Digging deeper: Germinating students’ appreciation toward mathematics through STEAM

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**Abstract**. Due to tedious teaching method in classroom, some previous studies showed how people value mathematics as an exclusive subject. It leads to the lack of awareness that mathematics can be learned from and for different perspectives. This study aims at exploring students’ appreciation of mathematics through its relation towards different field in Science, Technology, Engineering and Art. Together with mathematics, all those four branches established an emerging concern in professional work called STEAM. The participant of the study was 67 first year mathematics education students of a university in West Nusa Tenggara, Indonesia. The data were gathered through a written test and analyzed using descriptive quantitative method. From the analysis, the students performed a moderate appreciation of mathematics in STEAM (average score 65.94). The result provides essential remark for teacher training institution to support the students’ development to be effective mathematics teachers by acknowledging the application of mathematics in various domain of knowledge and human’s daily activities.

1. Introduction

Previous studies found that children complaint about mathematics for being not interesting, difficult to understand and have no connection with their life [1], [2] & [3]. Mathematics got the image of tedious subject due to its exclusiveness to be learned [4]. By means, the students were hardly seeing the connection between mathematics and different fields of knowledge or its application in nature or human’s activity. Therefore, mathematics seems only need to be learned by those who want to be mathematician. Nevertheless, if the students find mathematics useful for their prospective careers, they will be willing to learn it further even though they might still consider it as difficult subject [5].

In contrary, from the very beginning, mathematics was emerged due to people’s need to arrange their daily life [6]. For instance, number was originally developed as the answer to record the number of live stocks, counting days and for goods exchange [7]. It leads to the question, where it turns wrong? How can many people with different ages and education level failed to see the use of mathematics?

To remove the segregated portrait of mathematics, classroom reformation is urgently needed [8], [9] & [10]. The word reformation calling for the balance identities of mathematics as a computational knowledge, way of knowing, creative medium and its application [11]. Those images of mathematics will encourage the students to learn through engagement, imagination, alignment and nature [12] in which they feel valuable and reluctant to learn mathematics [13]. For that, mathematics gains more attention as people start to see their benefits for humankind. In other words, the reformation in mathematics teaching and learning aims at establishing mathematics appreciation in the society.

Teachers and their teaching method play important role in engaging students in learning. Indeed, one of the factors that influence the interest and success of students in learning mathematics is the teacher. It was found that the lack of adequate teaching materials and methodology contributed to the students failure in mathematics [14] & [15]. Therefore, if the target is to provide an attractive yet meaningful lesson for students, we need to prepare a creative and effective mathematics teacher to plan, conduct and assess the overall lesson. Nowadays, there are a number of concern and attempt to enhance the teachers’ creativity in developing a meaningful mathematics lesson so that through their classes the students will be able to see the benefits of learning mathematics [16], [17], [18] & [19].

Giving a professional development for in service teachers is necessary but not enough. The movement should also be started from the education process to be a teacher or in a teacher training institution since we need to prepare teacher as early as possible. However, before talking further about the plan to increase mathematics appreciation of the students, we need to figure out what was it in the prospective mathematics teachers’ head when they heard the combination of mathematics and other branches of knowledge.

Recently, a new and promising field has been raising. It is the integration of Science, Technology, Engineering and Mathematics (STEM). Sometimes, Art is also inserted there and make the combination more beautiful with STEAM. The notion of the STEAM stands for the collaboration of those involved knowledge to solve problem or create new things together, not apart as it used to be [20]. Not only be used in industry and research laboratory, it is also applied in the classroom. Research suggests the implementation of STEAM in every educational level from early childhood to university [21], [22] & [23]. Now, the question is how far the ideas of the relation between fields in STEAM can be acknowledged by the prospective teachers? It is important since according to the study the obstacle in preparing STEM related class is due to teachers inability to find its real life application [24].

Due to the limitation of the study, we solely will focus on the mathematics appreciation as resulted on its collaboration with other fields in STEAM. As the long-time goal to promote a meaningful mathematics learning, we conducted this study by targeting the students who just graduate from high school and have a plan to be mathematics educator. First year students were selected since they have no experience in taking any advance course in education. Therefore, their responses will be authentic, taking from background, practices or involvement with STEAM in their environment.

Following the aforementioned background this study aims at exploring the prospective mathematics teachers’ appreciation toward mathematics through STEAM. The result of this study is important since it can provide input for teacher training institution to choose the best learning route that will be supporting the mathematics education students to be effective mathematics teachers.

1. Method

We employed survey as the method since the purpose of the study was to figure out how the students appreciate mathematics with respect to its collaboration in Science, Technology, Engineering and Art. Therefore, a written test in which the participants should write their ideas related to the phenomenon/event/nature/product or something similar for every given condition.

In total, we asked 11 condition consists of the combination of (1) Mathematics and Science, (2) Mathematics and Engineering, (3) Mathematics and Technology, (4) Mathematics and Art, (5) Mathematics, Science and Engineering, (6) Mathematics, Science and Technology, (7) Mathematics, Science and Art, (8) Mathematics, Engineering and Technology, (9) Mathematics, Engineering and Art, (10) Mathematics, Technology and Art, and (11) Mathematics, Science, Engineering, Technology and Art. The data were converted to binary score, 1 if its correct, 0 if it does not.

Afterwards, the collected data analyzed descriptively using quantitative method. We calculated the mean, standard deviation and confidence interval of the students’ responses in general and for each item.

The participants of the study were 67 first year students of mathematics education study program in a university located in West Nusa Tenggara, Indonesia. First year students were selected because they just finished their high school and had experienced of using mathematics in different field of study. Also, they were not experienced in education related topic course yet. Therefore, their responses will be genuine and reflect their personal circumstances.

1. Results and Discussion

From the gathered data we found that students were having various ideas of how mathematics related to the different fields in STEAM. It can be seen from their sample responses where ideas were emerged based on their personal experiences. In general, the quantitative result of the study can be observed in Table 1.

**Table 1**. Students’ Appreciation toward Mathematics

|  |  |
| --- | --- |
| Data | Value |
| Mean | 0.6594 |
| Standard Deviation | 0.2294 |
| Number of Sample | 67 |
| Confidence Interval | 95% |

The mean in Table 1 showed how the participants can be considered to have moderate appreciation in mathematics and its relation towards STEAM. Furthermore, from the analysis it was found that using 95% confidence interval, we can generalize that the true population mean will be around 0.6034 and 0.7153.

Looking deeper to the different combination of mathematics and different fields in STEAM, students showed different level of appreciation. It means, the event or product as the combination of mathematics and certain fields were more easily be seen by the students compared to the rest. Consider the following Figure 1 (S = Science, T = Technology, E = Engineering, A = Art, M = Mathematics).

M-S

M-E

M-T

M-A

M-S-E

M-S-T

M-S-A

M-E-T

M-E-A

M-T-A

M-S-E-T-A

**Figure 1**. Comparison of students’ mathematics appreciation in different STEAM field

We also tested the Standard Deviation and evaluated the mean of population in Confidence Interval of 95% from the obtained data in each item code category as can be seen in the following Table 2.

**Table 2**. Students’ Appreciation toward Mathematics within each STEAM Strands

|  |  |  |  |
| --- | --- | --- | --- |
| **Item Code** | **Mean** | **SD** | **Approximation Mean in Confidence Interval (95%)** |
| M & S | 0.8358 | 0.373 | 0.7448 – 0.9269 |
| M & E | 0.9104 | 0.2877 | 0.8403 – 0.9806 |
| M & T | 0.9403 | 0.2387 | 0.8821 – 0.9985 |
| M & A | 0.8806 | 0.3267 | 0.8009 – 0.9603 |
| M, S & E | 0.6866 | 0.4674 | 0.5726 – 0.8006 |
| M, S & T | 0.5672 | 0.4992 | 0.4454 – 0.6889 |
| M, S & A | 0.3433 | 0.4784 | 0.2266 – 0.46 |
| M, E & T | 0.6866 | 0.4674 | 0.5726 – 0.8006 |
| M, E & A | 0.5075 | 0.5037 | 0.3846 – 0.6303 |
| M, T & A | 0.5821 | 0.4969 | 0.4609 – 0.7033 |
| M, S, E, T & A | 0.3134 | 0.4673 | 0.1994 – 0.4274 |

The Figure 1 and Table 2 showed that the participants were mostly able to find the relation between Mathematics and Technology followed by Mathematics and Engineering. But hardly figure the combination between Mathematics, Science and Art. The lowest score was obtained in the combination of those all in Mathematics, Science, Engineering, Technology and Art.

Generally, in most of the combination - besides those two who scored around 0.3, the students were successfully found the combination of mathematics with different fields of knowledge in term of their usefulness in daily life or natural phenomenon. It means, the students were having enough experiences to appreciate mathematics.

A closer look at students’ responses showed that this appreciation likely emerged from their personal experiences with their environment and information they got from movies, television or social media. It can be seen from some example of their responses which are making robot/software/machine, forecasting of weather/ earthquake/volcanic eruptions, golden ratio and other techniques in painting (some students specifically mentioned the title of painting, such as the Birth of Venus and Algorithmic Taxonomy of Fractals), producing drugs in pharmaceutical industry and another tools for medical purposes, designing clothes, making handcraft, generating musical instrument and constructing building/bridge/transportation facilities.

Even though only limited students who were able to figure out the nature or daily life issues related to the use of all STEAM fields, they provided various interesting responses which can be used as a meaningful context to teach integrated mathematics in the future. Some examples of students’ ideas were related to the previous recommendation in STEAM application and education, e.g. hologram [25], animation [26] and farming/agriculture [27]. Similarly, despite of their difficulties in finding the events related to the use of Mathematics, Science and Art, 34.32% students who provide correct responses came with meaningful thought. Some examples of their responses were, indeed, become a rich resource in learning such as waterfall, puppets and statue.

The various ideas of how mathematics can support other fields to create or to explain phenomenon reflect the students’ awareness toward the use of mathematics. Also, it can be seen that the students’ examples were not limited to specific phenomenon, i.e. only appeared in certain profession’s issues but varied into what will be used by the artisan (e.g. painting), farmer (e.g. farming), programmer (e.g. software) and scientist (e.g. earthquake research). Therefore, in this study we revealed that the question related to the phenomenon in STEAM supported the students to acknowledge how mathematics does have practical usefulness, not limited to theoretical used in the classroom.

The aforementioned findings indicated the opportunity to raise more appreciation of mathematics toward the integration of mathematics in STEAM topics. It follows two major implications. First, teacher training institution should be aware with the students’ intuitive sense to see the application of mathematics in different field of STEAM and can use the opportunity to encourage students to meaningfully learn mathematics [28], [29] & [30].

Second, as the students of our study were a group of prospective mathematics teachers, teacher training institution should focus on the development of these students’ creativities and awareness toward the use of mathematics many different aspects and support their attempt to be effective teachers with a rich and varied learning context to be applied in their future classroom. One example of this was showed in the integration of mathematics and art in the number pattern investigation classroom [31] & [32].

All in all, the questions related to the application of mathematics in combination with other branches of STEAM were able to initially rise the students’ appreciation toward mathematics. However, to maintain or furthermore attain optimum result, it is recommended for teacher training institution to promote integrative learning mathematics [33], [34] & [35] and create project related to STEAM [36] & [37] to prepare the prospective mathematics teacher. This recommendation is in line with the finding of the previous study that prospective teachers aware with the important of integrated education as in STEAM but feel less confidence about their ability to conduct the lesson [38].

1. Conclusion

Reflect to the result and discussion, it can be concluded that first year mathematics education students were having a moderate appreciation toward mathematics with respect to its combination in STEAM fields in various domain of lives. As the score obtained were not too high nor too low, it brings challenge and opportunity in the same time to the teacher training institution. The students were showed their interest and creative mind in finding the application of mathematics in STEAM and it can be a good starting point to encourage them in creating a rich integrative mathematics classroom in the future. In the same time, if this potency be neglected, we are likely to lost the opportunity to germinate the future teachers’ and students’ mathematics appreciation.

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