IMPLEMENTING A WEB-BASED MODEL SLICER FOR 3D PRINTERS

BY

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Abstract

3D printing currently has a large gap between software and hardware. A hobbyist machine can now be purchased for less than $500 but having good software to drive it is hard to find. Currently the only competent and free slicing software available is Cura and Repetier Host. Currently, Cura has varied support on all platforms, and Repetier Host is intended only for Windows. Neither software have any web support nor will they be likely to have any support in the future as the slicing process requires a computer with a considerable amount of both graphical and computational power. The purpose of this research is to construct a web based slicing software and make it simple for users without any prior knowledge of 3D printing to take full advantage of their printer and as a result will make 3D printing much more approachable for users who are not computer savvy. Additionally, this opens up opportunities for educators in STEM programs to teach students about 3D printing in a simple and practical way.

Acknowledgments

Acknowledge those who helped you. I offer no comment on proper degree of mushiness. The work in this thesis was only possible because of all the helpful and guiding members of the UMass Lowell engineering education community. Many people have helped me not just in research effort, but in introducing me to new thoughts and ideas that became foundational to this project.

I would like to first thank someone for being so inclusive towards me. She involved me in her work, where I learned about many of the foundational works that appear in this document. It was not just about getting sources for the literature review, it was about having an experienced colleague. She taught me that everything is always a learning process, for students, teachers, and researchers alike.

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Contents

1 Introduction **1**

1.1 Research Focus . . . 1

1.2 Problem Statement . . . 2

1.3 Approach . . . 2

1.4 Hypothesis and Contributions . . . 2

1.5 Rationale . . . 3

2 Background **4**

2.1 Brief History of Engineering Education . . . 4

2.2 Design Activity Studies . . . 4

2.3 This Study . . . 5

3 Methodology **6**

3.1 Subject Selection . . . 6

3.2 Session Protocol . . . 6

3.3 Design of Activities . . . 7

3.3.1 Parts of the study . . . 7

3.3.2 Week 4: Word Search . . . 8

3.4 Coding and Analysis . . . 8

4 Analysis **9**

5 Discussion **10**

5.1 Conclusions . . . 10

5.2 Recommendations 11
5.3 Future Work 11

A If you need an Appendix **13**

B Analysis Codes **20**

C IRB Compliance Documents **22**

C.1 Parent Consent Form 22
C.2 Student Assent Form 22

List of Figures

3-1 Example word search puzzle provided to students. 8

A-1 Gear Reduction handout, page 1. 13
A-2 Gear Reduction handout, page 2. 14
A-3 Word Search handout, page 1. 14
A-4 Word Search handout, page 2. 15
A-5 Word Search handout, page 3. 16
A-6 Word Search puzzle. 17
A-7 Elevator Control instruction sheet. 19

C-1 Parental consent form, page 1. 23
C-2 Parental consent form, page 2. 24
C-3 Student assent form, page 1. 25
C-4 Student assent form, page 2. 26

List of Tables

3.1 List of design activities. 7
3.2 Rush Hour activity success and iteration criteria. 7
3.3 Gear Reduction activity success and iteration criteria. 8
4.1 Results from the Light Optimization activity. 9
5.1 Average non-iterating times for each activity. 10
5.2 Correlations of success to iteration time. 11
B.1 Starting codes. 21

Chapter 1

Introduction

So here we are in the introduction chapter. Fun times are ahead! First, how to do citations. The basic citation is "citet", the textual citation, and should be done like the following sentence. Design and engineering lack such a body of work, as **?**, p. 35 stated about the field of computing. The other kind is the parenthetical citation, "citep," which looks like this. Most adults use strategies to overcome natural limitations of memory retention and recollection (**?**). The only difference is how the citation will render. How you use them is up to you and your desired writing style. You can even lead a sentence with a textual citation. **?** conducted much of her work around the development of a learning community in lieu of the traditional didactic classroom experience.

These are functions of natbib, the details of which can be easily found by internet search.

1.1 Research Focus

Creating sections is easy enough. Basic LaTeX. I highly recommend the wikibook on LaTeX. It is complete and wonderful.

1.2 Problem Statement

Let's do a list. Lists are great. The four questions of interest are:

- Do students exhibit patterns in testing and iteration? What are those patterns?
- What characteristics of a design activity elicit specific iteration patterns?
- What is the correlation between iteration in designing and success of the design?
- What guidelines can be written for the creation of future activities?

1.3 Approach

This research used a laboratory study of a small sample population of middle school students. The sessions were video and audio recorded. The data was coded for many different design behaviors, informed by (**?**).

1.4 Hypothesis and Contributions

Here, each research question is framed in more detail:

Do students exhibit patterns in testing and iteration?

It is expected that individual students will demonstrate personal trends across all activities.

What characteristics of a design activity elicit specific iteration patterns?

The design activities were designed to differ in complexity, speed of construction, and level of abstractness. These types of properties are expected to have a specific effect on iteration patterns in students, resulting in each activity having general trends that cross all students within the specific activity.

What is the correlation between iteration in design the design process and the success of the final design?

Multiple sources in the literature depict iteration as critical to design success. For example, **?** showed that, in college students, forced iteration makes an inexperienced designer just as good as non-iterating designer who has domain experience. In this study, it was expected that rate and count of iteration would strongly correlate with success. Each activity is analyzed with individual success metrics, so this hypothesis was tested within each activity separately.

What guidelines can be written for the creation of future activities?

Each activity was expected to result in a certain unique pattern of testing and iteration. By comparing these patterns, it would then be possible to generate recommendations on properties of the activities themselves. These guidelines could be generalized for use by educators.

1.5 Rationale

Exploring the tacit processes of novice engineers will further our understanding of human design faculties. With this study, motivations behind why students engage in certain models of behavior was explored. This study chose to focus on iteration, a single component of the engineering process. As is discussed in the Background chapter, iteration is a fundamental characteristic of the design process. This study chose to use design iteration as a lens for analysis of the student design work.

Chapter 2

Background

This chapter has been cut down significantly as this is just a template. You should write a LOT more than is here.

Education has evolved with culture and technology. Classical wisdom calls only for the "three R's" (reading, writing, and arithmetic) in schools, which today is considered foundational but insufficient for life.

2.1 Brief History of Engineering Education

STEM education, of which engineering is a component, is in need of "evidence-based" tools to measure their effectiveness (**?**). Conversely, lab-generated scientific data on education is often too abstract to be directly usable for real teachers (**?**).

2.2 Design Activity Studies

? performed an experiment on design activities carried out by seventh grade students. The steps are:

1. Understand the problem
2. Generate possible solutions
3. Model a possible solution

4. Build a solution

5. Evaluate the solution

This paragraph shows how to use a label. A model-eliciting activity (MEA) is designed such that the students' product is not a single answer, but a rule or process that can be applied to solve similar problems.

2.3 This Study

Many studies have examined the design process, providing a variety of insightful models and theories.

Chapter 3

Methodology

This chapter is mostly stubs and is heavily cut down. Origional content is left as context examples for LaTeXmechanisms.

3.1 Subject Selection

All students read, understood, and signed a student assent form and their guardians read, understood, and signed a parental consent form (see Appendix C.1).

3.2 Session Protocol

At the conclusion of the activity, students were led in a group conversation about what they learned and developed. These conversations were also recorded. The questions asked by researchers during this conversation were variations of:

- What did you do to find your solution?
- Did you do anything early on that you did again to help yourself?
- If you had a friend who was coming in to work on this problem tomorrow, what would you recommend they do?
- Are there any other tricks you discovered?

Week	Activity	Related Field
1	"Rush Hour" Game	math problem solving
2	Light Optimization	electrical engineering
3	Gear Reduction	mechanical engineering
4	Word Search	computer science
5	Elevator Control	computer science

Table 3.1: List of design activities, in order that they were conducted by students, with their related field.

Rush Hour Specifications		
Success Criteria	Solution:	Solved puzzle
	Process:	Described Strategies
Iteration Metric	Backtracking or resetting: deviation from current course	

Table 3.2: Rush Hour activity success and iteration criteria.

3.3 Design of Activities

This is a beautiful, professonal-looking table.

In total, the activities are intended to support computational thinking, as discussed in Chapter 2. Every activity represented a real engineering or design problem, had observable iteration behavior, defined metrics of success, and were process-oriented, as discussed in Section 2.2.

Each activity had two levels of success. The first level is the completion of a successful design that solves the problem. The second level is synthesizing a general process for arriving at a solution. Both levels are defined as success criteria for each activity in the following sections. The five activities are now presented. They are also summarized in Table 3.1.

3.3.1 Parts of the study

I proceeded to have a subsection for each component activity of my study. Your study will likely be different in structure, so I removed it. I do have a few cool tables, so I left those in.

Gear Reduction Specifications		
Success Criteria	Solution:	Built transmission that lifts mass
	Process:	Non-trivial suggestions for a friend
Iteration Metric	Applying energy to system, either by hand or by motor	

Table 3.3: Gear Reduction activity success and iteration criteria.

Y	E	S	L	F
M	N	H	R	I
P	T	O	U	R
A	C	E	M	E

Figure 3-1: Example word search puzzle provided to students.

Purpose

3.3.2 Week 4: Word Search

3.4 Coding and Analysis

Videos from student sessions were analyzed using coding techniques informed by **?** and **?**, where specific codes were defined to describe important behaviors. Additional codes were created in the style of grounded theory (Strauss and Corbin, 1997): as behaviors and patterns that were not predicted were observed.

The body of codes covered a wide range of design behaviors, as seen in Appendix B.1, but only the TEST code was used in analysis, as it was used to characterize design iteration.

Chapter 4

Analysis

This chapter is mostly stubs and is heavily cut down. Origional content is left as context examples for LaTeXmechanisms.

Be careful with your quotation marks. Double backtick and double single-quote are used in latex to give the proper effect. “This is correct.” While ”This is incorrect.”

The most significant observation was the students’ self-motivation to use mathematics to improve their design, discussed in Section **??**.

	A/B	C/D	E/F
Iteration Count	3	8	7
Time per iteration	18 min	5 min	7 min
St.Dev. of time per iteration	14.8 min	3.7 min	4.8 min
Non-iterating time	21%	35%	20%
Success (0,1,2)	2	1	1

Table 4.1: Results from the Light Optimization activity. The best performing team had the fewest iterations, which is believed to be based on that team utilizing prior knowledge.

Chapter 5

Discussion

This chapter is mostly stubs and is heavily cut down. Origional content is left as context examples for LaTeXmechanisms.

5.1 Conclusions

The data presented in Table 5.2 shows that the most successful students were consistently slower to begin testing across all activities, indicating that they spent more time in each activity trying to understand the problem before attempting a solution. The speed of iteration also correlates with success, but not as strongly as the introductory time spent.

	Light Opt.	Gear Reduction	Elevator Control
Average Non-Iterating time	25.5%	28.6%	35.8%
Standard Deviation	7.0	13.0	13.5

Table 5.1: Average non-iterating times for each activity. These data do not include instances where students did not complete an activity.

	A/B	C/D	E/F
Overall Success Rating	3/6	5/6	1/4
Average Non-Iterating time	14.4%	37.9%	incomplete/4.9%
StdDev Non-Iterating time	*6.0*	*2.7*	
Average time per iteration	7.8 min	3.8 min	incomplete/6 min
StdDev Av time per iteration	*7.8*	*3.1*	

Table 5.2: Success correlations with non-iterating time and average time per iteration based on three activities. Group E/F participated in, but did not complete, the Gear Reduction activity and did not participate in the Elevator Control activity. That group's listings for non-iterating time and time per iteration considers only the one activity they completed: Light Optimization.

5.2 Recommendations

Recommendations that bear on the challenge of creating design-based engineering activities can be made from this study.

5.3 Future Work

New methods for characterizing and analyzing design behaviors, specifically testing and iteration, were created in this project.

References

A. Strauss and J. Corbin, editors. *Grounded Theory in Practice*. Sage, 1997.

Appendix A

If you need an Appendix

If you need an appendix, make them here. You can copy this file so each appendix has its own tex file, or you can put them all in this one file. I don't care. Just keep yourself organized.

This file has great example of how to tables and graphics, so be sure to look at the source. The tables I use are "professional style"

This file will probably not build as I did not include the graphics files in the template distribution.

Now, back to the content. Paper handouts were used in three of the activities to provide instructions and work space for the students. They are included here.

Figures A-1 and A-2 show the handout that was provided to students when doing the Gear Reduction activity. At the conclusion of the session the students were asked to draw their design in the style of the example in Figure A-2.

Figures A-3 through A-5 show the handout that was provided to students when during the Word Search activity.

Figure A-6 is one of the two puzzles given to the students. Solutions have been highlighted.

Figure A-7 shows the instruction sheet that was given to students at the beginning

Figure A-1: First page of the worksheet given to students during the Gear Reduction activity.

Figure A-2: Second page of the worksheet given to students during the Gear Reduction activity.

appendix/word_search_worksheet1.pdf

Figure A-3: First page of the worksheet given to the students during the Word Search activity. This worksheet explains algorithms through the explanation of tic-tac-toe.

appendix/word_search_worksheet2.pdf

Figure A-4: Second page of the worksheet given to the students during the Word Search activity. This sheet guided the student through the creation of an example algorithm.

appendix/word_search_worksheet3.pdf

Figure A-5: Third page of the worksheet given to the students during the Word Search activity. This sheet provided space for students to design their algorithm.

appendix/word_search_puzzle1key.pdf

Figure A-6: Word Search puzzle provided to the students. The hidden words are shown.

of the Elevator Control Activity.

appendix/elevator_instructions.pdf

Figure A-7: Elevator Control instruction sheet.

Appendix B

Analysis Codes

Design Step	Code	Definition
Understand the problem	RB	Read design brief as given to the subjects by the researcher
(“ASK”)	DPER	Discussing/referring to performance criteria
	DCON	Discussing/referring to constraints
	PK	Accessing prior knowledge
	CAR	Check available resources
Generate possible solutions (“IMAGINE”)	DIS	Discussing possible solutions
	SBS	Selecting best solution
	MAN	Manipulation of materials to explore properties
Modeling a possible solution (“PLAN”)	PP	Planning a prototype
	DRAW	Sketching or drawing possible solutions
	MP	Making a prototype
	TEST	Testing one element as the making continues
	AB	Abandon current solution; begin new solution
Building a solution	IP	Identify a problem with the prototype
(“CREATE”)	MDC	Making a design change to the prototype
	REF	Refining construction of prototype
Evaluation	EO	Evaluate as subjects observe prototype
(“IMPROVE”)	ET	Evaluate as subjects talk about prototype
	ED	Evaluate as subjects draw possible solution
	EDB	Evaluating in terms of the design brief

Table B.1: Starting codes designed by **?** and informed by **?**. Each code indicates a specific design behavior, and are categorized by the steps of the Boston Museum of Science Design Cycle.

Appendix C

IRB Compliance Documents

C.1 Parent Consent Form

Figures C-1 and C-2 are the Parental Consent Form completed by the legal guardians of all participants in the study. This form was also available in Spanish.

C.2 Student Assent Form

Figures C-3 and C-4 are the Student Assent Form completed by all of the participants in the study.

appendix/irb_parent_consent.pdf

Figure C-1: Parental consent form, page 1.

appendix/irb_parent_consent2.pdf

Figure C-2: Parental consent form, page 2.

appendix/irb_student_assent.pdf

Figure C-3: Student assent form, page 1.

appendix/irb_student_assent2.pdf

Figure C-4: Student assent form, page 2.