

Enhancing the Teaching & Learning of Differential Equations Via Writing Reflections -A Case Study-

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Abstract - Writing reflection statements is not a practice in the teaching and learning of Differential Equations at a local university in Perak, Malaysia. The objective of this study is to investigate students' responses and performance with the implementation of writing reflections of their learning experience after each session of Differential Equations class, thrice a week. One hundred and eleven first semester undergraduate students in the first year of the Engineering program are involved in the study. After fourteen weeks of teaching and learning, data is collected for the purpose of the study. Students are given clear instructions at the onset of the study. Data is collected by using a questionnaire, interviews, scoring rubric and pencil and paper tests scores. The outcomes of this study indicate that writing reflection statements plays an important role in the enhancement of teaching and learning of Differential Equations.

Index Terms - Differential Equations, Enhancement, Learning Experience, Reflection Statements.

INTRODUCTION

Differential Equations (DE) forms a compulsory course for students enrolled in all engineering disciplines in a local private university in Perak, Malaysia. Students sit for this course in their first semester of their first year undergraduate studies. The requirement is that students will have to at least pass this course in order to be able to sign up for a higher level engineering mathematics course. The curriculum for all engineering courses here demands a total of fourteen weeks of teaching and requires effectively three contact hours weekly.

Although students enrolled into this university went through a stringent selection process, the number of students having academic difficulties particularly in this course raised a concern to the author. These students' common complain was that their poor rate of retention was a big contributing factor to their difficulties in passing the course. According to Kolb, the experiential learning cycle involved experiencing or noticing, interpreting or reflecting, generalizing or judging and applying or testing [1]. The author felt that the interpreting or reflecting stage was something that had been missing in many students' learning in order to make their learning meaningful. When learning is made meaningful, it

will contribute to students' better rate of retention. The objective of this study is to investigate the students' performance and their responses with the implementation of writing reflections of their learning experience after each session of DE class.

Reference [2] shows that Carpenter and Lehrer proposed five forms of mental activity from which mathematical understanding develops and they include

1. Constructing relationships,
2. Extending and applying mathematical knowledge,
3. Reflecting about experiences,
4. Articulating what one knows, and
5. Making mathematical knowledge one's own

Experience alone is not sufficient for learning. What converts experience into learning and what enables learners to gain the maximum benefit from the situations they are in? How can learners apply their experience in new contexts? Structured reflection is the key to learning from experience, and that reflection can be very difficult. "[3].

BACKGROUND

Reflective thinking is defined as "active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends [that] includes a conscious and voluntary effort to establish belief upon a firm basis of evidence and rationality." [1]

"Reflection is the process of stepping back from an experience to ponder, carefully and persistently, its meaning to the self through the development of inferences; learning is the creation of meaning from past or current events that serves as a guide for future behavior." [4]. Writing reflections is a common practice in teacher preparation programs, where teachers undergoing the teacher training will write reflections of their teaching experiences, declaring their strengths and weaknesses in performing the task.

The authors in [5] indicate in their book, "Writing in the Teaching and Learning of Mathematics," and provided guidance in incorporating writing in class.

In the teaching and learning of DE at Universiti Teknologi PETRONAS (UTP), writing reflection statements was never implemented before. Writing reflection statements would require students' explanation of the DE lesson for the day, their learning experience encountered in their own words. This is something new to the students, so a clear

instruction and guidance need to be provided by the instructor. In addition, students' interest in writing reflection statements must be instilled to steer and maintain their consistency and commitment. Writing reflection statements is an alternative to the traditional pencil and paper type of assessment. Reflection statements are sentences constructed to describe students' personal understanding or perceptions of what was being taught and what the students managed to capture.

The students who were involved in this study are a mix of local Malaysians and international whose native language is not English. Being a university with students from abroad, this university adopts English as the medium of instruction in its education delivery. These students have had a whole semester of fourteen weeks of Calculus in UTP Foundation Program for engineering (second semester) and must pass the course as a pre-requisite for DE. In writing the reflection statements, the students will be constructing sentences to demonstrate and describe their perception of concepts and method of solution in the problem solving of differential equations in words rather than just totally mathematical expressions and equations.

Research questions

In doing the study, the author would like to address the following questions:

1. How did reflection statements enhance students learning of DE?
2. In what way does this study contribute towards the teaching and learning of DE?
3. What are other benefits that students gain from writing reflection statements?

METHODOLOGY

One hundred and eleven first semester students in the first year July 2006 intake of the Engineering program were involved in the study. They were given clear instructions at the onset of the study. A full schedule of tests, quizzes, the 'how-to-write' reflection statements, and the scoring rubric set of criteria, prepared by RubiStar were prescribed.[6] Students were also made aware that they will be requested to complete a questionnaire prepared by the author at the end of the fourteen weeks of study. Students were given fourteen weeks to submit all reflections. They were expected to do reflections after each DE class session. Lectures were delivered and students' participation in demonstrating problem solving after a short lecture and examples by instructor went on three sessions per week. Each full session lasted for about fifty minutes. Every few weeks, the author would give reminder and encouragement to the students to do their best in keeping up with writing their reflection statements. Students sat for two tests in weeks five and twelve. Quizzes were dispensed in weeks three, six, eleven and thirteen.

Writing Reflection Statements

The author provided a structured way of writing the reflections. She dispensed a handout that posed four

questions for the students to answer after each learning session. A requirement set was that students must first do at least five problems before setting out to writing the reflection statements. For this study, reflection statements were effectively answering the following four questions:

1. What have I learned today?
2. How did I learn what I have learnt today?
3. What do I feel about what I have learnt today?
4. How can I apply what I have learnt today?

The first question "What have I learned today?" addressing the cognitive and psychomotor domains of learning, required the students' detailed explanation of what he/she could grasp, i.e. their perception of what was taught. Here, the students' mathematical competencies were tested as well as their abilities to express the procedures in the methods of solutions in their own words. The second question, "How did I learn what I have learnt today?" and the third question, "What do I feel about what I have learnt today?" addressing the affective domain of learning, required a description of students' experiences in learning what was taught. The last question requires the students' thinking forward as to how they think it will be of any use to them.

At the end of week nine of the semester, students were required to submit their reflections of their learning experience to be graded according to the criteria that had been revealed to them as handouts on day one of the semester. So the students were well aware of what was expected of them. Basically the students need to summarize what they have managed to learn and phrase them all in their own words. To be able to do a comprehensive write-up, the students must be quite familiar with the methods of solutions to the problems posed to them. To motivate them further, the author showed samples of writing reflection statements written by their own colleagues in class on a couple of occasions.

Scoring rubric

To assess students' reflection statements, a scoring rubric was employed. The author used the Google search engine to surf the internet for RubiStar to assist her in developing the required scoring rubric [6]. In developing the rubric, all that the author needed to do was to select the project area with the desired categories and a template was provided by RubiStar meeting those requirements she needed to evaluate the students' reflection statements. The rubric designed by RubiStar, consists of a set of detailed standards and explicit criteria to which the performance or product will be compared as shown in TABLE I. The table provides an example of the standards and criteria under the category of "Mathematical Concepts." Students were provided with the scoring criteria created and distributed at the onset of the semester.

TABLE I
THE SCORE LEVEL CRITERIA SET BY RUBISTAR

Score	Criteria
4	Shows full understanding of mathematical concepts with no computational errors; executes algorithms for equations completely and correctly.
3	Shows nearly complete understanding of concepts and principles with few or minor computational errors; executes algorithms correctly.
2	Show some understanding of concepts and principles with serious computational errors that affect the successful completion of algorithms.
1	Show very little, if not limited understanding of concepts with major computational errors; failure to execute algorithms.

Questionnaire and interviews

Students were also required to answer a questionnaire, as shown in TABLE II designed by the author to probe into their experience in writing reflections while doing the DE course. They were also interviewed by the author to find out what other comments or views they might want to express. Comments and views by students received were also noted.

Tests and Quizzes

Two tests and four quizzes were employed under formal exam conditions during the period of fourteen weeks to gauge students' performance. Scores for writing reflection statements were also recorded. Data collected then were from the tests, quizzes, reflections scoring rubric, interviews and the questionnaire.

RESULTS AND DISCUSSION

The objective of this study was to investigate students' responses and performance with the implementation of writing reflections of their learning experience after each session of Differential Equations class, thrice a week. Data was collected to look into the students' responses and performance.

Students' Responses

Motivation and encouragement were valuable in establishing the culture of writing reflections in the learning of DE. In the fourteenth week of the semester, students submitted their reflection statements. Some were on compact discs, but mostly were paper-based. Using the Likert scale of 1 to 5, indicating responses of strongly disagree to strongly agree respectively, TABLE II shows the mean of students' responses for each of the questions posed. FIGURE 1 till FIGURE 7 give graphical displays of responses by students to each question posed.

TABLE II
STUDENTS' RESPONSES TO WRITING REFLECTION STATEMENTS

Questions		Mean
1.	Writing reflection statements is something new to me.	4.48
2.	Writing reflections statements took a lot of my time.	3.19
3.	I recommend writing reflection statements for other courses as well.	2.97
4.	More marks should be allocated for writing reflection statements.	3.17
5.	Writing reflection statements in differential equations helps me express my understanding in the subject.	4.04
6.	I enjoyed writing reflection statements for differential equations.	3.25
7.	Writing reflection statements helps improve my communication skills.	3.71

From these responses, we may infer that most students were newly exposed to writing reflections for DE.

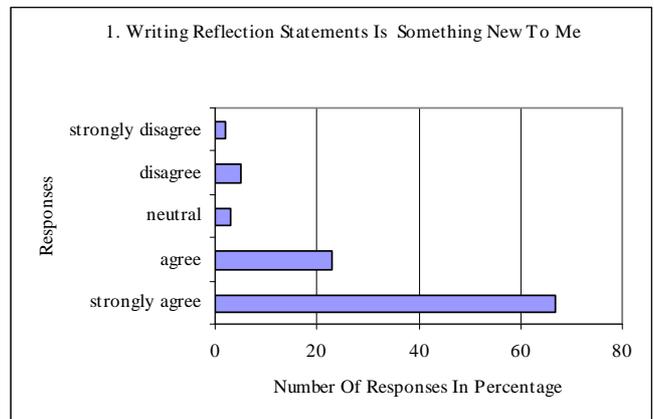


FIGURE 1
STUDENTS' RESPONSES TO QUESTION 1

Being new to this experience, students' responses revealed that they need to spend a long time doing the task.

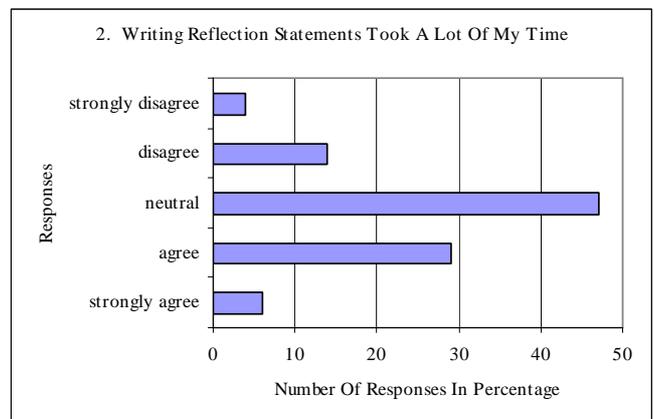


FIGURE 2
STUDENTS' RESPONSES TO QUESTION 2

Perhaps that explains why most of them were unwilling to recommend this assessment method for other courses.

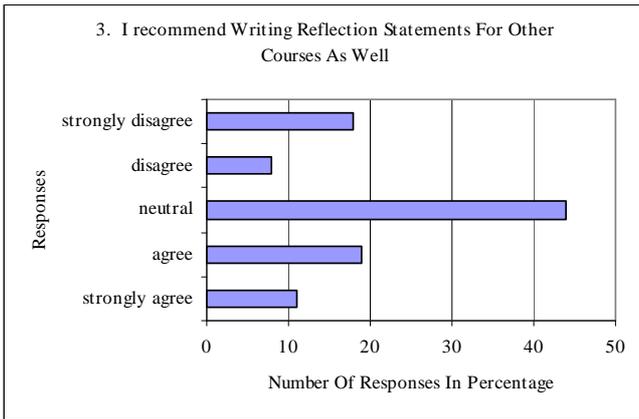


FIGURE 3
STUDENTS' RESPONSES TO QUESTION 3

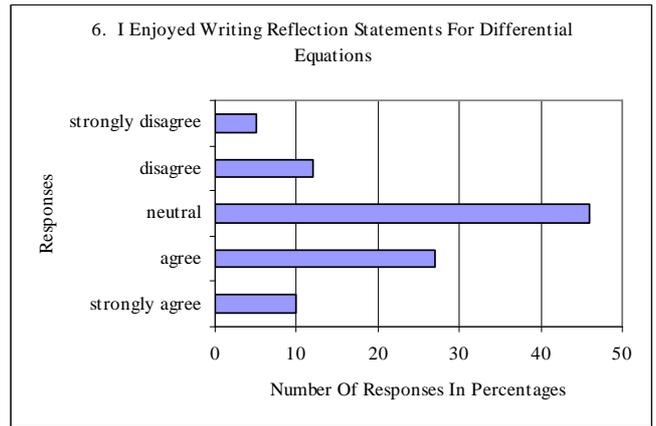


FIGURE 6
STUDENTS' RESPONSES TO QUESTION 6

Although the students were rather undecided on giving more marks for writing the reflections, many of them agreed that writing reflection statements helped them in understanding DE and many enjoyed writing reflections on DE.

Another positive aspect that was revealed in this study was that the students felt that their communications skills were also enhanced.

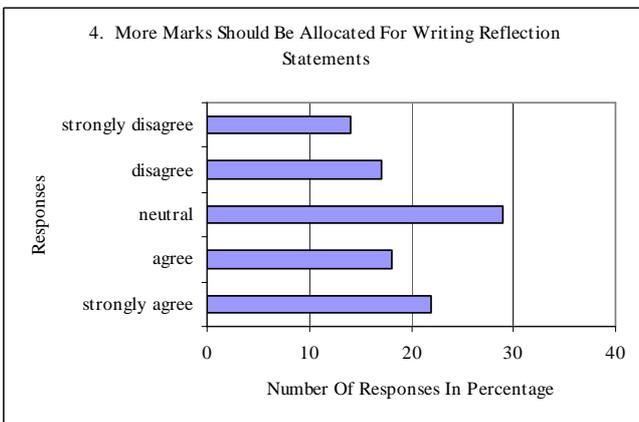


FIGURE 4
STUDENTS' RESPONSES TO QUESTION 4

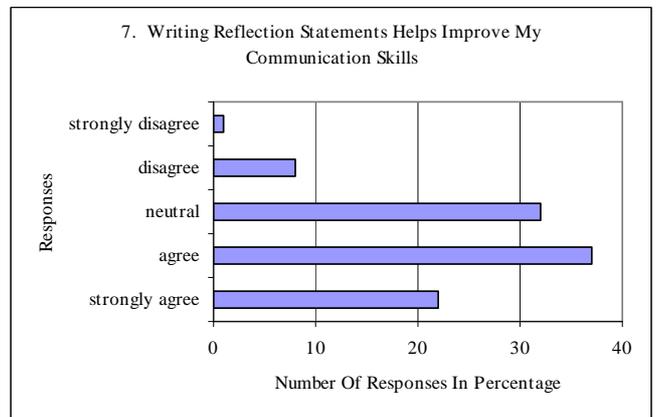


FIGURE 7
STUDENTS' RESPONSES TO QUESTION 7

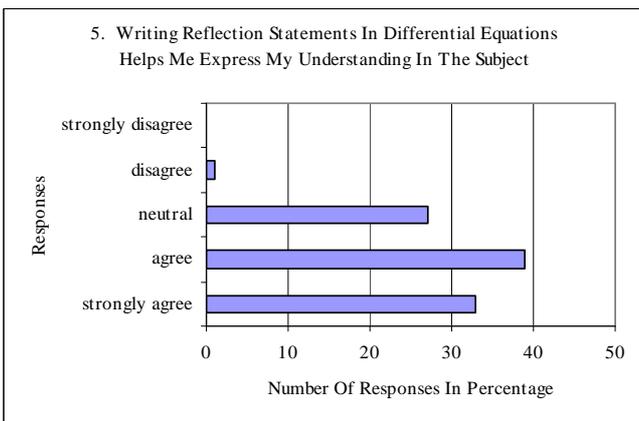


FIGURE 5
STUDENTS' RESPONSES TO QUESTION 5

What may be more encouraging to students in the implementation of this type of assessment is probably to reward more marks since the students took time to do the write-up. It should also be remembered that the students need to be quite familiar with each topic done before being able to do a good reflection.

Students' performance

The students' performances were monitored and recorded over the fourteen weeks of work. TABLE III shows the average scores in percentage of all the tests and quizzes completed during the period of time.

TABLE III
STUDENTS PERFORMANCE IN TESTS, QUIZZES AND REFLECTIONS

	No.	Mean Scores (%)
Tests	1	84.59
	2	72.13
Quizzes	1	60.93
	2	75.14
	3	61.17
	4	75.23
Reflections		69.5

The following FIGURE 8 till FIGURE 11 provide graphical representations of students' performances in four quizzes, two tests, writing reflections and the overall achievement, respectively.

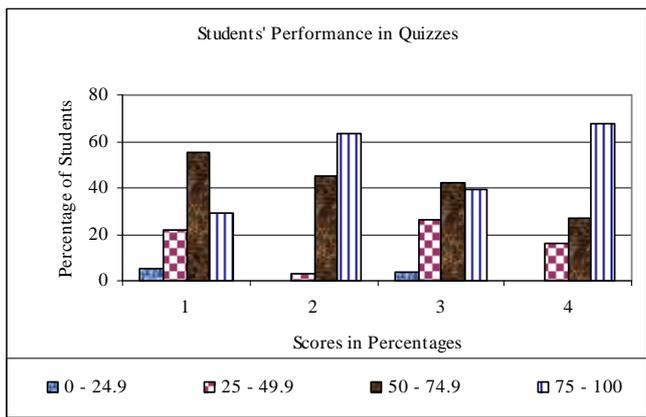


FIGURE 8
STUDENTS' PERFORMANCE IN FOUR QUIZZES

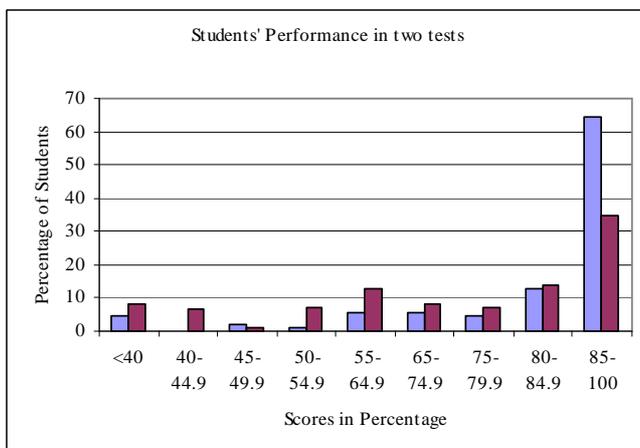


FIGURE 9
STUDENTS' PERFORMANCE IN TWO TESTS

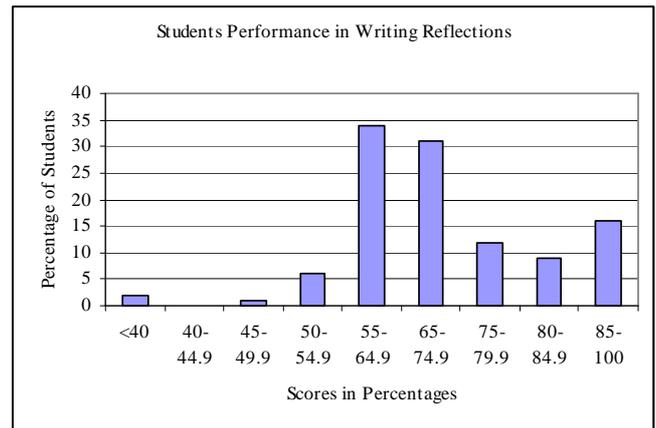


FIGURE 10
STUDENTS' PERFORMANCE IN WRITING REFLECTIONS

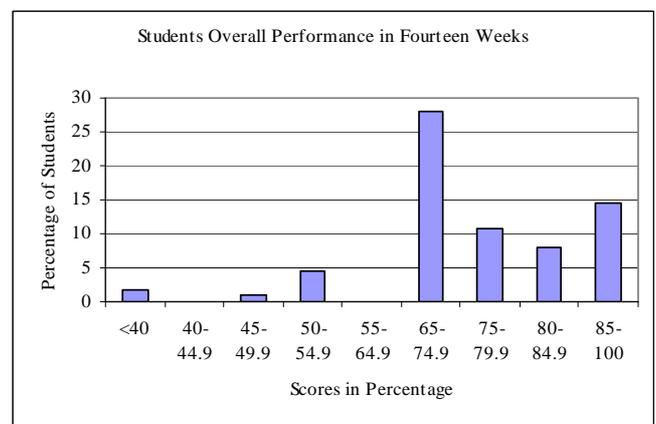


FIGURE 11
STUDENTS OVERALL PERFORMANCE

Past records showed that the percentage of students failing the course (scores less than 40%) was about 9 – 10%. The overall students' performance here revealed that there were less than 2 % of cases scoring less than 40%.

Writing reflections was something new to students at this particular university and the author had anticipated some resentments from students, so to prepare the students mentally, she had elaborated to students that reflecting on what was taught and confirming what was perceived is a method of processing information. Students have different ways of processing information received; by actively involving himself or herself in discussion or by thinking through this alone. The former scenario was a norm in-class activity for these students, whilst the latter was an independent activity. Whilst in class students involved in this study had been actively engaged in doing activities collaboratively and doing presentations in class, discussing their methods of solution in solving problems assigned, they were then expected to ponder on their own what they could make out of the learning experience during each learning session. On occasions when some students made mistakes while demonstrating problem solving as a presentation, some students captured that in their reflections. A comment made by a student was, "I remember not to commit the mistake that my friend did while he was showing us the method of

solving exact equation in class.” More comments made by students are as quoted:

1. “The reflections are useful in the sense that I need to be very familiar with the topic before I can write good reflection statements.”
2. “It will be best if we could write the statements after each topic rather than writing the reflections after each class session.”
3. “It really helps in ensuring that I know the subject well.”
4. “I am still not really sure how to do these reflection statements.”
5. “I was not keen on this idea in the beginning, but now I can see that it does help me in many ways.”

CONCLUSION

A major concern from students was the time they needed to dedicate in order to write the reflection statements as well as the need for more examples so that they have better idea of how to write the reflections. However, the students’ responses indicated two important aspects of writing reflections that are significantly important in the learning of Differential Equations, i.e. majority of students responded that writing reflection statements in differential equations helped them

- express their understanding in the subject and
- in their communication skills

Of course ‘understanding a subject’ is not measurable. Thus in order to measure the claim of ‘understanding’, students were prescribed tests, quizzes and demonstration of their skills in explaining in their own words, the methods of solutions. The overall performance reflected was encouraging. The average performance is about 72%. Writing reflections contributed a mean score of 69.5%. From this study, it was apparent that, students discovered for themselves that in order to be able to acquire the skills is to be able to not only be technically competent but also be able to explain how solutions can be obtained. Writing reflection statements was creating a similar situation of explaining the method of solution to someone else, thus encouraging and enhancing their writing skills, and using correct mathematical terms and reasoning. Writing reflection statements in the learning of DE is certainly a new experience to most of the students at this university, resulting in their feeling that writing these statements took a lot of their time hence contributing to some mixed feeling as regards to their willingness to recommending this method of assessment for other courses. Perhaps their responses would have been more encouraging in this aspect if more credit were allocated for this continuous effort. Looking on the positive side, the majority of the students voted that writing reflection statements in the learning of DE helped them express their understanding of the subject matter as well as helped them improve their communication skills.

Limitations

This study was however, limited to students who took Differential Equations course in Universiti Teknologi PETRONAS (UTP). However, writing reflections could be

extended to the teaching and learning of other mathematics courses and other courses as well. The challenge would be for lecturers themselves to believe that this method will work provided implemented accordingly, and then to be able to convince the students and create the excitement and the environment that would drive them to consistently persevere in doing it. The outcomes of this study indicate that writing reflection statements plays an important role in the enhancement of teaching and learning of Differential Equations.

RECOMMENDATION

Whilst this study was done to a mathematics course to create a meaningful experience, which requires students to demonstrate their technical skills into illustrating them by describing and explaining them in their own words, further research could well be recommended for other technical courses.

ACKNOWLEDGMENT

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