Entrepreneurial Minded Learning in App Development Courses

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***Abstract*—Engineering courses often make use of term projects to tie together course concepts and enable open-ended learning. Projects can also be used to teach entrepreneurial-minded learning (EML). At Rose-Hulman we offer mobile/web app development in 4 different courses. In each of these courses, we have two goals for our students: (1) to master fundamental technical skills for that platform and (2) to create an app of their choosing to add real value for users of the app. To meet the first goal, we use a traditional approach with a series of hands-on lectures and labs. To meet the second goal, students complete a 10-week term project in which they work with a partner to identify a real world need and create a high quality app to meet that need. We surveyed students about their motivation and learning experience in the project. Students reported that self-selected projects that add value for others helped motivate them to work harder in the course which improves student learning. Students leave our app development courses with both an understanding of the technical material and a hands-on learning opportunity where they solve real problems for users.**

Keywords—Android; iOS; web frameworks; entrepreneurship.

I. Introduction

Many engineering courses make use of term projects. A term project, as opposed to smaller homework assignments, has many potential advantages for students. First, they give students an opportunity to make use of concepts learned in the course and to make connections between those concepts [1]. Second, some kinds of projects can motivate students to work harder since the students see the value of the project they are creating. There are many kinds of projects and most serve the purpose of strengthening students' understanding of course material. However, we hypothesize that some projects do a better job of motivating students than others. Fig. 1 shows various categories of projects.

(No choice; already solved) Some projects are assigned by the professor and allow the students little to no choice of what problem they are trying to solve. For example, in our Data Structures course, the 3-week long term project is to create a balanced binary search tree to implement a List interface: this is technically challenging and requires students to use and connect many concepts, but it provides little intrinsic motivation, since they know the problem has already been solved. In that way, it isn't much different from a homework assignment from the textbook.

(Choice; open-ended) Some projects are open-ended; the professor allows the students to propose project ideas based on their own interests. For example, in our Introduction to Programming course, we use small mobile robots for the project and allow students to pick their own robot behaviors to demonstrate their technical competency. This project adds the element of student choice, but the projects selected are contrived examples that add no user value.

In any project driven by student choice, students suggest project ideas and the instructor guides them to the appropriate level of technical competency. Few projects suggested by students are not technical enough; the vast majority need to be scaled back to features that can be completed within the allotted time frame.

(Choice constrained by value added) Finally, some projects, those studied in this paper, encourage students to choose projects that add value for others by solving real world problems. For example, this is the heart of service learning, for example senior capstone projects that involve students building robots for Children's Museums or planning playgrounds for community centers [2]. Requiring students to create user value can potentially help motivate them to stay actively engaged with the project until completion because the external impact gives them a reason to stay focused when the project becomes challenging. Creating extraordinary value is a goal of entrepreneurially-minded learning (EML), the main thrust of KEEN (Kern Entrepreneurial Engineering Network) [3]. KEEN's primary goal is instilling an entrepreneurial mindset in engineering students, to support them contributing to their future employers through their own innovation and creativity to create new products, markets, and industries [4].

We believe that the term projects in mobile/web app development courses are a perfect opportunity to teach students to be entrepreneurially-minded.

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At Rose-Hulman we teach mobile/web app development in four different courses:

1. CSSE480 Web App Frameworks with App Engine
2. CSSE483 Android Application Development
3. CSSE484 iOS Application Development
4. CSSE490 Web App Frameworks: Firebase and Angular

It is natural to have students choose which apps to create for these courses - for example, simple games like battle games and board games were popular apps among students before we introduced the idea of creating value for others. Most were purely for fun and some for personal interest.

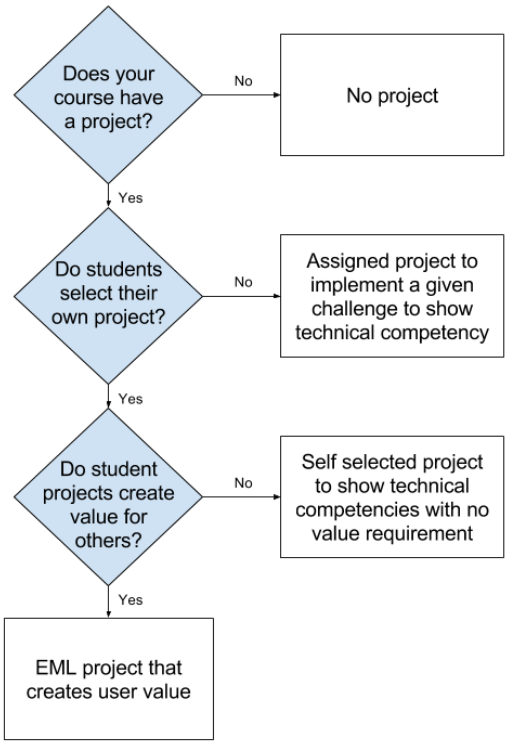

Fig. 1. Choices for a course project format.

Open-ended projects have long been at the heart of problem-based learning (PBL) [1]. PBL has been shown to increase students' learning [5]. For these reasons, we think that students would agree that having a project motivates them and that choosing their project motivates them. Additionally Gerhart and Melton [5] show that by adding a hypothetical customer to the problem statement, PBL projects can be successfully modified to include EML; they give several examples from a fluid dynamics course.

Similarly, does guiding students in app development courses to select projects that create value for others lead to greatest student motivation and the highest-quality projects? This study describes four courses in which students develop the entrepreneurial mindset by building apps to create user value for their term project. We describe the methods used in the implementation of the project. We also present the results of surveying students about their experiences completing the term project. We believe that the results of this work generalize to any other discipline and course in which students do term projects.

Our motivation is to instill the entrepreneurial mindset well before they start their capstone experience. Ochs [6] asserts that by the time students start their capstone design experience, they have forgotten basic principles from classes like statics and need to relearn them, because they had no context to their learning when they first learned the principles. His solution was to add case studies to the lower level courses. Our solution is to motivate students to learn deeply by having them create value for others in their app development courses.

II. Methods

When choosing a project format for a course, we have many options. A project should of course use and reinforce material students learn in that class, but even within that constraint, there are many other potential goals for a project. Is this a team project or an individual? Are projects self-selected with open ended requirements or should students implement a known challenging problem? Does the project solve a real problem? These choices have been outlined in Fig. 1.

We now present our application of our EML project to create user value in mobile app development courses. In our implementation, based on a 10 week academic quarter, each week contains both technical content for the course and deliverables for the project. For example in our Android course we have a series of follow-along lectures and hands-on labs to teach the skills necessary to do Android app Development (the first column of Table 1). The second column shows the technical content for a totally different course in web development in which students learn to do web development using a specific data framework (Angular) and cloud storage library (Firebase). In each course, students develop their skill set as they would in any course. However, they also concurrently develop a self-selected project. While the technical content is very different in the Android course and web course, the project deliverables in each course are identical (column 3 of Table 1). Our courses in iOS development and App Engine web development use the same project deliverables as well.

TABLE I. EXAMPLE OF COURSE AND PROJECT TOPICS IN TWO COURSES

Week	Android course topic (Lab name)	Web course topic (Lab name)	Project deliverable
1	Model-view-controller paradigm; apps with buttons (Tic Tac Toe)	TypeScript (Tic-Tac-Toe model)	Brainstorming app ideas
2	Menus and dialogs (Point of Sale)	Components and Pipes (Favorite Things)	Three product idea sheets
3	Adapters for list views (FoodRater)	AngularFire (Movie Quotes)	Proposal + Screen mocks
4	Fragments and activity intents, extras, lifecycle (ComicViewer)	Authentication (Password Keeper)	Data design, setup
5	Polishing an interface (FamousArtists)	Reactive RxJs (Quick Chat)	Coding sprint 1
6	Cloud storage via Google Firebase (PhotoBucket)		Sprint 2, meet to demo to instructor or assistant
7	Firebase authentication (OurPhotoBucket)	Cloud storage via Google Firebase (PhotoBucket)	Sprint 3
8	Firebase complex data models (GradeRecorder)	Cross compiled apps with Ionic (Movie Quotes)	Sprint 4, meet to demo
9	Maps (VacationTracker)	Firebase complex Data using Ionic (GradeRecorder)	Sprint 5 Video planning
10	Publishing apps on Google Play, Project submission and demonstration	Deploying projects to custom domains, Project time	Video presentation, technical documents, and evaluations

A. Project Deliverables

Starting with week 1 and continuing until the course ends in week 10, students submit a weekly deliverable for their project.

a) Brainstorming: This is an in-class activity where we introduce the concept of creating apps that look for real world problems and try to solve a need for users. We first let students work in small groups to come up with ideas, which then report their ideas to the whole class. The goal is to generate ideas to get students curious about the opportunities around them. Many ideas are specific to local problems and focus on solutions to problems that exist in the lives of people around our campus and community. Curiosity is the first important step in the EML process [5].

b) Three Product Idea Sheets: The next project deliverable is for students to work with a partner to pick three of their favorite project ideas and explore them in more depth before choosing their final project. In their project idea sheet they need to identify their customer. *Who is this app for? Who would pay to use it or value from having it?* Next, they identify the opportunity. *What is the problem you are solving for your customer?* They then begin a research phase to make connections between their problem and existing work. Students search online and within app markets to find the closest existing products. *What are those solutions missing that you could improve?* We ask students to question potential customers to interview them for information. Finally we have students state their proposed solution to the problem. *How does your solution meet the needs of the customer?* We also recommend students add images of any work they find as illustrations help communicate their research to others. This assignment is focused on adding connections between their work and the world. Connections are the important second step in the EML process [5].

c) Proposal and screen mocks: The next project deliverable is to identify their project and to describe the features of their solution. The first step in the design process is to make a rough drawing of every screen in their app, which is called a mock. Students present their mocks to their instructor or TA. They should be able to make that person feel like a user of their product. The only difference is that the experience is happening on paper instead of a real app. At this time, the instructor provides feedback to the students on the complexity of their app, suggesting features to

remove or to add to meet the technical goals of the course. During this pivotal step of the design process, students begin to really see how their solution creates value for users. Creating value is the third critical step in the EML process [5].

d) Coding sprints: The next phase of the project is very specific to the content of the course and ties together the EML mindset with the technical skills of the course to produce a real-world product. Over the course of several weeks students plan their deliverables for a coding "sprint" (a time period during which they complete a small set of features) and then share the results of their work for that sprint. Often students set goals higher than what they can reasonably finish in a week, but this helps to motivate them to work harder in the course. Since students have been given on opportunity to set their own goals they are more self motivated to deliver on their promises.

e) Video presentations and technical documents: At the end of the coding sprints, students have a project that they can communicate with the world. Often projects are not as polished as originally planned, but some student work is truly exceptional. Regardless of the project status, students need to turn their focus to communicating their work for the final week. The primary student submission is a video of their work. Videos can be at most 5 minutes in length, must include the authors, a statement of the customers and solution, and a demo of their app. To share their videos, students submit their work to the Rose-Hulman Project Vault, as discussed in the next section. Students know that they will be reviewing videos for other teams and that other teams will be reviewing their video. The external pressure that their work will be reviewed by their peers is another motivator to deliver a quality project. Students are encouraged to have fun with their video and to try to show clearly how they are creating value. In addition to the video, students also submit a technical document that describes a specific feature they learned that was not part of the course. Every project forces students to do some independent research and the technical document is their opportunity to communicate their learning. These documents constitute a library of documentation created by students that then serve as reference material for future students in the class wanting to use the same technical features.

f) Peer evaluations: After students complete their project they evaluate classmates' projects. Students are assigned three projects that they must review and they are required to pick at least 3 more of their choice to review. Reviewing projects and writing evaluations for the authors is important for student reflection and for sharing ideas. Often students see user interface (UI) solutions used by other teams and get ideas and inspiration for how they might implement their next project.

All of these project deliverables are submitted to the Rose-Hulman Project Vault. Each student project has a page on the Vault, which helps organize their project deliverables and showcase their work. Links to the project descriptions for the four courses are given in Appendix A.

B. Rose-Hulman Project Vault

The Rose-Hulman Project Vault is a web application the authors developed specifically to showcase student's real-world software project prototypes in support of EML (see https://rosehulmanprojectvault.org). The Vault itself focuses on software prototypes, but is set up so that other courses could showcase their software work on the site. The format allows Rose-Hulman students to upload a video of their project, add text descriptions, and upload any supporting files used in the development process. Users can browse the project pages and see the EML project work students have done, contact the developers by email, and provide ratings and feedback on their work. Faculty members additionally use the tool for the submission of interim milestones to evaluate project work during the process and to provide feedback to help guide student work.

Some projects from the Winter 2016-17 offering of the Android course are shown in Fig. 2.

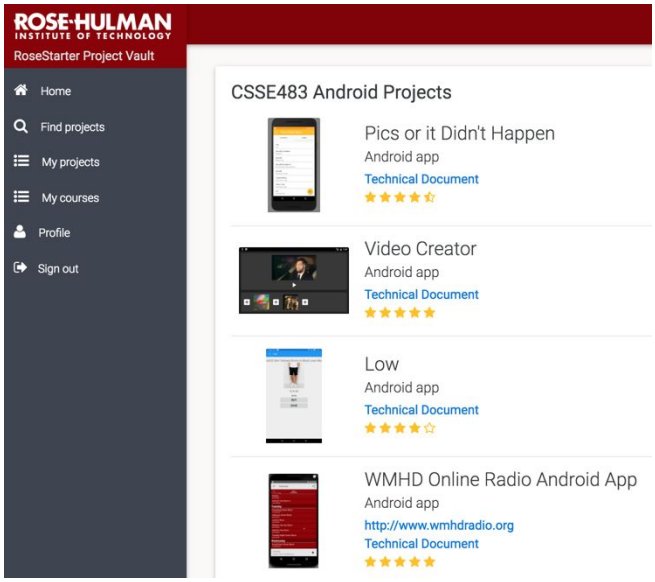

Fig. 2. Examples of Android projects on the Rose-Hulman Project Vault (https://rosehulmanprojectvault.org).

Students have been using the Vault for the past year and have submitted a total of 40 projects (12 App Engine, 21 Android, and 7 Angular; iOS coming soon). Each project has a primary screenshot, description, video, links to the technical documentation, author links, and reviews. The reviews for the apps help give the site a more real-world feel, much like an in-house app store. Before the course even begins students can visit the Vault and see work students have done before them. This helps raise the bar for expectations of student submissions.

The final, and perhaps most important purpose of the

Vault, is to help students showcase their work for the next step of their career. For example, in a job interview students could talk about work they have done by showing their Vault page, or they could include a link on a resume. While maintaining a good GPA is important to students getting their next job, they must also learn to sell themselves and their work. The project vault aims to help them organize their message and better communicate their experiences.

C. *Student Survey*

We asked students who took one or more of the app development classes this year about their experience completing the term project using the instrument in Appendix B. We wanted to learn what types of projects motivated students and what parts of the process they found useful.

III. Student Feedback

Twenty-five students completed the survey, out of the 78 students in these courses. Students' responses to the first question, Fig. 3, show that they definitely appreciate the value of having a term project, with 84% giving positive responses (agreed or strongly agreed) and an average response of **μ**=4.24.

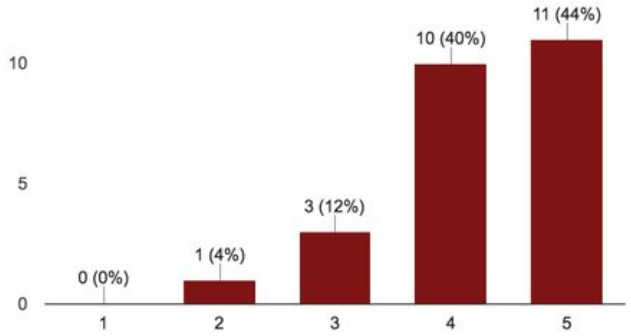

Fig. 3. Question: The fact that we *did* a term project (vs no term project) motivated me to work hard in the class. All responses in this section follow this scale: 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree.

As much as students appreciate having a term project, they appreciate even more the ability to choose their own project (88% positive; **μ**=4.50), as shown in Fig. 4. Choice is important to learning: this question is not referring to design choices but of choosing what problem to solve. One student wrote, "This was something that I wanted to do instead of something I was assigned. I think that having a choice of project creates a stronger connection to the project and increases the likelihood I put more effort into it." Another student wrote, "When I choose the project I tend to care more about it, it's nice to have control over the design choices that are being made. This leads to a more vested interest in the project, and consequently better results because of increased motivation."

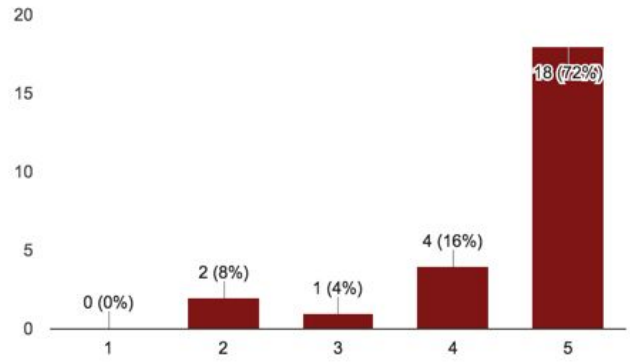

Fig. 4. The fact that I was able to *choose my own* project (vs having one assigned to me) motivated me to work hard in the class.

Fig. 5 is the most relevant one, relating to the motivation associated with creating projects that are valuable to others. While not as strong as having a choice of projects, a full 80% of students answered positively (**μ**=4.35). One student captured this sentiment nicely: "Projects that have a value added provide both our own learning, but we can also see how other people can use them. For projects that have a value added, I also feel like I work harder because I don't want users to have to deal with bugs."

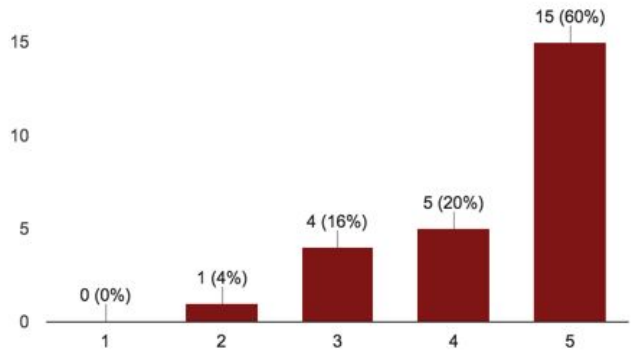

Fig. 5. The fact that my project *created value for others* (vs one that I choose that only shows that I have technical proficiency) motivated me to work hard in the class.

The next two questions relate to the value of the Project Vault. Students (84% positive; **μ**=3.92) agreed that the public website motivated them, although few felt strongly about it, Fig. 6.

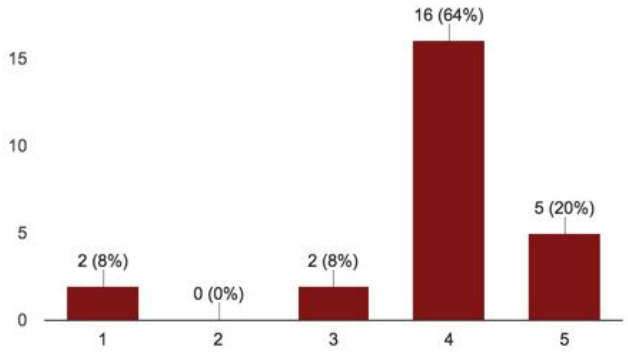

Fig. 6. Having a public website to showcase our apps motivated me to polish my submission.

Likewise, having to create a demo video also motivated students (80% positive, **μ**=4.04), Fig. 7. One student wrote, "I feel like this project was the most complete at the end of the term out of all the other class projects I have done. I think that was influenced by both the peer reviews we had to do as well as self motivation to make an app that could be on the app store and be used by other students."

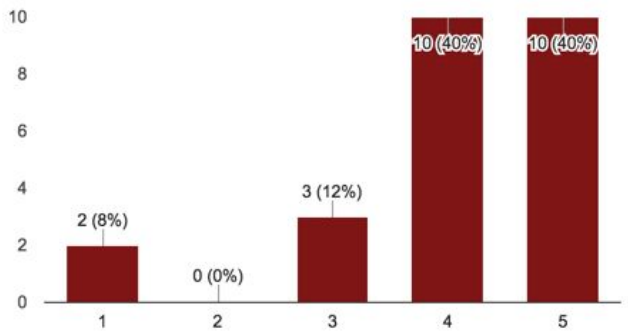

Fig. 7. Knowing I was going to have to create a public video demo motivated me to create an app that I would be happy to present.

Additional survey results are presented in Appendix C.

IV. Conclusions

Based on the student survey results and on our own perceptions while teaching these courses, we feel very confident that a student selected, EML based project that creates value for others is a very effective tool to aid student learning. Additionally the results indicate that the Rose-Hulman Project Vault website is a motivator for students and an effective way to communicate their work with others.

Acknowledgment

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Appendix A: Links to project specifications

Detailed descriptions of each project can be found at the following links. They were developed together, but each has some content specific to the course.

CSSE480 Web App Frameworks with App Engine
CSSE483 Android Application Development
CSSE484 iOS Application Development

CSSE490 Web App Frameworks: Firebase and Angular

Appendix B: Student Survey Questions

The following survey was given to students in the 2016-2017 offerings of CSSE480 Web App Frameworks with App Engine, CSSE483 Android Application Development, and CSSE490 Web App Frameworks: Firebase and Angular.

Background

At Rose-Hulman, you take many classes, some with term projects, some without. Some projects are self-selected, some are assigned to you, and some projects create real value for people while others don't. In all of our app development courses, the goal of every project is to develop an app of your choosing that creates value for people.

1. Do you see a difference between projects of your choice that add value for others (like in the app development courses) versus projects that are assigned to you (like in CSSE120, 220, 230)? (Yes/no; explain your answer)

Motivation

Please rate each statement. Each uses the Likert scale: 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree.

1. The fact that we **did** a term project (vs no term project) motivated me to work hard in the class.

2. The fact that I was able to **choose my own** project (vs having one assigned to me) motivated me to work hard in the class.
3. The fact that my project **created value for others** (vs one that I choose that only shows that I have technical proficiency) motivated me to work hard in the class.
4. Having a public website to showcase our apps motivated me to polish my submission.
5. Knowing I was going to have to create a public video demo motivated me to create an app that I would be happy to present.
6. The format and technical content of this course prepared me to complete the term project.
7. Creating a technical document to help others learn from my research was helpful to me.
8. Viewing and rating other course projects helped me think about new ways to make apps in the future.

Project process - as it relates to YOU
Please rate each statement in its value **to you** in developing the project, ranging from 1 (not at all useful) to 5 (very useful).

1. Brainstorming ideas as a class
2. Three project idea sheets
3. Proposal's 1-2 paragraph summary of the project
4. Screen mocks
5. User stories
6. Database schema (data design)
7. Planning the sprints
8. Coding itself
9. Sprint review meetings

Project process - as it relates to communicating your work with others
Please rate each statement in its value **to others** (your TA and professor) to understand the direction of your project.
(The same 9 project deliverables were rated using the same scale as in the last section.)

Comments
Please give any other comments you'd like to make regarding the term project.

Appendix C: Additional survey results

The following are the results of the other survey questions. Additional relevant student comments are shown first. Figs 8-10 and Tables II-III use the scale: 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree. Tables II and III show the results of the remainder of the survey.

"It's a little harder to find an idea, but building something different and useful allows us to plan our project ourselves and learn from that"

"While I do not think that our chosen projects bring more value/usability to the project, it is definitely preferable. The class is much more interesting without ten versions of the same app"

"I love making our own projects! Being able to see a project from its idea stage all the way to a professional level developed application is extremely rewarding!"

"I really enjoyed all the projects I did in the various app development courses. The fact that we can choose our own project makes it very interesting!"

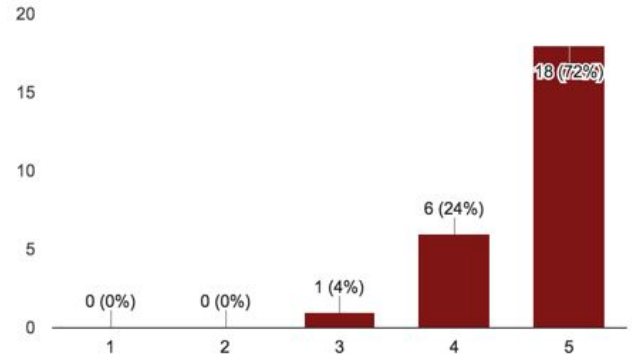

Fig. 8. The format and technical content of this course prepared me to complete the term project.

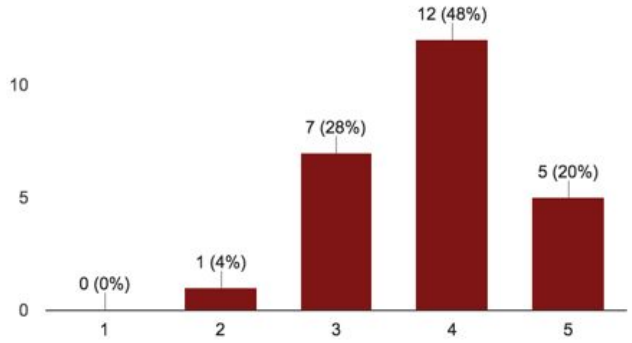

Fig. 9. Creating a technical document to help others learn from my research was helpful to me.

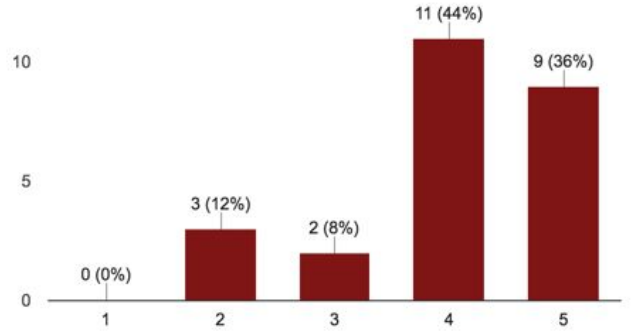

Fig. 10. Viewing and rating other course projects helped me think about new ways to make apps in the future.

TABLE II. RESPONSES TO THE PROJECT PROCESS AS IT RELATES TO HELPING YOU DO YOUR PROJECT

Project process step	5	4	3	2	1	Mean
Brainstorming ideas as a class	21%	32%	36%	11%	0%	3.64
Three project idea sheets	29%	43%	21%	7%	0%	3.93
Proposal's 1-2 paragraph summary	25%	43%	21%	11%	0%	3.82
Screen mocks	54%	46%	0%	0%	0%	4.54
User stories	36%	32%	14%	18%	0%	3.86
Database schema (data design)	32%	29%	36%	4%	0%	3.89
Planning the sprints	54%	29%	11%	7%	0%	4.29
Coding itself	71%	29%	0%	0%	0%	4.71
Sprint review meetings	43%	18%	39%	0%	0%	4.04

TABLE III. RESPONSES TO THE PROJECT PROCESS AS IT RELATES TO COMMUNICATING YOUR WORK

Project process step	5	4	3	2	1	Mean
Three project idea sheets	18%	50%	25%	7%	0%	3.79
Project proposal's 1-2 paragraph summary	50%	39%	11%	0%	0%	4.39
Screen mocks	57%	39%	4%	0%	0%	4.54
User stories	46%	50%	4%	0%	0%	4.43
Database schema (data design)	32%	29%	25%	11%	4%	3.75
Planning the sprints	32%	36%	21%	7%	4%	3.86
Coding itself	29%	21%	32%	14%	4%	3.57
Sprint review meetings	79%	18%	4%	0%	0%	4.75