*	Post Hoc Tests
THU	Arts	Between Groups	15.360	3	5.120	4.158 *	1 > 2; 1 > 4; 3 > 2; 3 > 4
		Within Groups	332.421	270	1.231		
		Total	347.781	273			
NTUA	Technology	Between Groups	7.531	3	2.510	2.037 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
		Within Groups	332.834	270	1.233		
		Total	340.365	273			
	Arts	Between Groups	10.122	3	3.374	2.560 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
		Within Groups	355.892	270	1.318		
		Total	366.015	273			
NTUST	Science	Between Groups	104.447	3	34.816	28.296 ***	2 > 1; 1 > 3; 1 > 4; 2 > 3; 2 > 4
		Within Groups	332.213	270	1.230		
		Total	436.661	273			
	Technology	Between Groups	142.449	3	47.483	37.513 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
		Within Groups	341.756	270	1.266		
		Total	484.204	273			
	Engineering	Between Groups	131.618	3	43.873	36.913 ***	2 > 1; 1 > 3; 1 > 4; 2 > 3; 2 > 4
		Within Groups	320.907	270	1.189		
		Total	452.526	273			
	Arts	Between Groups	80.579	3	26.860	20.877 ***	2 > 1; 1 > 3; 1 > 4; 2 > 3; 2 > 4
		Within Groups	347.380	270	1.287		
		Total	427.960	273			
	Mathematics	Between Groups	77.393	3	25.798	18.630 ***	1 > 3; 1 > 4; 2 > 3; 2 > 4
		Within Groups	373.877	270	1.385		
		Total	451.270	273			
RISD	Science	Between Groups	24.161	3	8.054	6.662 ***	1 > 4; 2 > 4
		Within Groups	326.379	270	1.209		
		Total	350.540	273			
	Technology	Between Groups	29.150	3	9.717	6.948 ***	1 > 4; 2 > 4
		Within Groups	377.566	270	1.398		
		Total	406.715	273			
	Engineering	Between Groups	30.366	3	10.122	8.300 ***	1 > 4; 2 > 4; 3 > 4
		Within Groups	329.269	270	1.220		
		Total	359.635	273			
	Arts	Between Groups	34.989	3	11.663	7.401 ***	1 > 4; 2 > 4; 3 > 4
		Within Groups	425.479	270	1.576		
		Total	460.467	273			
	Mathematics	Between Groups	27.345	3	9.115	7.171 ***	1 > 4; 2 > 3; 2 > 4
		Within Groups	343.184	270	1.271		
		Total	370.529	273			
MIT	Science	Between Groups	55.207	3	18.402	11.838 ***	1 > 3; 1 > 4; 2 > 4; 3 > 4
		Within Groups	419.727	270	1.555		
		Total	474.934	273			
	Technology	Between Groups	61.438	3	20.479	13.406 ***	1 > 4; 2 > 4; 3 > 4
		Within Groups	412.459	270	1.528		
		Total	473.898	273			
	Engineering	Between Groups	61.263	3	20.421	13.480 ***	1 > 3; 1 > 4; 2 > 4; 3 > 4
		Within Groups	409.015	270	1.515		
		Total	470.277	273			
	Mathematics	Between Groups	57.359	3	19.120	12.143 ***	1 > 3; 1 > 4; 2 > 4; 3 > 4
		Within Groups	425.112	270	1.574		
		Total	482.471	273			

Note: * $p < 0.05$, *** $p < 0.001$; respondents from four universities: 1. NTUA, 2. NTUST, 3. THU, 4. TJU.

Table 7. The curriculum of four universities.

NTUA	Science	Technology	Engineering	Arts	Mathematics	Other	Total
			1. Department of Visual Communication Design				
Curriculum	0	16 (20.50%)	4 (5.12%)	32 (41.02%)	0	26 (33.33%)	78
			Arts > Other > Technology > Engineering				
			2. Department of Crafts and Design				
Curriculum	1 (1.02%)	6 (6.12%)	6 (6.12%)	53 (54.08%)	1(1.02%)	31 (31.63%)	98
			Arts > Other > Engineering > Technology > Mathematics > Sciences				
			3. Department of Multimedia and Animation Arts				
Curriculum	0	42 (56.75%)	1 (1.35%)	7 (9.45%)	0	24 (32.43%)	74
			Technology > Other > Arts > Engineering				
			4. Curriculum in General Education				
Curriculum	0	6 (35.29%)	0	6 (35.29%)	0	5 (29.41%)	17
			Science = Arts > Other				
NTUST	**Science**	**Technology**	**Engineering**	**Arts**	**Mathematics**	**Other**	**Total**
			1. Department of Design				
Curriculum	0	23 (28.78%)	8 (10%)	27 (33.75%)	0	22 (27.5%)	80
			Arts > Other > Technology > Engineering				
			2. Department of Architecture				
Curriculum	0	5 (8.77%)	19 (33.33%)	14 (24.56%)	5 (8.77%)	14 (24.56%)	57
			Engineering > Other > Arts > Technology = Mathematics				
THU	**Science**	**Technology**	**Engineering**	**Arts**	**Mathematics**	**Other**	**Total**
			1. Department of Visual Communication				
Curriculum	0	4(7.69%)	1(1.92%)	43 (82.69)	0	4 (7.69%)	52
			Arts > Technology = Other > Engineering				
			2. Department of Environmental Art Design				
Curriculum	2 (3.5%)	1(1.75%)	8(14.03%)	36(63.15%)	1(1.75%)	9(15.78%)	57
			Arts > Other > Engineering > Science > Technology = Mathematics				
			3. Department of Industrial Design				
Curriculum	0	5(9.43%)	3(5.66%)	33(62.26%)	0	12(22.64%)	53
			Arts > Other > Technology > Engineering				
TJU	**Science**	**Technology**	**Engineering**	**Arts**	**Mathematics**	**Other**	**Total**
			1. Department of Media & Communication Design				
Curriculum	0	14(37.84%)	0	14(37.84%)	1(2.7%)	8 (21.62%)	37
			Technology = Arts > Other > Mathematics				
			2. Department of Industrial Design/Product Design				
Curriculum	0	8(21.62%)	6(16.21%)	14(37.83%)	1(2.7%)	8 (21.62%)	37
			Arts > Technology = Other > Engineering > Mathematics				
			3. Department of Environmental Design				
Curriculum	0	8(21.62%)	6(16.21%)	14(37.83%)	1(2.7%)	8 (21.62%)	37
			Arts > Technology = Other > Engineering > Mathematics				

Source: quoted from the official website of these six universities, and collated by the authors.

Many students are not familiar with the curriculum of the relevant college or department when choosing a university, but will be influenced by the university's attributes. When they enter university, it is important to ensure that the curriculum is appropriate.

This study indicates that the curriculum arrangement of the design department largely depends on the orientation of the university to which it belongs. In general, it requires not only highlighting the advantages and characteristics of the university, but also flexibly adapting to the actual circumstances and focusing on a particular direction, such as the field of human–computer interaction (HCI). Consequently, the curriculum planning of the design department should find a balance in the STEAM model. It is also critical to note that these courses cannot be designed simply to incorporate the five dimensions of STEAM.

Moreover, in order to better grasp the objectives of the curriculum, teachers and students must have a deep understanding of the essence and connotations of STEAM.

5. Conclusions and Recommendations

5.1. Conclusions

Based on the results presented in the questionnaire, as well as the sample curriculum planning of the sample, the three hypotheses proposed in this study are deemed to be valid. If the respondents have no experience studying abroad, their knowledge of schools they have never attended is limited, which may lead to assessments that do not match the actual situation. Although the STEAM model has been widely used, there are still differences in its implementation between different countries or regions. For example, since STEM was introduced to universities in mainland China in 2016 and is still in the development stage (STEAM is also not widely practiced in design education in mainland China), participants from universities in the United States, where STEM and STEAM were developed, are encouraged to support the identification of cognitive difference, thus improving the replicability of the results.

Design educators and researchers need to have a deep understanding of the essence and implications of STEAM. Students must also consider how to acquire the knowledge and skills needed for 21st-century design through STEAM courses. For example, in some countries or regions, the STEAM model has just been applied to design education, and teachers and students lack rich experience. It is necessary to continuously collect feedback from these people. So, the use of STEAM in design education needs to be continuously evaluated and improved.

5.2. Limitations and Follow-Up Research

The limitations of this study, which will be further addressed in subsequent studies, include the fact that all of the respondents in this study are from Chinese-speaking areas, and a large proportion of them have no experience studying abroad, so their assessment of STEAM cannot be discussed more widely for the time being. As part of this research series, we will further cross-compare the results obtained from different perspectives. In the future, we will analyze respondents' evaluations of two samples from the USA. If possible, we plan to invite teachers and students from these two universities to answer our questionnaire. Their answers can be compared with our findings.

This study posits that science, technology, engineering, and mathematics can be mastered through systematic, scientific, standardized, and continuous training, but artistic and humanistic literacy requires the long-term accumulation of knowledge. In addition, using art to connect science, technology, engineering, and mathematics can also prompt people to think about the humanistic connotations of the four dimensions of STEM from another perspective.

From STEM to STEAM, it is possible that the concept of "arts" can play a major role in connecting the other four attributes. It is expected that future research will focus on what changes "art" brings when it is connected to the other four attributes (science, technology, engineering, and mathematics) as well as what new inspiration and enlightenment these changes can bring to design education. Researchers and educators in the field of design should pay attention to this issue. Although the current research is still ongoing, we would like to reiterate our call for more people to participate in the exploration of the use of STEAM models in design education.

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