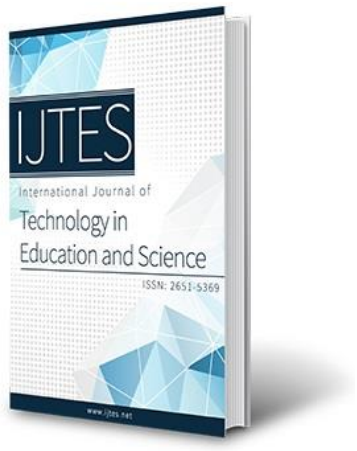

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Abstract

Self-directed learning is learning in which the conceptualization, design, conduct and evaluation of new content is directed and driven by the learner itself. This is an essential skill for students in the 21st century. Many large undergraduate courses use an online homework system to engage the whole class in the course material simultaneously. A very important advantage of using an online homework system is the quick feedback that gives students an immediate indication on how well they understand the work. The purpose of this study firstly focuses on constructing a framework along which to determine the role and success of an online homework system towards making students self-directed learners. The second purpose of this study is to give an example of how the framework can be used. The sample group consists of both engineering and mainstream first year mathematics students using the online homework system WebAssign. The study investigates the extent to which the online homework system fosters independent learning in these cohorts of students. The article concludes by discussing the findings, some discussion and conclusions of this framework.

Introduction

Digital technology is now a ubiquitous feature of teaching at tertiary institutions (Koumachi, 2019). Making use of an online homework system when teaching tertiary mathematics is a feature of 21st century teaching and has a definite role to play in the blended learning model followed by many tertiary institutions. The motivation for turning to online homework systems includes: providing effective tuition for increased enrolment figures, engaging students outside the classroom as well as the advantages that instant grading and feedback offer (Lenz, 2010; Lunsford & Pendergrass, 2016; Richards-Babb, Drelick, Henry, & Robertson-Honecker, 2011; Zerr, 2007).

The benefits of using an online homework system are well-documented in literature. Lenz (2010) found that students in a first-year mathematics course were more likely to attempt homework exercises and to receive higher homework grades when using an online homework system as compared to doing paper homework. The benefits of being relieved of the burden of grading and students receiving instant feedback are commendable, complimented by the finding that the online homework system does not impact negatively on grades.

Arasasingham, Martorell and McIntire (2011) conclude from a study ranging over a number of years that the

online homework system used, provided an overall benefit that promote student learning in large-scale introductory science instruction. They found that students and instructors generally responded positively to using online homework. Most students acknowledged that it helped them to improve their understanding of the material and instructors felt that the online homework offered a realistic alternative to the traditional approaches of grading handwritten homework. They conclude that appropriately designed online homework can be engaging to students, present opportunities for self-directed study, provide effective feedback and supply a range of practice.

Zerr (2007) reports on the overall effectiveness of an online homework system in a first-semester calculus course for significantly enhancing the out-of-class engagement of students, resulting in improved learning. In a college algebra course students' using an online homework system outperformed those using traditional paper homework in the exam and showed a better retention rate (Burch & Kuo, 2010). Richards-Babb, Drelick, Henry and Robertson-Honecker (2011) report on experiences with an online homework system in general chemistry. They found that success rates improved, that the majority of students completed the voluntary assignments and were overwhelming in their recommendation that the online homework should continue. They also found that students reported on effective problem-solving approaches for questions marked as incorrect, a significant finding for our study. Cuadros, Yaron and Leinhardt (2007) conclude that the two most significant activities that influence course achievement in chemistry at the college level are self-directed study and homework.

Online Homework and Self-directed Learning

A lesser explored avenue in looking at the benefits of online homework systems lies in the benefits offered in terms of cultivating self-directed learning amongst students. Van der Hoff and Harding (2016) describe the development of a new teaching model for first year calculus students through conducting a constraint analysis. One of the features of the new model is extensive use of an online homework system and initial results indicate that the system aids in making students independent learners.

This study explores the link between online homework systems and self-directed learning. The first task is to get consensus as to what the features of self-directed learning are that are applicable to using an online homework system. A lens is developed through which online homework activities can be viewed to determine its contribution towards self-directed learning.

Critique on Definitions of Self-directed Learning

The purpose of this section is to analyses existing and prominent definitions of self-directed learning in order to come to a framework of features of self-directed learning that are applicable to the environment of online homework systems. The theory of adult learning of Knowles (1975) is well-known and has survived time despite its perceived limitations (Keesee, 2010). It still provides a practical instructional guide for all ages, especially adults. Knowles sees self-directed learning as the basic competence of learning on one's own. His influential definition of self-directed learning is respected and often quoted:

> In its broadest meaning, self-directed learning describes a process by which individuals take the initiative, with or without the assistance of others, in diagnosing their learning needs, formulating learning goals, identify human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluate learning outcomes. (Knowles, 1975, p.18)

By dissecting the definition, we notice that Knowles sees self-directed learning as a process consisting of three phases – firstly identifying learning needs and goals, secondly choosing and implementing appropriate learning strategies and thirdly evaluating learning outcomes. In short, the three steps in the process could be described as firstly deciding to learn, secondly managing the learning process and thirdly establishing whether you have learned. The bold premise of this paper is that the process of self-directed learning as described by Knowles (1975) is not complete. The final step in the process as described by Knowles is that of evaluating learning outcomes. Once the student has evaluated his/her learning outcomes s/he would have identified areas in which knowledge or skill is lacking. The self-directed learner would then take a further step in the process, namely to take action for remedying his/her learning deficits. The action of selecting and utilizing resources for addressing areas of weakness is an important one in self-directed learning. Zerr (2007) says that in the "attempt-feedback-reattempt" sequence feedback is not the end of the story, it provides the opportunity for success.

Garrison (1997) identifies three overlapping dimensions of self-directed learning, namely: (a) motivation (entering and task), (b) self-management (task control) and (c) self-monitoring (cognitive responsibility). There is some correspondence between the three dimensions of Garrison (1997) and the definition of Knowles (1975). Firstly, having the motivation to learn (entering and task) could correspond to identifying needs and goals. Secondly, managing the learning process (task control) corresponds to choosing and implementing appropriate learning strategies and thirdly, checking that you have learned (self-monitoring) corresponds to evaluating learning outcomes. The third dimension of Garrison's self-monitoring involves cognitive responsibility, which the author expands on: "To assume cognitive responsibility is to self-monitor the learning process, assess outcomes, and develop new strategies to achieve intended outcomes" (p.25). The third dimension therefore incorporates to act if the outcomes are not favorable. The third dimension of Garrison (1997) then incorporates the perceived absent step of acting in the process of Knowles (1975).

The definition of self-directed learning as formulated by Gibbons (2002) emphasizes the student's role in taking ownership of his learning. He defines self-directed learning as "any increase in knowledge, skill, accomplishment, or personal development that an individual select and brings about by his or her own efforts using any method in any circumstances at any time" (p.2). This definition does not view self-directed learning as a sequenced process but rather puts the focus on "own efforts", leaving freedom for method, circumstances and time. Gibbons perceives the gains of self-directed learning as wider than mastering a subject - it could be in knowledge, skill, accomplishment or personal development. The aspect of choice is also seen by Brockett (2006) as one of the hallmarks of self-direction in learning and in life. He also states that through technology choice is virtually unlimited in nearly all aspects of life including learning. Swart (2018) states that with self-directed learning that students become agents in the learning process. They engage with the work, they are more active learners and self-directed learners enjoy and get satisfaction from learning.

Chee, Divaharan, Tan and Mun (2011) advocate self-directed learning in the context of education in Singapore. The authors identify three salient aspects of self-directed learning, each accompanied by possible behavioral indicators. The first of these is ownership of learning with behavioral indicators such as students identifying their own goals for learning and own tasks to achieve goals, students charting their own learning processes, students challenging themselves and setting standards for achieving their goals. The second salient aspect is management and monitoring of own learning with behavioral indicators being students formulating and generating relevant inquiries, students exploring a range of possibilities and making sound decisions, students self-managing planning and time and students critically reflecting on their own learning, gathering feedback from peers and teachers. The third salient aspect of self-directed learning is extension of own learning, and the behavioral indicators are students applying what they have learned to new contexts and utilizing the skills they have acquired to learn beyond the curriculum contexts.

The model of Chee et al (2011) gives prominence to the aspect of taking ownership of learning, an aspect that was implied in other definitions. The managing aspect and the monitoring aspect of the learning process are condensed into one in this model. This is reasonable; especially where online homework is concerned as monitoring is done automatically and could be considered as part of the management process. The third salient aspect, namely extension of one's own learning through applying gained knowledge to new contexts and venturing beyond the curriculum warrants critique. Extending one's own learning implies that the learning process was completed successfully. Again, no provision is explicitly made by Chee et al (2011) for strategies of addressing learning deficits as they occur.

Following on the definitions of self-directed learning as reviewed here, we present a framework for fostering self-directed learning that is shown to be feasible for application in the environment of online homework assessment, called the SLOH framework. The SLOH acronym is derived from Self-directed Learning and Online Homework. The proposed SLOH framework, described below, consists of three components, similar to the three salient features of Chee et al (2011), the three dimensions of Gibbons (2002) and building on the definition of Knowles (1975).

The SLOH Framework for Self-directed Learning in an Online Homework Context

The three essential elements in the process of using an online homework system that pertain on self-directed learning are:

1. **Ownership:** Ownership refers to the choice made by the student to use the online homework system to his/her own benefit. The student believes that there is sense in making use of the online homework system and that it will improve his/her understanding and performance. In other words, there is buy-in from the student's side.
2. **Management:** Management refers to how the student uses the online homework system. It includes how much time is spent on using the system, whether the student gives himself/herself enough time to do the homework and not leave it until shortly before the deadline and whether he/she chooses to do the homework alone or in a group. Built into the management element is the process of self-

monitoring, towards which immediate feedback contributes.

3. **Redress:** Redress refers to the steps taken following on one or more failed attempts. The student could decide to redo the problem, consult peers, the textbook, tutors or online resources, amongst others.

Research Aims

In the research part of this paper we present a case study for investigating student involvement in an online homework system, focusing on how such a system aids in cultivating self-directed learning. The SLOH Framework is the lens through which student involvement and activities are viewed.

Method

Research Design

The study focuses on two large first year groups of students doing calculus in 2016, one group of students enrolled for an engineering degree (Group E) and the other group doing mainstream mathematics (Group M). Group E consists of 1506 students and Group M of 750 students. The two groups of students were enrolled for two similar calculus courses but each with a different approach - Group E doing a calculus course geared towards a more pragmatic engineering approach and Group M doing a calculus course more geared towards theoretical aspects of mathematics. The two groups use the same textbook.

The online homework system that both courses subscribed to is WebAssign, a Cengage product. Both Group E and Group M did weekly online assignments, 14 in total over a term of 14 weeks, and consisting of problems from the prescribed textbook. For both groups, students were allowed three opportunities for completing a problem. For Group E every assignment opened on a Monday and it remained open until the following Monday, allowing students to access it at their own convenience for the duration of the week. The assignments contributed marginally towards the term mark, amounting to around 3% of the term mark. This small percentage was intended as a token, enough not to ignore but not enough to go to extreme lengths such as copying someone else's answers. Students could work together in a small group or choose to do it as an individual.

For Group M the assignments were used as preparation for their weekly course tutorials. They were given a week to complete it and it was due midnight on a Sunday evening. The assignments were a combination of mostly standard problems and occasionally a few more challenging problems. The assignments contributed around 10% of their semester mark. This ensured that students take the assignments seriously and as an important out-of-class room activity to engage with the course content.

A questionnaire was issued on the Blackboard learning management system, on the course website towards the end of the term. Students were encouraged to complete the questionnaire but it was not compulsory. Of Group E a total of 614 students completed the questionnaire and of Group M a total of 114 students completed the questionnaire. The study was conducted after these students had been using the WebAssign online homework system for two semesters. Using the data gathered from two groups presented multiple perspectives resulting in

a form of triangulation for validating conclusions.

Findings and Discussion

We analyses and discuss responses to the issued questionnaire, categorizing responses along the lines of the SLOH framework of Ownership, Management and Redress. The results of the survey for both Group E and Group M and are shown in the tables that follow.

Ownership

Entering into the task, that is, taking ownership for one's own benefit is reflected in the first four items of the questionnaire. Students were firstly asked how they feel about doing online homework, focusing on WebAssign in particular. The responses are shown in Table 1.

Table 1. Percentage Breakdown of How Students Feel about Using the Online Homework System

I feel about WebAssign that …	Group E	Group M
It is totally worth doing	62.2	67.8
It is a fair thing to do	28.2	25.3
I tolerate it	8.1	6.2
I think it is a waste of time	1.5	0.7

A large percentage of students in both streams feels that the online homework assignments are totally worth doing with less than 2% in both cases thinking that it was a waste of time. In total 90% (62.2% + 28.2%) of Group E and 93.1% (67.8% +25.3%) of Group M found the online homework to be totally worth doing or a fair thing to do. The fact that the assignments count so little towards the term mark strengthens the indication that students take ownership of the activity. The smaller percentages of students who merely tolerated the online homework, 8.1% of engineering students and 6.2% of main stream students did not take ownership and possibly experienced external pressure to do it.

Secondly, students were probed as to how many of the tasks they had completed as another indication of taking ownership. The responses are given in Table 2.

Table 2. Percentage Breakdown of How Many Tasks Students Completed

I have …	Group E	Group M
done all the tasks	67.6	46.9
skipped one or two	21.3	32.8
missed a few	10.3	19.7
not done them	0.5	0.6
Unanswered	0.3	0.0

The student needs to buy into the idea of doing the online homework assignment but may miss out on one or two due to personal circumstances. The premise is that because the online homework tasks contribute so little to the term mark students would realize that doing the exercises are for their own good. An impressive number of students (67.6%) of Group E did all the tasks with fewer students (46.9%) of Group M doing them all. The percentages are even more impressive if just missing one or two is considered. In this case 88.9% of the engineering students either did all or missed one or two of the assignments and 79.7% of main stream students either doing all or missing just one or two assignments.

A further indication of ownership lies in the reasons behind students doing the online homework assignments. A breakdown of reasons and responses is presented in Table 3.

Table 3. Percentage Breakdown of Reasons for Doing Online Homework Tasks

Why do you do WebAssign?	Group E	Group M
I feel forced to	10.4	11.6
I am scared to miss out	6.7	11.6
I feel it is beneficial to my learning	70.8	60.9
I enjoy being presented with maths problems	11.7	15.9
Unanswered	0.4	0.0

The majority of students in both engineering (70.8%) and main stream (60.9%) felt that doing the online homework assignments is beneficial to their learning. A group of students admitted to doing the tasks because they enjoyed being presented with mathematics problems (11.7% of engineering students and 15.8% of main stream students). However, approximately 17% of the students in engineering and 23% in main stream did the tasks either because they felt forced to do it or were scared of missing out. Again, these students did the tasks because they felt external pressure and they did not take ownership of the online homework.

Taking ownership of the online homework is reliant on students seeing the benefit in doing the tasks. Students could choose more than one option when responding to an item that probes on where the benefit of the online homework system lies. Responses are shown in Table 4.

Table 4. Percentage Breakdown of Benefits for Doing Online Homework Tasks

If you feel WebAssign is beneficial to you, where do you think the benefit lies?	Group E	Group M
Forcing me to do problems outside of class	54.9	59.4
Letting me do it any time, any place	46.4	54.1
Giving me repeated attempts	65.5	77.5
Giving me immediate feedback	28.0	28.1

Students in both streams most of all liked the fact that they get immediate feedback on their assignments (65.6% of engineering students and 77.5% of main stream students) and that they were allowed repeated attempts (56%

of engineering students and 68.8% of main stream students). The freedom of doing the assignment anywhere, anytime and that it forces them to work outside of class also emerged prominently. Exercising a choice is a positive indication of self-directed learning. It is also clear that few students see the benefit of the system in doing the tasks online (28% of engineering students and 28.1% of main stream students). It is not the fact that the system is online but rather the benefits that an online system brings that count.

From these findings it appears that the majority of students do take ownership of the learning opportunities offered by the online homework system. In particular the overwhelming participation and positive attitude towards the online system is evident and contributes towards students becoming self-directed learners.

Management

In this section on management we explore how effectively students manage their interaction with the online homework system and how it aids in their development towards becoming self-directed learners. We investigate how students prepare for doing an online homework assignment, whether there is a preference for working alone or in a group and when they do the assignments in the time leading up to the deadline. We also explore how the online homework blends in with their studies. We firstly investigate what preparation students do before attempting an assignment. Responses are given in Table 5.

Table 5. Percentage Breakdown of Doing Preparation for Attempting Online Homework Tasks

Before I attempt a WebAssign task ...	**Group E**	**Group M**
I study the prescribed section	38.9	17.5
I glance at the prescribed section	42.1	36.5
I just go for it without preparing	18.9	46.6
Unanswered	0.1	0.3

The responses are significant as only 38.9% of engineering students and even fewer, only 17%, of mainstream students study the prescribed section before attempting the task. It appears that most of the students use the online homework assignments as a starting point for mastering a topic. In other words, if there are no WebAssign questions on a section of the work, students would most probably not be mastering it. Bigger percentages (42.1% and 36.5%, respectively) claim to glance at the prescribed section, possibly taking a quick check on what work the assignments are based on. The role of online homework seems to lie in presenting a practical challenge in the form of an assignment, which students are keen to do (See responses in Table 1). They exercise choice in how they approach it, although they may not be making the optimal choice for mastering the subject in total. Ultimatelyself-directed learning involves the number and kinds of decisions that are taken by learners themselves (Van Hout, Simons & Volet (2000)).

Another indication of how self-directed students are in their learning is obtained by looking at when they do an assignment with respect to the deadline. Responses to a question on this aspect are given in Table 6.

Table 6. Percentage Breakdown of When Students Do the WebAssign Tasks

When do you mostly do your WebAssign task?	Group E	Group M
As soon as it opens	5.9	8.8
Well-ahead of the deadline	40.9	37.2
On the day before it closes	48.0	48.8
I postpone until I can't any longer	5.2	5.2

Of the engineering students 40.9% and of the main stream students 37.2% do the tasks well ahead of time but more students do it on the day before it is due (48% of engineering students and 48.8% of mainstream students). This finding should be seen in context that when the task opens, they have not necessarily covered all the work in class and they leave it until they feel they have the knowledge to do it. The indication is that students seem to be responsible and self-directing when dealing with an assignment. To support this statement, just more than 5% leave the tasks until they cannot postpone any longer. These students do not manage the activity well.

According to van Hout, Simons and Volet (2000) an indication of self-directed learning is whether a student takes care of learning and understanding on their own or with other students. Responses to a question on whether students do online homework tasks alone or in a group are given in Table 7.

Table 7. Percentage Breakdown of Whether Students Work alone or in a Group

Do you work alone or in a group?	Group E	Group M
Alone	58.0	76.9
With a friend	33.1	15.3
In a group of 3	5.2	6.6
In a group of 4 or more	3.4	0.6
Unanswered	0.3	0.6

The majority of students in both streams prefer to work alone on the online homework tasks (58% of engineering students and 76.9% of mainstream students). The figure for mainstream students is particularly impressive. It seems that the engineering students are more likely to work with a friend than the main stream students. An explanation for this might be that the engineering students attend many lectures together since they are divided into groups according to their discipline. They therefore get to know their fellow students better than in the case of the main stream students. They are then more likely to work with a friend on an assignment. The engineering students have a full program and this also contributes to them spending more time on campus, thus enabling them to work together. Working with a friend still involves taking responsibility for your own learning as it less easy to be a passenger in a group of two than it is in a larger group. Noticeably small percentages work in larger groups.

Time management is a crucial skill in the self-directed learning process, but often students do not know how to pace themselves so that they can meet the due dates (Pilling-Cormick, 1997). There is no set time for doing the online homework assignments and students have to manage their time to fit it into their studies. Students were

thus asked whether they are able to fit the online homework tasks into their study programmes. Results are shown in Table 8.

Table 8. Percentage Breakdown of How WebAssign fits into Students' Study Programmes

Does WebAssign fit into your study programme?	Group E	Group M
Yes, easily	35.5	49.7
Yes, but it takes effort	51.1	38.4
No, it is difficult to fit in	11.4	9.1
It is almost impossible to fit in with all my work.	2.0	2.2
Unanswered	0.0	0.6

Results indicate that most students manage to fit the online homework assignments into their study programmes, even if it takes effort. Of the engineering students 86.6% report that it fits into their study programmes, although 51.1% say it takes effort. The engineering students have a full programme and from their responses it suggests that it takes somewhat of an effort for them to fit the online homework assignments in. Of the mainstream students 88.1% report that it fits into their study programmes with only 38.4% saying that it takes effort. Their programmes are not quite as full as for the engineering students. It is pleasing that students view the online homework assignments as important enough to make time for it, however difficult. Much smaller percentages maintain that is difficult to fit into their study programmes or even impossible (a total of 13.4% for engineering students and 11.3% for mainstream students). These students are not skilled in time management and it impacts on them becoming self-directed learners.

Redress

Redress refers to what the student does when he faces failure, in particular when failing to do an online homework problem correctly. Positive action is advisable instead of simply redoing the problem in the same incorrect way. The student could decide to make use of a number of resources. Since each assignment offered three attempts, the student has time for redress and therefore has the opportunity for scoring high marks.
Students were asked what they do if the answer they obtained to a problem was pointed out as being incorrect. Responses are shown in Table 9.

Table 9. Percentage Breakdown of What Students Do When They Get an Answer Wrong

Say you do a WebAssign question and the answer is wrong, do you …	Group E	Group M
Immediately try again	12.9	17.2
Try and figure out why the answer is wrong before redoing it	80.1	72.8
Get help elsewhere	5.7	8.8
Skip the question	1.0	0.3
Give up	0.2	0.3
Unanswered	0.2	0.6

Of the engineering students 12.9% admit to immediately trying it again and of the mainstream students 17.2%. These students do not adequately redress the problem and hence is lacking in developing as self-directed learners. In addition, small groups (1.2% of engineering students and 0.6% of mainstream students either skip the question or give up, also showing no progress towards becoming self-directed learners. However, a large group, 80% of engineering students and 72.8% of mainstream students spend time on determining why an answer is wrong before re-attempting the question. Adding to that the group of students that seek help elsewhere (5.7% of engineering students and 8.8% of mainstream students), there is reason to conclude that the majority of students redress failure in a responsible way.

Further probing was done into how students deal with problems that they struggle with, probably still struggling after repeated attempts. Responses are shown in Table 10.

Table 10. Percentage Breakdown of What Students Do When They really Struggle with a Problem

Say you really struggle with a problem. What do you do?	Group E	Group M
Try by yourself until you succeed	12.9	17.2
Ask a friend	80.1	72.8
Consult the textbook	5.7	8.8
Consult a lecturer / tutor	1.0	0.3
Consult notes	0.2	0.3
Consult YouTube or the internet	0.2	0.6
Unanswered	0.3	0.6

What may be surprising at first glance is that student's view consulting a lecturer as one of the last resorts for seeking help. They much prefer consulting a friend or the textbook and trying by themselves rather than consult a lecturer or tutor. This is perhaps a feature of our current student generation and could be seen as a move towards self-directed learning and less dependency on the lecturer. Asking a friend is observed as the favorite option with 80.1% of engineering students and 72.8% of mainstream students subscribing to this. A substantial portion of students (12.9% of engineering students and 17.2% of mainstream students) reports that they try by themselves until they succeed. These students are the ones that learn by themselves and persevere until they succeed, showing themselves to be self-directed learners.

Conclusion

Results show that for our study group, the typical student works alone, feels that online homework assignments are totally worth doing, has done almost all the tasks and does it because s/he feels it is beneficial to his/her learning. The student manages to fit it into his/her programme although it may take some effort. Should s/he find that his/her answer to a question is wrong, the student tries to figure out why the answer is wrong before redoing it. Should s/he encounter a real problem with a question s/he would consult a friend, try by himself/herself but is unlikely to consult a lecturer. The typical student profile that emerges from this study is one that indicates a tendency towards self-directed learning in terms of ownership, management and redress.

The online homework system offered this student the option of taking ownership through realizing how buy-in can contribute towards learning and not being driven by marks because of the very small contribution towards the term mark. The online homework system gave the student the opportunity to make choices as to the management of the activities. They could choose how they prepare for assignments, whether they choose to work alone or not, at what stage before the deadline they choose to do assignment and how they blend it into their study programmes. The system also presented opportunity for redress through repeated attempts, making the student aware that action should be taken when a problem is encountered. The aim of the online homework system is to aid in students' learning and thus to enhance their chances of success but the added benefit of the system contributing towards students becoming self-directed learners should by no means be underestimated.

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