

Effects of Motivational Orientation on Mathematical Writing

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Abstract

This study, modeled by a similar study on creative writing (Amabile, 1983), explored the impact of extrinsic and intrinsic motivators on the development of mathematical writing skills. In particular, a comparison was made between treatment groups that were primed with a series of extrinsic or intrinsic reasons for studying mathematics. The intent is to provide insight into mathematical writing talents that may or may not surface as a result of underlying intrinsic or extrinsic beliefs about why we learn and study mathematics. Ranking of a list of intrinsic or extrinsic statements was the adopted form of priming. Priming occurs when subtle triggers influence behavior without awareness of such changes (Gladwell, 2005). This type of orientation assumes that individuals do not know reasons why they engage or do not engage in mathematical writing. If asked to articulate reasons, people will more often than not, provide a reason at the conscious level that may not accurately reflect the unconscious truth. Not knowing the purpose of the study, participants in this study were brought to think about their individual reasons to engaging in mathematics when ranking intrinsic or extrinsic statements. Truth was measured inters of individual performance on a subsequent mathematical writing activity. Participants in the extrinsic group were brought to think about extrinsic reasons for studying mathematics by ranking extrinsic statements according to personal choice. Similarly, participants in the intrinsic group were brought to think about intrinsic reasons for studying mathematics by ranking intrinsic statements according to personal choice. Immediately after ranking preferences, each student participant was asked to write everything they knew about triangles. Ensuing written responses underwent blind quality analysis performed by mathematicians. Contrary to the results of the Amabile study, the researcher found no evidence that a subject would receive a lower mathematical writing score after ranking extrinsic statements than for one written after ranking the intrinsic statements. One may infer that the difference in mathematical writing scores was not influenced by intrinsic or extrinsic orientation. Reasons why the results of the Amabile study did not transfer to the mathematical writings of elementary education majors are investigated.

Introduction

Do rewards and praise stimulate children to learn mathematics? Although reward systems are deeply embedded in schools and in the workplace, a growing body of evidence suggests that extrinsic rewards may operate in precisely the opposite way from what is intended. A remarkable demonstration of this phenomenon was provided by psychologist Teresa Amabile (1983) in an experiment concerning the effect of intrinsic and extrinsic motivation on creative writing. Participants in the Amabile study had considerable experience in creative writing and were randomly assigned to one of two treatments groups: 24 of the subjects were placed in the intrinsic treatment group and 23 in the extrinsic treatment group.

The questionnaire, shown in Figure 1, which involved ranking intrinsic reasons for writing, was intended as a device to establish a thought pattern concerning intrinsic motivation - doing something because doing it brings satisfaction. The extrinsic group completed the questionnaire, shown in Figure 2, which was used as a device to get this group thinking about extrinsic motivation - doing something because a reward is associated with its completion.

INSTRUCTIONS: Please rank the following list of reasons for writing, in order of personal importance to you (1 = highest, 7 = lowest)

- You get a lot of pleasure out of reading something good that you have written.
- You enjoy the opportunity for self-expression.
- You achieve new insights through your writing.
- You derive satisfaction from expressing yourself clearly and eloquently.
- You feel relaxed when writing.
- You like to play with words.
- You enjoy becoming involved with ideas, characters, events, and images in your writing.

Figure 1: Amabile intrinsic questionnaire

After completing the questionnaire, all subjects were asked to write a poem in the Haiku style about laughter. All poems were submitted to 12 poets, who evaluated them on a 40-point scale of creativity based on their own subjective views. Judges were not told about the study's purpose. Results provided evidence that a subject would receive a lower creativity score for a poem written after the extrinsic motivation questionnaire than for one written after the intrinsic motivation questionnaire (two-sided p -value = 0.005, from a two-sampled-test).

INSTRUCTIONS: Please rank the following list of reasons for writing, in order of personal importance to you (1 = highest, 7 = lowest).

- You realize that, with the introduction of dozens of magazines every year, the market for free-lance writing is constantly expanding.
- You want your writing teachers to be favorably impressed with your writing talent.
- You have heard of cases where one bestselling novel or collection of poems has made the author financially secure.
- You enjoy public recognition of your work.
- You know that many of the best jobs available require good writing skills.
- You know that writing ability is one of the major criteria for acceptance into graduate school.
- Your teachers and parents have encouraged you to go into writing.

Figure 2: Amabile extrinsic questionnaire

This paper describes what happens when one attempts identical methods, but shifts the focus to how extrinsic or intrinsic thought processes motivate mathematical writing performance among elementary education majors. We find that results of intrinsic or extrinsic orientation for writing among experienced writers does not apply to mathematical writing among elementary education majors and explore explanations of why this is true.

Methods

In this and the Amiable study (1983), adult participants were individually randomly assigned to one of two treatment groups: intrinsic or extrinsic. Placing the handouts in a randomly ordered stack and administering each according to the order in which each participant voluntarily agreed to be a part of the study assured random assignment. No time constraints were offered or implied.

Two sheets of paper were collected from each participant. The first piece of paper contained the intrinsic or extrinsic statements. The second sheet of paper contained the single question about triangles with ample room to for written response. Each participant received an anonymous identification number written on the first and second page. The intrinsic group completed a questionnaire, shown in Figure 3, which involved ranking intrinsic reasons for writing. The questionnaire was intended as a device to establish a thought pattern concerning intrinsic motivation for studying, learning, and writing mathematical content. The reader is encouraged to compare this questionnaire with that used by Amiable in Figure 1.

INSTRUCTIONS: Please rank the following list of reasons for mathematical problem solving, in order of personal importance to you (1 = highest, 7 = lowest).

- You get a lot of pleasure out of writing detailed mathematical solutions.
- You enjoy the opportunity for mathematical problem solving.
- You achieve new insights through mathematical problem solving.
- You derive satisfaction from expressing mathematical solutions clearly and accurately.
- You feel relaxed when studying mathematically related material.
- You like to play with numbers.
- You enjoy becoming involved with mathematical concepts, formulas, graphs, and data in your problem solving.

Figure 3: Intrinsic questionnaire

The extrinsic group completed the questionnaire, shown in Figure 4, which was used as a device to get this group thinking about extrinsic motivation for studying, learning, and writing mathematical content. The reader is encouraged to compare this questionnaire with that used by Amiable in Figure 2.

INSTRUCTIONS: Please rank the following list of reasons for mathematical problem solving, in order of personal importance to you (1 = highest, 7 = lowest).

- You realize that, with the introduction of multiply forms of advanced technology, the market for careers in mathematics is constantly expanding.
- You want your math teacher to be favorably impressed with your mathematical talent.
- You have heard of cases where one mathematical discovery has made a mathematician financially secure.
- You enjoy public recognition of your work.
- You know that many of the best jobs available require good math skills.
- You know that mathematical ability is a the major criteria for acceptance into graduate school.
- Your teachers and parents have encouraged you to go into mathematics.

Figure 4: Extrinsic questionnaire

After participants in each treatment group completed either the intrinsic or extrinsic questionnaire, each was prompted to write everything they know about triangles (Figure 5) on a second sheet of paper, that was, with the exception of the question, blank.

Question: Write down everything you know about triangles.

Figure 5: Technical writing question given to all participants.

An underlying assumption was that each participant knew something about triangles and could potentially write as many or as few details as desired. The quality of the written response to this question formed the basis of subsequent analysis.

Data Analysis

A total of 109 volunteer undergraduate elementary education majors participated in the study; 57 were in the extrinsic treatment group and 52 were in the intrinsic treatment group.

Ten instructors of mathematics, each holding a B.A., B.S., M.S, or Ph.D. in Mathematics, scored 10 to 15 responses to the writing everything you know about triangles question. Scoring instructors received only the second page and were not given any indication of the intend of the study or whether any particular response was from a participant in the extrinsic or intrinsic treatment group.

Instructors did receive a 40-point scoring rubric and a randomly selected batch of mathematical writing responses to score. The rubric divided scoring criteria into four 10-point categories: accuracy, neatness, attention to detail, and number of mathematical connections. In any category, responses that were below expectations received a score between 0 to 3 points; responses that met expectations received a score between 4 and 7 points, and responses that exceeded expectations received scores between 8 and 10 points.

Results

The mean score of participants in the extrinsic group was 12.72 with a standard deviation of 9.01. The mean score of participants in the intrinsic group was 12.92 with a standard deviation of 7.92. Equal variances were assumed based on assumptions of Levene's test for equality of variances ($F=2.30$, $p=0.132$). There was no statistically significant difference in mathematical writing scores between extrinsic and intrinsic treatment conditions ($t = 2.578$, $df = 107$, $p=0.901$, two-tailed).

Conclusion

Making mathematical content enjoyable is an essential part of elementary education mathematics courses. One goal of these college level courses is to provide future elementary education teachers with a new and uplifting perspective on mathematical content. The purpose of the goal is to alter poor attitudes that tend to dominate the subject among education majors. It is thought that by altering the attitude from negative to positive, elementary education majors will increase their willingness to engage future students in the subject. To affirm the goal of making mathematical content intrinsically satisfying, it is desirable, therefore, to establish some evidence that intrinsic orientation sets the stage for greater achievement in mathematics among elementary education majors. This research began with the intent to duplicate the findings of the Amabile study for elementary education majors and thereby establish that underlying intrinsic beliefs about mathematics lead to a greater level of engagement in content-based activities, such as writing everything one knows about triangles.

Amabile found that people who enjoy writing, when reminded of their intrinsic reasons for that fulfillment tend to experience greater achievement in writing than those who are reminded of extrinsic reasons for writing. However, directing elementary education majors, who typically do not enjoy writing mathematical content, to intrinsic statements for potential fulfillment does not inspire them to greater achievement in mathematical writing any more than ranking extrinsic statements. This suggests that it is not simply the ranking of intrinsic statements that moved Amabile's participants to greater writing abilities, but it is the strength of pre-established agreement with the intrinsic statements that influenced results.

Notes

Amabile, Teresa M. "Effects of Motivational Orientation on Creative Writing." Paper presented at the Meeting of the American Psychological Association, Anaheim, California, August 1983.

Gladwell, Malcolm. 2005. *Blink: The power of thinking without thinking*. New York: Back Bay Books.