

# Calculus I Faculty Academy Project: Scaffolded Discussion Problems

Daniel Swenson

University of California, Merced

Spring 2017

# What is Conceptual Scaffolding?

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

Scaffolding is “a process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his [or her] unassisted efforts” (Wood, Bruner, & Ross, 1976, p. 90).

# What is Conceptual Scaffolding?

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

**An Example of a Non-scaffolded Calculus Problem.** Using calculus, sketch the graph of  $y = x^3 - 3x^2$ .

# What is Conceptual Scaffolding?

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

**The Same Problem, Written as a Scaffolded Problem.** Consider the function  $f(x) = x^3 - 3x^2$ .

- Find the zeroes of  $f(x)$ .
- Identify where  $f(x)$  is increasing and where it is decreasing.
- Identify where  $f(x)$  is concave up and where it is concave down.
- Using the information you obtained in parts **(a)** through **(c)** of this problem, sketch the graph of  $y = f(x) = x^3 - 3x^2$ .

# Scaffolding in the Mathematics Literature

Calculus I  
Faculty  
Academy  
Project:  
Scaffolding  
Discussion  
Problems

Daniel  
Swenson

Papers exist that discuss the role of scaffolding in mathematics instruction, but mostly in the context of mathematics instruction for children.

- Anghileri discusses various scaffolding strategies within mathematics instruction.
- Ferguson and McDonough describe a case study involving the “scaffolding practices of two upper primary teachers and the impact on two low-attaining students in each of these classes.”
- McCosker and Diezmann discuss what happens when scaffolding is implemented in ineffective ways.
- Bakker, Smit, & Wegerif wrote a helpful survey paper of scaffolding papers in mathematics education published from 2010-2015.

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

# Project Overview

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

Our hypothesis is that **explicitly scaffolded problems in discussions will lead to better Calculus I exam scores**. In order to examine this, we implemented an optional “hints” document for each worksheet that gave hints about how to engage each worksheet problem, in order to scaffold students’ approaches to the problems.

The following slides display the results of the closed-response questions on a Calculus I survey regarding the “hints” documents. 96 out of 370 students responded to this survey.

# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

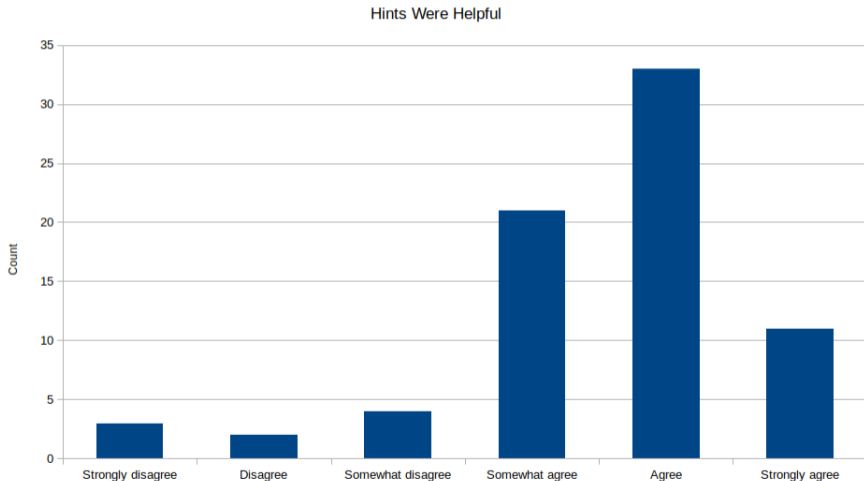
Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

**Data and  
Analysis**

Discussion and  
Conclusion

Works Cited





# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

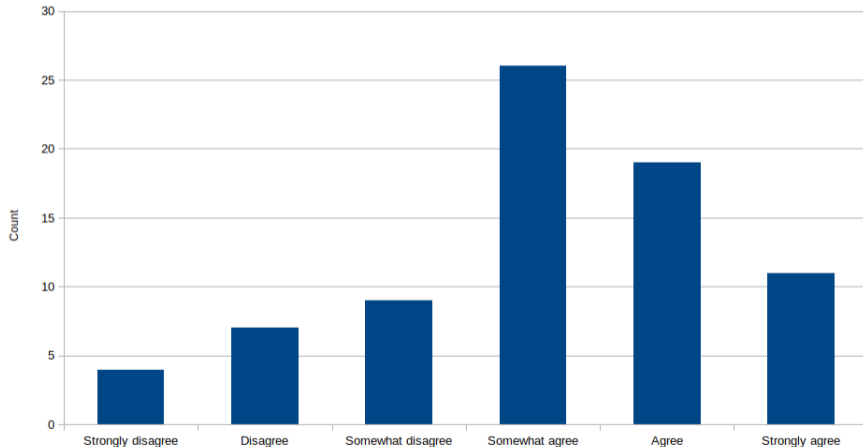
Project  
Overview

**Data and  
Analysis**

Discussion and  
Conclusion

Works Cited

Hints Reduced My Anxiety About the Worksheet Problems



# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

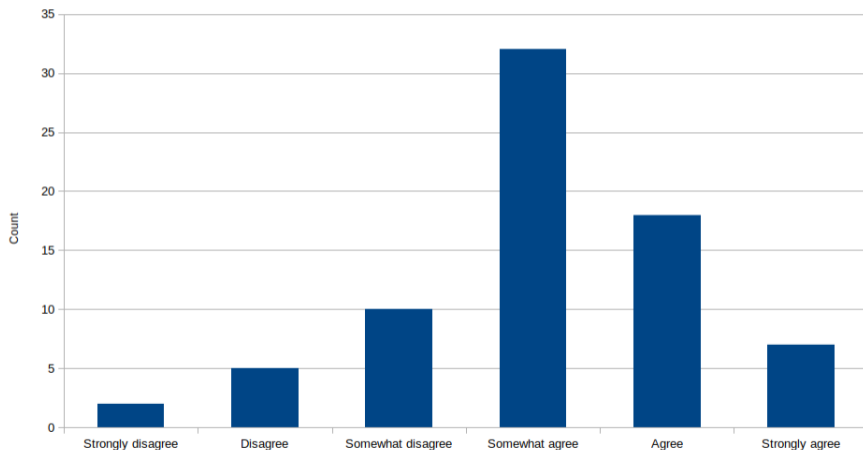
Project  
Overview

**Data and  
Analysis**

Discussion and  
Conclusion

Works Cited

Hints Made Me More Confident About the Worksheet Problems



# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

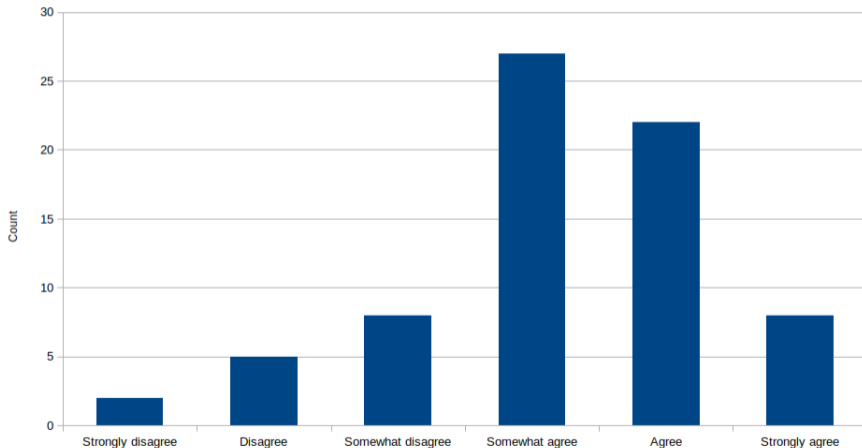
Project  
Overview

**Data and  
Analysis**

Discussion and  
Conclusion

Works Cited

Hints Helped Me to Better Understand the Worksheet Problems



# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

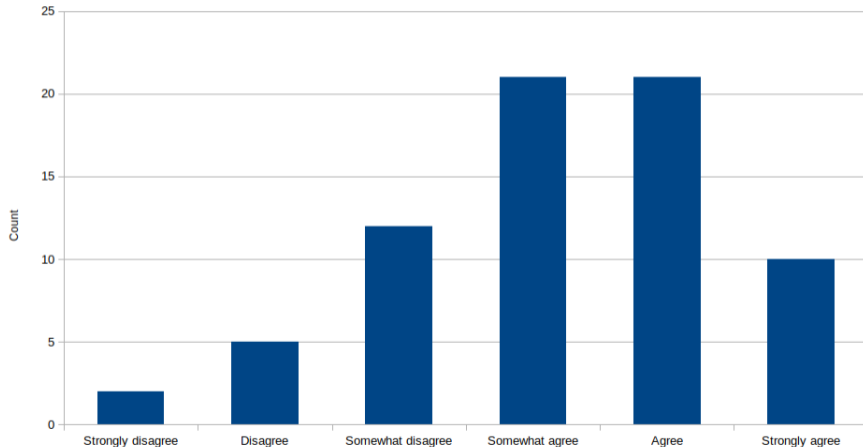
Project  
Overview

**Data and  
Analysis**

Discussion and  
Conclusion

Works Cited

Hints Helped Me Do the Worksheet Problems More Quickly



# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

<b>Survey Item</b>	<b>Median Response</b>
Hints Were Helpful	Agree
Hints Reduced My Anxiety	Somewhat Agree
Hints Made Me More Confident	Somewhat Agree
Hints Helped Me Better Understand the Worksheet	Somewhat Agree
Hints Helped Me Do the Worksheet Problems More Quickly	Somewhat Agree

Overall, based on the median responses, the students generally agree or somewhat agree that the hints were helpful to them.

However, since the median response to the latter four questions was “somewhat agree,” they appear to be somewhat lukewarm about the idea that the hints reduced their anxiety, made them more confident, helped them better understand the worksheet, or helped them do the worksheet problems more quickly.

We will now examine the plots of the students' exam and quiz scores against the frequency with which they used the “hints” documents.

# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

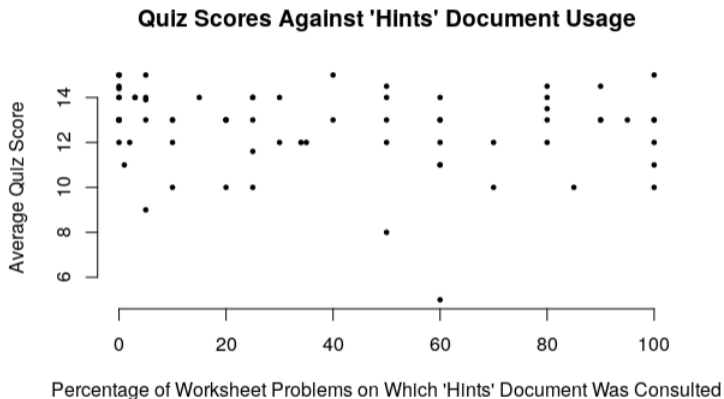
Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

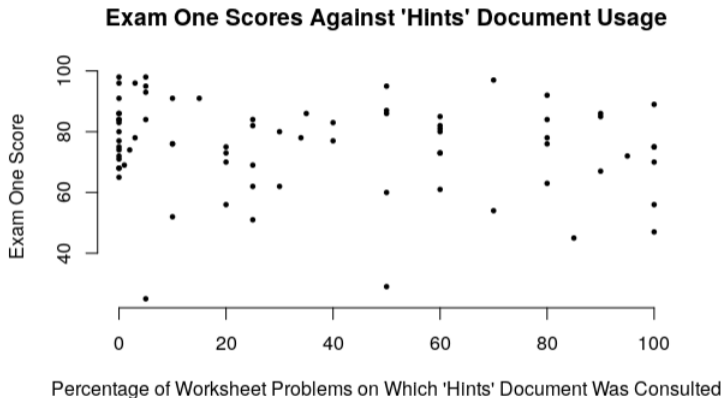
Discussion and  
Conclusion

Works Cited



**Figure:** There is no statistically significant association between quiz scores and the usage of the “hints” document.





**Figure:** There is no statistically significant association between the exam one scores and the usage of the “hints” document.

# Data and Analysis

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

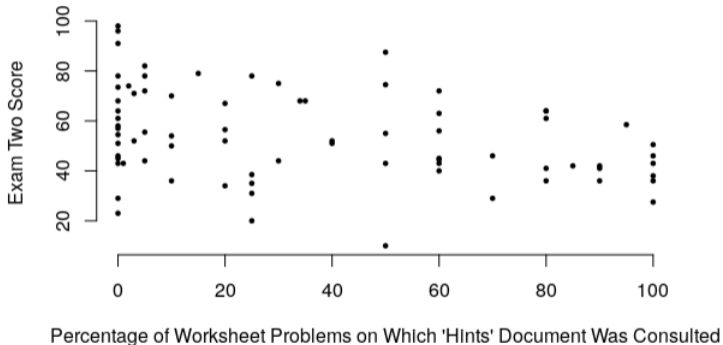
Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

## Exam Two Scores Against 'Hints' Document Usage



**Figure:** The exam two score is negatively associated with the usage of the “hints” document at a statistically significant level ( $p = .0027$ ). A statistically significant negative association is still observed when controlling for the students’ previous math course’s grade.

Overall, the students who used the “hints” document more often did not get better grades than other students. In fact, on the second exam, they received worse grades, on average, than students who used the “hints” document less often.

Based on the responses to the open-response questions on the survey, the following observations can be made:

- Stronger students don't seem to need the "hints" document in order to engage the worksheet problems; they already have the knowledge that the "hints" document provides.
- A number of students would have preferred to see a problem exactly like the given problem (i.e., with different numbers) completely worked out step-by-step.
- Some students who would not have been able to engage a problem were able to begin making progress on a problem due to the "hints" document.
- Some students remarked that they would get lost in the "specifics" (or algebra) of the problem and that the hint would not help them at that point.
- Overall, the "hints" document changed students' study habits very little.

# Discussion and Conclusion

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

There is no evidence from this study that the “hints” documents help students to learn calculus better. However, students do generally feel that the “hints” documents help them to feel somewhat more confident and less anxious about the worksheet problems, and that they are able to finish the worksheet problems somewhat faster by using the “hints” documents.

# Discussion and Conclusion

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

**Discussion and  
Conclusion**

Works Cited

Since this is only an observational study, we cannot make any firm conclusions about causality. However, it is possible that some students came to rely too much on the “hints” documents and were not able to do well on quizzes and exams in their absence, particularly on exam two.

# Works Cited

Calculus I  
Faculty  
Academy  
Project:  
Scaffolded  
Discussion  
Problems

Daniel  
Swenson

What is  
Conceptual  
Scaffolding?

Scaffolding in  
the  
Mathematics  
Literature

Project  
Overview

Data and  
Analysis

Discussion and  
Conclusion

Works Cited

- Anghileri, J. (2006). *Scaffolding Practices that Enhance Mathematics Learning*. J Math Teacher Educ 9: 33.
- Bakker, A., Smit, J. & Wegerif, R. (2015). Bakker, A., Smit, J. & Wegerif, R. *Scaffolding and Dialogic Teaching in Mathematics Education: Introduction and Review*. ZDM Mathematics Education. 47: 1047.  
doi:10.1007/s11858-015-0738-8.
- Ferguson, S. and McDonough, A. (2010). *The Impact of Two Teachers' Use of Specific Scaffolding Practices on Low-Attaining Upper Primary Students*. Paper presented at the Annual Meeting of the Mathematics Education Research Group of Australasia (33rd, Freemantle, Western Australia, Jul 3-7, 2010).
- McCosker, N. and Diezmann, C. (2009). *Scaffolding Students' Thinking in Mathematical Investigations*. Australian Primary Mathematics Classroom, 14(3). pp. 27-32.
- Wood, D., Bruner, J., & Ross, G. (1976). *The Role of Tutoring in Problem Solving*. Journal of Child Psychology and Psychiatry 17, 89-1.