Beware of the Parallel-Replacement Zombies!

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Abstract: *In this paper, the authors discuss the use of computer homework systems and describe what many students do when they are completing their work online. Strategies are provided to help students develop a more conceptual understanding of mathematics and help to avoid the number replacement method.*

Keywords: *computer textbook programs, conceptual and procedural learning*

Introduction

Zombies seem to be everywhere these days; in movies, in insurance commercials, and even in one's yard collecting candy during late October. Some don't mind seeing these zombies because they are often entertaining, funny, or cute. What educators do mind is when students transform from perfectly normal adolescents into parallel-replacement zombies.

In this article, we illustrate examples where students use pattern recognition skills to complete their assignments in a manner that defines the characteristics of parallel-replacement zombies. Then, we describe an experiment where a perfectly normal ninth-grader 'zombie-walked' through several calculus problems involving differentiation of functions. We also provide suggestions and strategies to prevent students from transforming into parallel-replacement zombies.

What are parallel-replacement zombies?

Humans are converted into 'traditional' zombies by various means. Certain Haitian religions believe that a Voodoo priest can cast an evil spell on wayward souls turning them into mindless zombies (Gandhi, 2013). In George Romero's cult classic, *Night of the Living Dead*, people became zombies after they were exposed to poisonous radiation emitted from a wayward spacecraft (Romero, 1968). However, the making of parallel-replacement zombies can be traced to something different - certain advances in educational technology. One such advancement comes in the form of online course packages. These packages are very popular because they offer many benefits to both teachers and students. Teachers like the availability of pre-made Powerpoints, interactive applets, and self-grading assessments often included in course materials. Students like the help features that aid them in finding solutions to homework tasks. These help features consist of video clips of educators solving related tasks, links that connect students to relevant portions of the textbook, and written guidance on how to solve a task like the one on which students are working.

While the help features can be beneficial to students, they must be used with caution. These features may end up being the catalyst that converts students into parallel-replacement zombies.

The transformations occur when students click on the 'View an Example' help feature. After clicking this link, the publisher provides students with the solution to a problem very similar to the one on which they are working. Students analyze the solution, but instead of trying to gain a conceptual understanding of the problem, many of them engage in a parallel replacement strategy (F. Adkins, personal communication, March 7, 2019) to arrive at the answer. This parallel replacement strategy allows these students to progress through their assignments with minimal mental energy. With the absence of thought, the students become parallel-replacement zombies.

The transformation into a parallel-replacement zombie.

To illustrate the transformation into a parallel-replacement zombie, an author provided his daughter, Graelynn, with a couple of calculus problems. Graelynn is a ninth-grade Algebra I student. Needless to say, she has never had a calculus course. The first problem the author presented to Graelynn was a task in which she needed to use the Power Rule to find the derivative of the function $f(x) = x^5$ (see Figure 1).

Figure 1: *Using the Power Rule to find a derivative.*

After Graelynn read the problem, she clicked on the 'View an Example' link. When she clicked the link, a screen popped up that allowed her to see how the Power Rule was used to find the derivative of a similar function (see Figure 2).

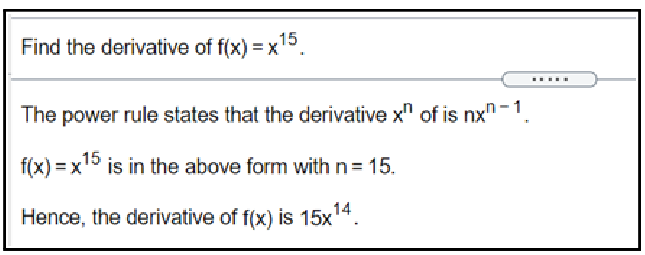


Figure 2: *The solution to a Power Rule problem.*

After about two minutes of analyzing the provided solution, Graelynn correctly determined that the derivative of $f(x) = x^5$ was $f'(x) = 5x^4$.

Since Graelynn answered that task successfully, the author decided to present her with a more difficult task where she had to use the Chain Rule to differentiate the function $y = (7x - 12)^4$ (see Figure 3).

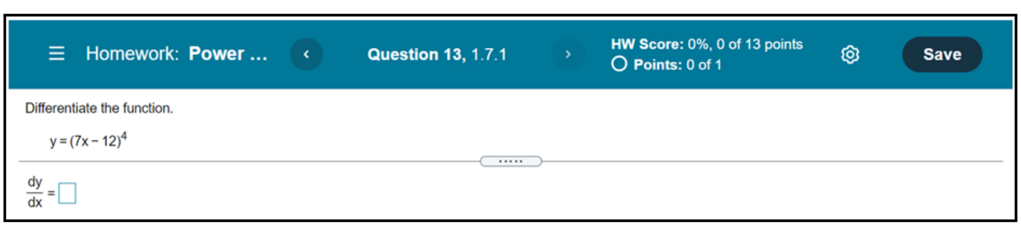


Figure 3: *Finding the derivative using the Chain Rule.*

Again, Graelynn selected the ‘View an Example’ feature. When she did, the solution process for a similar function appeared. Part of the process is shown in Figure 4.

Simplify this result.

$$\frac{dy}{dx} = 4(8x-7)^3 \cdot 8 \quad = 32(8x-7)^3$$

Therefore, $\frac{dy}{dx} = 32(8x-7)^3$.

Figure 4: *Part of the solution process for using the Chain Rule to differentiate a function.*

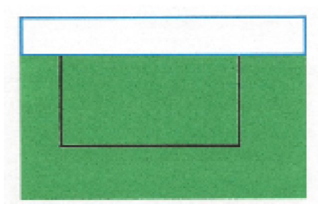
Although it required a greater amount of time, Graelynn was able to arrive at the correct answer of $\frac{dy}{dx} = 28(7x-12)^3$, even though she has never heard of differentiation, the Power Rule, or the Chain Rule. When asked how she arrived at her answer, she stated, “The fours in both problems were the same so I put the four out front. I changed the four to three on top. Instead of four times eight, I did four times seven and put that answer out front. The numbers on the inside stayed the same.” Her transformation to a parallel-replacement zombie was complete.

What can mathematics teachers do to prevent students from becoming parallel-replacement zombies?

When analyzing the previous examples of Graelynn’s problem-solving approach, they show Graelynn using a form of pattern recognition to arrive at her answers. However, her version of pattern recognition did not lead to a meaningful understanding of the Power Rule. As described in Principles to Action (NCTM, 2014), Graelynn was engaging in a low-level activity where she was performing procedures without meaningful connections.

As an example of a higher-level activity that involves procedures with connections (NCTM, 2014), consider the following Rancher’s Pasture problem that an author presented to Graelynn.

A rancher wants to fence in a rectangular pasture adjacent to a river in such a way that her cattle have the maximum number of square feet of grass to eat. She has 1000 yards of fencing available. If she does not fence the side along the river, what dimensions of the pasture will maximize the amount of grass available for her cattle to eat?



Width	Length	Area
50 yards	1,000 − 2(50) = 900y	50 (900) = 45000y²
100 yards	1,000 − 2(100) = 800y	100 (800) = 80,000y²
300 yards	1000 − 2(300) = 400y	300 (400) = 120,000y²
x yards	1,000 − 2(x) = 1,000 − 2x	x (1,000 − 2x) 1,000x − 2x² y²

Figure 5: *Graelynn’s efforts finding a function to model the Rancher’s Pasture problem.*

In the above example, Graelynn was quickly able to find the areas for the widths of 50, 100, and 300 yards. She understood how the numerical pieces of the tasks fit together. However, when she tried to compete the row in the table where the width was 'x', she hesitated. The following dialogue occurred:

> Author: "What stayed the same in the middle column for all the rows so far?
> Graelynn: "The 1000 and the two."
> Author: "What do you think the middle column will look like if we replace the numbers with an x?"
> Graelynn: "I guess *1000-2x*."
> Author: "Then how can we find the area?"
> Graelynn: "I guess we multiply the two."

Although the above dialogue does not continue until the completion of the problem, it shows how Graelynn was able to recognize patterns and note regularities (NCTM, 2000) in a way that enabled her to calculate the area in terms of the variable x. The Common Core Standards for Mathematical Practice indicates this type of pattern recognition is beneficial to students' learning because it encourages them to make observations and it aids them in forming predictions of relationships in order to generate formulas (NGA, 2010). These types of higher-level pattern recognition activities should be the prevalent type of pattern recognition activities used in the mathematics classroom.

Conclusion

The current architecture of online course packages makes it difficult to ensure students are engaged in higher-level tasks. If we, as educators, are going to take steps to prevent students from becoming parallel-replacement zombies, we must consider the goals of homework assignments and the process by which students achieve these goals. Is the assignment designed so students can practice the mechanics of an algorithm, or is homework an assessment where students have the opportunity to show mastery and an understanding of concepts? Depending on the purpose of the assignment, educators might want to limit the types of help features available to students. An additional strategy would be to provide two assignments: one 'practice' assignment that includes all the help features and another evaluative assignment that limits some of the features. Whichever approach is chosen, we need to do our part as educators in keeping students from becoming parallel-replacement zombies.

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