Analyzing students’ achievement and attitude through the Frankards context in learning probability

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Abstract. In learning abstract mathematical concepts such as probability, students’ critical thinking and problem-solving skills are enhanced. However, learning this concept through abstraction would be a great challenge to students who are struggling in mathematics. Hence, an instructional support would be a great help. This study analysed the effect of using Frankards, an instructional material manipulative in teaching probability, on students’ achievement and attitude. Specifically, it aimed to determine the students’ level of achievement, students’ level of attitude, towards mathematics and the relationship between achievement and attitude. Quasi-Experimental Pretest-Posttest Control Group Design and purposive sampling were used where respondents were grouped into two: experimental group (taught with Frankards) and control group (taught without Frankards). A multiple choice pretest and posttest were administered to both groups to determine the difference between students’ achievement. Guce and Talen’s Scale on Attitude Towards Mathematics (SATM) and a multiple-choice achievement test were utilized as research instruments. The results showed that there was a significant difference between the experimental and control group in terms of achievement where students taught with Frankards outperformed the control group. It was also found that there was no significant difference between the experimental and control groups in terms of attitude. Moreover, the relationship between achievement and attitude (in terms of student engagement and liking mathematics) was found. The utilization of Frankards is recommended in teaching probability.

1. Introduction

International aptitude tests administered by TIMSS and PISA show the declining trend in the mathematical proficiency of students. Philippines ranked 2nd to the last in terms of mathematics literacy where 54% of students scored below Level 1, the lowest level of proficiency in PISA [1]. Thus, educators are encouraged to innovate and develop strategies that would help in enhancing students’ mathematical proficiency. In the same manner, the Commission on Higher Education and the Department of Education constantly value the role that teachers play in achieving academic excellence. However, it was found that there was a lack of instructional materials and most teachers depend on performance tasks provided in the learner’s module [2]. To address these issues, Frankards was developed. It is an instructional manipulative designed to teach probability. As shown in figure 1,
Frankards is a set of 56 cards specifically crafted to assist teachers in teaching probability concepts through concrete manipulation [3].

Figure 1. The Frankards, a set of 56 cards characterized with mathematical symbols and polygons. Copyright Notice: Frankards is owned by Romblon State University and Frankie A. Fran with Copyright Registration No. O2021-01

In mathematics education, manipulatives were considered as valuable tools for instruction. It helps learners to visualize mathematical concepts and to gain an in-depth understanding of the lessons other than an abstraction [4–6]. Evidence of positive results was found when concrete manipulatives were used in teaching mathematics, especially for students who have learning difficulties [7,8]. In support of this, the National Council of Supervisors in Mathematics endorsed the use of manipulative to enhance students’ proficiency in mathematics [9]. In the Philippines, DOST-SEI & MATHTED emphasized that the use of mathematical tools would allow students to vigorously involved in understanding mathematics concepts when properly used [10]. In terms of attitude, students tend to be more engaged and excited when manipulatives were used in teaching mathematics. Thus, it can be affirmed that attitude plays a crucial role in learning mathematics [11–13]. The students’ level of achievement and attitude were considered as variables when Frankards are used as an instructional material. The main purpose of this research is to determine the students’ level of achievement when taught with Frankards, determine the difference between the students’ level of achievement when taught and not taught with Frankards, determine the level of attitude based on Guce and Talens’ Scale on Attitude Towards Mathematics (SATM) and correlate students’ achievement and level of attitude. This paper intends to determine whether there is no significant difference between the pretest and posttest scores of the experimental group (with Frankards) and control group (without Frankards) in terms of probability.

2. Methods

This study utilized the Quasi-Experimental Pretest-Post-Test Control Group Design where the experimental (taught with Frankards) and control groups (taught without Frankards) are naturally assembled as intact classes [14]. This research used two instruments: Researcher-Made Multiple-Choice Test and Scale on Attitude Towards Mathematics (SATM). The multiple-choice test was used to determine the level of achievement of the students both for the experimental group and control group. Test items were analyzed, pilot tested, and interpreted based on the Range of Difficulty and Discrimination Indices and Verbal Interpretation [15]. The test was based on the learning competencies for probability as stipulated in the Curriculum Guide for Mathematics in the Basic Education as prescribed by the Department of Education. On the other hand, the SATM was utilized to determine the students’ level of attitude towards mathematics [16]. This is a standardized instrument created to quantify the students’ level of attitude. The standardized instrument was translated to Filipino to ensure that the respondents understand the concept provided in each indicator. Purposive sampling was used in selecting the student respondents from Grade 10; Experimental Group (n=45), Control Group (n=42). Both the achievement test and SATM were administered to both groups before and after the
implementation. The data gathered were statistically analyzed using Analysis of Covariance (ANCOVA), paired-sample t-test, Pearson r, and frequency in Statistical Package for Social Science Version 22.

3. Results and Discussion

In implementing the study, Frankards was used in teaching probability concepts. After completing the number of hours required by the learning competency, the following results were obtained. Table 1 shows the respondents’ level of achievement. This data is based on the transmuted results of the achievement test of both groups. Transmutation process was based on DepEd Order No. 8, s. 2015, “Policy on Classroom Assessment for K to 12 Basic Education Program”. It can be observed that 44.4% of the respondents in the experimental group are outstanding and no student falls in the lowest descriptor. Though a high number of students got an outstanding rating, 28.9% of the students in the experimental group got grades that are fairly satisfactory. On the other hand, 38.1% of the respondents in the control group got a rating of fairly satisfactory and also did not meet the expectations. This shows that most of the students got low academic achievement in the group where Frankards was not utilized as instructional aid in teaching probability concepts.

| Table 1. Level of Achievement of the Experimental and Control Group |
| --- | --- | --- |
| Descriptor | Experimental Group | Control Group |
| | f | % | f | % |
| Outstanding | 20 | 44.4 | 3 | 7.1 |
| Very Satisfactory | 5 | 11.1 | 1 | 2.4 |
| Satisfactory | 7 | 15.6 | 6 | 14.3 |
| Fairly Satisfactory | 13 | 28.9 | 16 | 38.1 |
| Did Not Meet Expectations | 0 | 0.0 | 16 | 38.1 |
| Total | 45 | 100.0 | 42 | 100.0 |

As shown in table 2, it can also be pointed out that the experimental group gained a higher score than the control group as shown in the adjusted and unadjusted means. In can also be pointed out in table 3 that there is a significant difference in the mean scores \[ F(1, 84) = 28.240, p<.05 \] between the experimental and control group whilst adjusting for pretest.

| Table 2. Unadjusted and Covariate Adjusted Descriptive Statistics for Scores of Students |
| --- | --- | --- | --- |
| Group | Pretest | Posttest (Unadjusted) | Posttest (Adjusted) |
| | N | Mean | SEmean | Mean | SEmean | Mean | SEmean |
| Control | 42 | 9.381 | .4867 | 15.000 | 3.457 | 15.064 | .544 |
| Experimental | 45 | 10.178 | .4430 | 19.156 | 3.574 | 19.096 | .525 |

| Table 3. Analysis of Covariance (ANCOVA) for Posttest Scores of the Students by Group with Pretest Scores as Covariate |
| --- | --- | --- | --- |
| Source | F | P | Interpretation |
| Group | 28.240 | .000 | Significant |

a. R Squared = .276 (Adjusted R Squared = .259)

After utilizing the pretest as the covariate, Analysis of Covariance (ANCOVA) shows the use of Frankards in teaching probability, with an F value of 28.240 and a p<.05. It revealed that the class taught with Frankards significantly performed better than the class taught without Frankards in terms of
students’ achievement. Consequently, this shows that the use of Frankards in teaching probability significantly contribute to the learning of the students. This includes the activities provided to the students through examples and word problems that are integrated in the lesson covered by the learning competencies.

In a similar research, it was found that concrete experiences provided by the teacher helps in aiding the learners in acquiring meaningful learning experience[17]. This helped them process the ideas and concepts provided to them with ease since a concrete experience was provided.

This is in consonance with Constructivism Principle and Theory of Cognitive Development where they emphasized the importance of concrete manipulation in students’ learning. Diene highlighted that learners whose mathematics understanding were strongly grounded on hands-on experiences were more likely to create links between the abstract concepts of mathematics and the world where they live [18]. This was affirmed by Piaget’s theory where he stressed that learning experiences can only be strengthened if abstract concepts will be taught with the aid of concrete objects such as manipulatives [19]. In connection with these literature, various research pointed out that difficulties in concept visualization of abstract concepts were common issues among students [20]. This is also evident in the topics covered by the learning competencies of this study where lessons are mostly abstract in nature.

As presented earlier in table 1, several students for the experimental group gained fairly satisfactory scores. Though there is an increase in their scores in the posttest results, students in the lower level of achievement should be considered. However, it was observed that the use of tangible materials rather than abstract concepts will facilitate the learning process considerably. It can be stressed that Frankards had assisted in translating these abstract concepts through concrete manipulation and hands-on experience.

Moreover, teaching mathematics with manipulatives, such as Frankards, was often described as an effective methodology when compared with instruction that only used abstract math symbols. It also assists teachers in facilitating students’ understanding of these abstract ideas [17,21]. Similarly, based on the meta-analysis study, it was found that the use of concrete materials and other instructional aids contribute and has a high influence in students’ academic achievement in mathematics [22]. Furthermore, Lu Pien emphasized that Singapore, the leading country in mathematics based on TIMSS and PISA results, recommended and encouraged teachers to give more investment to pedagogical knowledge and to explore more learning opportunities to students [23]. This will assist them in becoming competent in the endeavors that they will choose and to exhibit high level of mastery in mathematics accompanied by enhanced critical and intuitive thinking.

Table 4 further supports the results of table 2 where it was found that the experimental group is significantly different from the control group. In details, the table presents the mean gain of the experimental group and the control group, 8.98 and 5.62, respectively. It can be concluded, statistically, that the increase in scores gained by the experimental group is significantly higher than the control group. This is a further reiteration of the vital role of Frankards in assisting the teacher in achieving a meaningful learning experience as shown in their scores. Thus, teachers should use aids in teaching abstract concepts such as probability. Additionally, these gain in scores can be considered as one of the indicators of students’ progress in deeply understanding probability concepts [22].

Table 4. Difference in Mean Gain Scores of the Respondents in the Achievement Test

| Groups          | Pre Mean | Post Mean | Mean Gain | p     | Interpretation | Decision |
|-----------------|----------|-----------|-----------|-------|----------------|----------|
| Experimental    | 10.18    | 19.16     | 8.98      | .001  | Significant    | Reject H0|
| Control         | 9.38     | 15.00     | 5.62      |       |                |          |

Table 5 shows the pretest and posttest mean scores of Guce’s & Talens’ Scale on Attitude Towards Mathematics (SATM) for the experimental group. Before and after the intervention, SATM results show no statistical difference among the given subscales. This explains Frankards did not positively/negatively changed student’s attitude towards mathematics. Though the respondents’
excitement and involvement in the activities with the use of Frankards in the classroom is highly evident, low tendencies and engagement were recorded based on the results of the SATM. However, this is not an undesirable result but an eye-opener for teachers and educators to do more other than teaching. The data presents the current situation of the mathematics education. And this is quite alarming given that an intervention is already provided to them.

Table 5. Pretest-Posttest Mean Score Results of Scale on Attitude Towards Mathematics (Experimental Group)

| Subscale                                           | Test    | N  | Mean     | SD    | t      | p    |
|----------------------------------------------------|---------|----|----------|-------|--------|------|
| 1. Liking or disliking math                        | Pretest | 45 | 3.8889   | .93474| .813   | .420 |
|                                                    | Posttest| 45 | 4.0222   | .83907| .781   | .439 |
| 2. Tendency to engage in or avoid mathematical activities | Pretest | 45 | 3.9556   | .63802| -.198  | .844 |
|                                                    | Posttest| 45 | 4.0444   | .47461| -.489  | .627 |
| 3. Belief that one is good or bad in mathematics   | Pretest | 45 | 3.6444   | .57031| -.489  | .627 |
|                                                    | Posttest| 45 | 3.6667   | .63960| -.489  | .627 |
| 4. Belief that mathematics is useful or useless     | Pretest | 45 | 4.4000   | .78044| -.489  | .627 |
|                                                    | Posttest| 45 | 4.3333   | .82572| -.489  | .627 |

The results of SATM can also be associated with the researcher’s observation on the specific areas where Frankards can only be incorporated. As an instructional material, it was observed that Frankards cannot be used as the only support for learning abstract concepts of probability. Since, probability concepts, as specified in the Curriculum Guide for Mathematics, covers various topics. Other support materials can be used to assist the students appreciate mathematics even more. This is one of the areas that was observed to be taken into consideration. It was also observed that Frankards can only be used as instructional support in explaining probability concepts but must not be used as sole material in teaching. The use of Frankards in this study did not defeat its purpose since its primary role is to assist the teacher in the discussion.

These results were supported by literatures where students’ attitude toward mathematics were evaluated before and after using journal writing as an instructional intervention [24]. In the same way, it was found that despite of the increase in the posttest results of their academic achievement, no difference was observed between the pre and post survey results. Similarly, it was observed that the respondents of somewhat like math. It was further concluded that though the students have low tendency of liking math it does not mean that they dislike mathematics at all as supported by the focused group discussion conducted. These results are reinforced by literature which showed the other reasons that may affect students’ attitude towards mathematics such self-confidence, beliefs in the significance of math and its usefulness [25]. The use of Frankards may have only minimal contribution on enhancing students’ engagement towards learning mathematics since there are other factors that need to be considered.

Table 6 presents the Scale on Attitude Towards Mathematics (SATM) results for the control group. The control group, the respondents who were taught using the conventional method, shares almost identical results to the experimental group. This serves to be a confirmatory result which gives further emphasis on the status of mathematics as an academic discipline. This explains that without any intervention, or simply taught conventionally, students’ attitude towards mathematics is also in the lower level.

Table 6. Pretest-Posttest Mean Score Results of Scale on Attitude Towards Mathematics (Control Group)

| Subscale                  | Test    | N  | Mean     | SD    | t      | p    |
|---------------------------|---------|----|----------|-------|--------|------|
| Liking or disliking math  | Pretest | 42 | 4.0714   | .77752| -6.419 | .000 |
The relationship between students’ achievement and SATM’s subscales for attitude for the class taught with Frankards is shown in table 7. It can be noted that there is a significant relationship between the students’ achievement and their attitudes towards liking or disliking mathematics and tendency to engage or avoid mathematical activities at 5% and 1% level, respectively. The results support the previous results presented in table 4. These results are in consonance with a research result which deals with the role of manipulatives in providing meaningful learning experiences to the students. It encouraged teachers to consider the utilization of instructional materials that engages learners through concrete manipulation and hand-on drill and activities. It was believed that these learning experiences will be of great help not only to teachers but most especially to the students. Strengthening the link between the abstract and concrete experiences will aid them in understanding the value of mathematics as an academic discipline [26].

Table 7. Relationship Between Achievement and the SATM’s Subscales for Attitude (Experimental Group)

|                      | Liking or Disliking Math | Tendency to engage in or avoid mathematical activities | Belief that one is good or bad in mathematics | Belief that mathematics is useful or useless |
|----------------------|-------------------------|-------------------------------------------------------|-----------------------------------------------|---------------------------------------------|
| Achievement Pearson Correlation | .324*                  | .438**                                                 | .076                                          | -.009                                       |
| Sig. (2-tailed)       | .030                    | .003                                                  | .619                                          | .954                                        |
| N                    | 45                      | 45                                                    | 45                                            | 45                                          |

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

For the control group, table 8 shows that there is no significant relationship between the achievement and the attitude of the students in terms of the SATM’s Subscales. In detail, it shows that the p-values are greater than 0.05 which shows no significance. This implies that the achievement of the students based on the lessons in probability shows no connection with the students’ attitude towards mathematics.

Table 8. Relationship Between Achievement and the SATM’s Subscales for Attitude (Control Group)

|                      | Liking or Disliking Math | Tendency to engage in or avoid mathematical activities | Belief that one is good or bad in mathematics | Belief that mathematics is useful or useless |
|----------------------|-------------------------|-------------------------------------------------------|-----------------------------------------------|---------------------------------------------|
| Achievement Pearson Correlation | .172                   | .124                                                  | .128                                          | -.281                                       |
| Sig. (2-tailed)       | .277                    | .435                                                  | .420                                          | .071                                        |
| N                    | 42                      | 42                                                    | 42                                            | 42                                          |
4. Conclusion

The use of Frankards in teaching the concepts of probability was found to have a positive effect on students’ achievement while no difference was found in terms of attitude as exhibited in the scores gained and statistical analysis. Students tend to be more engaged in the activities and discussions when Frankards was used. Thus, its positive effect on achievement and attitude is evident. Students in the experimental group outperformed the students in the control group in terms of academic achievement. In addition, the use of this instructional material aided the delivery of the content by providing concrete experiences in an abstract concept like probability. Consequently, the use of Frankards helped in improving the level of their academic achievement. Though exhibiting a minimal effect on attitude, using Frankards in teaching contributed to the enhancement of student engagement and their attitude of liking the mathematics. This further confirms the role that manipulatives, such as Frankards, contribute to the teaching-learning process specifically in understanding abstract concepts through concrete manipulations.

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