The Inverted Agricultural Economics Classroom: A new way to teach? A new way to learn?

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Abstract:

The purpose of this paper is to introduce an emerging teaching method, the inverted classroom, to agricultural economists. The reader will learn the pros and cons of this method and the tools needed to create an inverted course. Data on student perceptions of the inverted classroom is presented, as well as an estimate of the relationship between student perceptions and student performance in an inverted classroom. The surveyed students responded positively to the inverted classroom concept; however it is unclear whether this method improved student learning outcomes compared to a traditional lecture classroom and there is very little evidence linking student perceptions to student performance.

Introduction:

The inverted classroom, also commonly referred to as a "flipped" classroom, is an emerging teaching method. Recently TED launched the TED-Ed website which is designed to assist users in creating "flipped" content using existing YouTube videos (TED, 2012). McDaniel and Caverly (2010) compare and contrast a traditional and inverted classroom as follows. In a traditional classroom lectures are used to introduce the material and students must process the information, solve problems and reach conclusions outside of the classroom. An inverted classroom leverages technology to "flip" the standard lecture model. Online material is used to provide the first introduction to course topics and classroom time is used to process the information and solve problems. The primary elements of an inverted classroom are online lecture materials, in audio/video format, that students can access on-demand, and a classroom environment that is conducive to working with peers, problem solving and answering questions.

Gannod *et al.* (2008) applied this concept to a software engineering course and claimed that "the approach takes advantage of the benefits of both collaborative learning and distance learning while at the same time targeting the millennial student" (p.785). The authors surveyed students in order to gather their perceptions of the inverted classroom. Students responded favorably 100% of the students found the Podcast lectures to be helpful. The authors also mapped course outcomes to learning outcomes. However, they did not establish a link between student performance and student perceptions of elements of the inverted classroom.

The true measure of success for a professor in the classroom is student success (Bain, 2004). The success of a particular teaching method should be evaluated using the same criteria. Brinthaupt *et al.* (2011) extend Bain's concept to online classes. Bain (2004) argues that one of the key elements to learning is asking questions. An inverted classroom has potential to improve upon a traditional lecture because students are placed in an environment where asking questions is a primary classroom activity. Bain also argues that engaging in the course material is a key learning tool. An inverted classroom provides an excellent opportunity to test this hypothesis because students can be tracked, allowing a researcher to observe a student's level of engagement.

1

The concept of using classroom time as a problem solving session is nothing new. It is common for economics classes that meet in a large lecture hall to hold weekly breakout sessions, typically with a TA, for discussion and problem solving. Providing learning resources for students to review before attending class is nothing new either as the printing press has been around for over 600 years. Prior to the internet faculty could even provide video-taped lectures. It would be inappropriate therefore to think of the inverted classroom as new. The modern version of the inverted class, which is characterized by online videos is already over a decade old at the time of this writing, (Lage, et al., 2000). As such, it would be inappropriate to view the modern inverted classroom as a pedagogical change; rather it is a technological change arising from the proliferation of high-speed internet access, a decrease in the cost of networked mass storage, and a decrease in the cost of video production.

There are several advantages to the inverted classroom and many situations where the format could be beneficial. This format has great potential in disciplines that emphasize problem solving skills and critical thinking, such as Economics. It also has great potential for disciplines that require a mix of practical and theoretical, such as Nursing. An inverted class could also work well in lab-based courses. Natural sciences, for example, are frequently taught as lecture/lab courses, where the lecture takes place in a large auditorium while the lab is characterized by small enrollment and individual attention. In a public speaking course, instructional time could be shifted online and classroom time could be used to practice speaking. The inverted format could also be a cost-saving tool for administration. Inverted lectures could free up classroom space and reduce instructional time while still providing an opportunity for individualized attention. Another advantage is flexibility as students can access course material when they are ready to learn, no matter the time of day. If a student misses a key point in a lecture, or misses a week of classes due to illness he or she can log on and learn at their convenience.

The method is not without its drawbacks. It assumes that each student has access to a connected device such as a computer, tablet or smartphone. In order to operate smoothly the majority of the students enrolled in the class must view the online material before class, a scenario that is highly unlikely without also developing an enforcement mechanism. Developing an inverted course is labor intensive. Creating video lectures is time consuming and, unlike an online course, faculty must still facilitate three hours of class every week. This paper will cover software tools that can be used to invert a classroom and present survey data on student perceptions of the inverted classroom. Then present a regression that attempts to link student perceptions to student performance in an inverted course.

Software Tools For Inverting A Classroom

Numerous tools exist that will aid the reader in creating video content for his or her inverted class. Faculty members will need to create a launch page for students as well as locate server space to store online content. In addition, faculty must be aware of relevant

copyright laws, specifically academic fair use. A review of software and tools that will assist in creating an inverted classroom is provided here in. This review is not intended as a comprehensive list of the tools that may be used to invert a course.

A launch page is a location where students can locate the online elements of a class. Faculty have many options for setting up a launch page. If the local institution does not provide access to a commercial learning management system (LMS) such as Desire2Learn or WebCt/Blackboard, an open source LMS, such as Moodle should be sufficient (Moodle, 2012). An LMS may be the most straightforward method to create a launch page, but a YouTube channel or a Facebook page could also work. A web-savvy professor may prefer to design his or her own course webpage.

Course material must also be stored online. Again, this can be accomplished inside of an LMS or on the same server as the professor's web page. However, videos can use a significant amount of bandwidth so hosting them on a dedicated server, and then using the launch page to link to content, may be best. Many of the software tools outlined below provide hosting services. However, these services often require one to make intellectual property open to the public where it can be expropriated. The companies that provide these tools may also go out of business in the middle of the term leaving students with a launch page full of broken links; therefore, backup copies are a must.

Faculty should also be aware of potential copyright issues arising from posting videos online and should be academic familiar fair use (U.S. Copyright Office, 2012). Academic fair use will allow faculty to post a clip from a movie to introduce a concept or illustrate a point, in a nonprofit educational setting. It would never be appropriate to provide the entire movie, only a portion of copyrighted material may be used. If this clip is made available to the general public, academic fair use may no longer apply as it may impact the market value of the copyrighted material.   For this reason it is best to require students to log-in to a university system, such as an LMS, in order to access copyrighted material. Faculty that create their own original content should not worry about violating copyright laws, but if quality content is made available to the public faculty must then worry about others expropriating their intellectual property.

Microsoft PowerPoint, or similar presentation software, should be readily available to all faculty members and thus is an excellent starting point for inverting lectures, especially if faculty already have existing PowerPoint presentations. Slide animations and transitions can be timed and recorded. With a simple microphone slides can also be narrated. The final version can be uploaded to a media server or LMS, but be aware that file sizes can be quite large. Drawing tools can be used to create graphs, and these can then be animated to illustrate concepts (e.g. a shifting demand curve or shading in total fixed cost). PowerPoint works well with a Tablet PC, or other touch-screen desktop computer, as on-screen annotations can be recorded.

Impatica for PowerPoint (Impatica, 2012) can be used to convert narrated PowerPoint files into streaming audio/video files. The software compresses the file, thus permitting students with slow download speeds to view the files. The student must have the latest

version of Java installed on their computer. Students can pause the presentation and skip forward or backwards. The author's personal experience with Impatica was not positive. Students frequently reported that video lectures would "hang." Complex diagrams and animations did not always render correctly, and the audio quality was low.

Techsmith (TechSmith, 2012) provides a number of high-quality tools that can aid faculty members in developing online course materials: Jing, Snagit and Camptasia Studio. Jing is a free tool that can be used to capture screen shots and to record on-screen actions. This is a handy feature if you need to show students how to use software, such as plotting cost curves in Microsoft Excel. It can also be used to show students how to locate information online, or how to navigate your LMS. With a simple microphone you can narrate your video, and you can add arrows to point out important on-screen elements. Techsmith provides hosting services through screencast.com. After taking a screenshot or recording video files can be saved locally or uploaded to screencast.com. Sharing material is as simple as providing a link. Jing limits videos to five minutes and has only limited editing capabilities. Personal experience with Jing was positive. Jing is a must-have tool if creating online content on a limited budget.

Snagit is an upgraded version of Jing, and users can test it with a 30-day free trial. Snagit videos are not limited by Jing's 5 minute cap and Snagit can also be used to edit video. Users can resize, zoom, and insert text callouts. [The author has no personal experience with Snagit.]

Camptasia Studio is a full-featured audio/video editing program. Like Snagit and Jing, it can be used to record screenshots, with more features such as SmartFocus. SmartFocus will automatically zoom when you record an action on screen. If, for example, you want to show students how to navigate an on screen menu, the software will automatically zoom in on the menu when you click on the menu. It includes a PowerPoint add-in that can be used to record and narrate PowerPoint presentations. Animations in PowerPoint display flawlessly when recorded with Camptasia Studio. Not only will Camptasia Studio record voice narration and on screen actions, you can also use a webcam to record the professor as he or she speaks. Camptasia Studio's audio editing tools can be used to filter out background noise and remove mistakes made when recording narration. If, for example, the professor sneezed during recording he or she would simply cut the sneeze out before finalizing the video. When editing the user can insert pre-made title clips and transitions between clips. Captions can be created with its speech to text feature, quizzes can be inserted at any point in the video and you can also include a table of contents. This is the author's favorite tool for producing videos in online and inverted courses.

A Livescribe (Livescribe, 2012) smart pen can also be a useful tool. This pen includes a microphone and a sensor that can capture handwriting when using specialized paper. The resulting audio/video file can be converted to a pdf format or uploaded as a "pencast" to Livescribe's server. One must merely provide students with a link to the pencast. This is an excellent tool for faculty that are less tech-savvy. One could simply sit at a desk and write out class notes while talking into the pen and then upload the pencast to create online content. The author uses a smart pen in online courses to solve example problems

as students request them; the resulting pencasts are then made available for the inverted class as well. This tool can be used to augment any classroom style. Melhorn et al. (2011) used a smartpen to create online study guides for students. Students can even use this device to assist in note-taking. When reviewing notes one simply uses the pen to point to written text and it will play the audio associated with the text.

If you are interested in adding some variety to your online material, consider using Xtranormal to create videos (Xtranormal, 2012). Xtranormal is a tool for turning text into animated movies. Simply select cartoon characters, a background and type your dialog. Completed movies can be hosted by Xtranormal, downloaded or shared via YouTube. The text-to-speech rendering and cartoon characters add an element of humor to online content and serve as an excellent tool for reiterating key points.

Digital video cameras have become commonplace, and can serve as a handy tool for creating inverted materials. A faculty member can utilize a smartphone, or a dedicated video camera to capture short clips for use in an inverted class. A camera set up in the classroom, whether it be a simple camera on a tripod or a full featured classroom capture system such as EDUcast by 323 link can be used to record lectures in a standard face-to-face class (323Link, 2012). These lectures can then be used in online or inverted classes. Alternatively, a faculty member can use a webcam to create lectures. One may be tempted to record a classroom experiment, such as building widgets to demonstrate diminishing marginal returns, and placing the video online. However, in an inverted class such activities should be conducted in the classroom. One should view the inverted format as a way to free up classroom time in order to create an interactive classroom.

The majority of this review of software tools has focused on creating video material. However, it may not be necessary to create custom videos for your course as textbook publishers often provide content. Relevant content may be available through MERLOT (MERLOT, 2012) a repository for online education materials, or on YouTube. The Ted-Ed project, which builds off of YouTube videos may also be of use. Using these materials may decrease course development time, but the material may not be useful for your specific course. YouTube is also problematic because the content is fluid. Copyrighted material, for example, may be removed as the result of legal action and content creators can remove or change content at any time. YouTube videos may be downloaded and backed to ensure continuity of content. One must again be careful to ensure that doing so is consistent with academic fair use and be aware that downloading videos may violate university policy regarding copyrighted material.

Survey Results

An important element of the inverted classroom is student satisfaction; if this teaching method is an improvement over traditional methods then students should report that they enjoy the format. In the fall of 2011 Principles of Agricultural Economics was converted to an inverted format. Lectures were converted to online audio/video files which students were instructed to view prior to attending class. During class students completed homework assignments and worked online quizzes with the assistance of the professor

5

and peers. Classroom time was also used to hold discussions. All elements of the course were contained inside the university's learning management system thus student activity could be easily tracked. This allows for the data collection needed to test the hypothesis that the online videos were a useful learning tool and that the inverted classroom is a successful teaching strategy. In addition, students in both the fall and spring sections were surveyed in order to solicit information about their comfort with technology and their impressions of the inverted course.

A description of survey variables can be found in Appendix Table 1, which also includes variables used in the regression model. Histograms of survey variables can be found in Figures 1 through 23, also in the appendix.

The first block of variables in Table 1 was gleaned from the LMS and student records. For the 51 students that completed the survey the average final grade in the course was 80.05%. The average for all students in the inverted class for the 2011-2012 academic year was 78.47%. Students that took the survey performed better in the class, but the difference is small. The average GPA among students that completed the survey was 3.01.

The remainder of the variables in Table 1 were items in a student survey designed to determine student satisfaction with the inverted class and student perceptions of learning as it related to the elements of the inverted course. Students were asked to rate their level of agreement or disagreement with each statement, where 1 corresponds to "Strongly Disagree" and 5 corresponds to "Strongly Agree." Variables are grouped based on the information that the questions were designed to elicit.

The second block of variables in were used to determine if the students felt that they were computer literate and determine if they had access to the tools needed to succeed in the course. With the average response above 4 it is safe to conclude that the majority of students felt that they were computer literate and had regular access to a computer and the internet. Figures 1 through 3, however, provide a better picture of these variables as 84 percent of the students agreed or strongly agreed that they were computer literate, 91 percent agreed or strongly agreed that they have access to a computer outside of the classroom and 89 percent had internet access.

The third block of variables was designed to determine the students' perceptions of the online videos. In Figures 4 and 5 we can see that 84 percent and 78 percent of the students agreed or strongly agreed that the onlinie videos helped them learn course concepts and complete quizzes. Figure 6 shows that only 47 percent of the students agreed or strongly agreed that they watched the majority of the videos on a timely basis. This is consistent with the result reported above, that the average student only visited 36 out of 52 online topics. Figure 7 indicates that less than 20 percent of the agreed or strongly agreed that they could learn the content without viewing the lectures. This is an interesting paradox, the students report that the online content is valuable, but they do not peruse the content with diligence.

The fourth block of variables were designed to determine the students' perceptions of peer-to-peer learning. As we can see in Figure 8, students indicated that working with peers helped them learn (56 percent agreed or strongly agreed), while Figure 9 shows that students felt that they learned more because they could work with peers (90 percent agreed or strongly agreed). Figure 10 shoes that 78 percent of the students agreed or strongly agreed that other students helped them complete quizzes in class.

The fifth block of variables focuses on the students perceptions about learning in the inverted classroom. As we can see in Figure 11, 54 percent of the students agreed or strongly agreed that they are learning more than they would have if the inverted classroom was not used, while 64 percent (Figure 12) reported that they agreed or strongly agreed that the inverted class leads to higher grades.

The sixth block of variables focuses on the students perceptions of the classroom environment within the online class. Histograms for these variables can be found in Figures 13 through 16. Students felt that they learned more because they were able to take quizzes in the classroom (74 agreed or strongly agreed) while 89% of the students agreed or strongly agreed that classroom discussions helped them learn. Students also reported that the professor helped them complete quizzes and that doing so helped them learn, 86 percent agreed or strongly agreed in both cases.

The seventh and eight block of block of questions were designed to capture the students' satisfaction with the professor in the invited course and the students' overall satisfaction with the inverted course. As reported in Figure 17, 92 percent of the students agreed or strongly agreed with the statement "I appreciate that the professor is willing to try new things to help me learn." In Figure 18 we see that 72 percent of the students agreed or strongly agreed that the professor should continue to teach this course using the inverted style while Figure 19 shows that 62 percent of the students agree or strongly agree that the professor should invert other courses. As can be seen in Figures 20 and 21, 64 percent agree or strongly agree that they would like to take another inverted course and 56 agree or strongly agree that other professors should invert a course.

The final block of questions was used to gauge student activity level outside of the classroom. As can be seen in Figures 22 and 23, 82 percent agreed or strongly agreed that they worked on quizzes outside of the classroom while 92 percent of the students agreed or strongly agreed that they used the online quizzes as a study tool when preparing for exams.

Model and Results

If the inverted classroom is a successful educational method then students in an inverted classroom should have improved educational outcomes. These improved learning outcomes can be measured in any number of ways. Students could, for example, earn higher grades in the course, score better on exams, or perform better on specific embedded exam questions. We can also understand how the specific elements of the inverted class influence student learning outcomes. Specifically, we would like to test

the hypothesis that watching online videos improves learning, this will be accomplished using a regression model with student grades on the left-hand side and the number of online content items the student visited on the right-hand side.

With the data at hand we cannot directly test the hypothesis that other elements of the inverted class, such as peer-to-peer learning and classroom interaction, influences student performance. However, we can test the hypothesis that student perceptions about these activities impacts student performance. If, for example, students report, that working with peers helped them learn is the the strength of this perception correlated with student performance. Therefore, student responses to survey questions about their perceptions of student learning will also be included on the right-hand side of the regression model.

Learning outcomes, however, are the result of many complex interactions. Students seek to maximize utility, both present and future, subject to a number of constraints, such as natural ability, motivation and prior academic training. Learning outcomes must then be conditioned on such variables thus GPA is included as a measure of prior academic performance and motivation.

A key pedagogical element of the inverted class is its impact on student motivation, by working side-by-side with students they should receive more utility and thus allocate more resources to the course. Thus we include student responses to questions related to their satisfaction with the inverted course on the right-hand side of the model.

Model Results can be found in Table 2 of the Appendix. Variables are grouped in the same categories as in Table 1. Model 1 includes all of the variables listed in Table 1. However, with only 51 observations Model 1 has less than 30 degrees of freedom. In model 2 the video were removed because the number of topics visited captures this information and the two variables covering general satisfaction of the inverted course were removed as they were collinear and had high variance inflation factors. Both models are statistically significant based on an overall F-test. The adjusted R^2 for Model 1 and 2 is 62.3 percent and 63.9 percent respectively. Due to the small sample size and low degrees of freedom no IV model is presented.

The primary hypothesis is that viewing the online videos will impact student outcomes. GPA is included as a control variable in the models. In both models we find that the coefficient on the "Number of Topics Visited" variable is positive and statistically significant. Thus, suggesting that the viewing online content increases student performance. This should come as no surprise that interacting with the course content will improve student grades, this result holds even when controlling for prior GPA. It is important to note that this is not necessarily a result limited to the inverted course format. If, in a traditional class, we could observe the effort students put into studying a textbook outside of class then we should observe the same result. The only novel contribution here is the fact that the LMS monitors student activity, thus making it very easy to show the correlation between effort and results.

A secondary hypothesis concerned the relationship between student perceptions of the online class and student performance. If students perceive that they are learning then student utility should increase, thus providing a motivation effect. The results in Table 2 do not seem to support this hypothesis. The majority of the student perception variables are not statistically significant. Students that more strongly indicated that they are computer literate and have access to a computer performed better. A difference that is both large and statistically significant. Holding other factors constant a student that strongly agrees that he or she has access to a computer scored, on average, a letter grade higher than a student that agreed that he or she has access to a computer. Paradoxically, as a student's self-reported internet access goes up performance decreases, in both models this variable is negative and statistically significant. This result is likely driven by the fact that most students that have a computer have internet access. Students tended to report that their grades were higher as a result of the inverted class, and this variable is statistically significant and positive. Students tended to report that other professors should invert a course, but as the strength of this belief increases student performance decreases, the variable is statistically significant and negative in both models. No other variables were statistically significant. Hence this model provides very little evidence to suggest that student perception influences student learning.

Conclusion

Students in the study report a high level of satisfaction with the inverted course and its elements. They indicated that the teaching method helped them learn. However, there is little evidence suggesting that their perceptions of how they learn and their satisfaction with the course are in any way related to their final grade. This study does establish a link between effort, measured by the number of topics visited, and performance. This study also establishes a link between computer knowledge and access to performance in an inverted setting. These factors have a positive impact on student grades in an inverted class. Interestingly, students reported that watching online videos did help them learn in spite of the fact that the average student only viewed 70 percent of the videos. Low performing students simply did not take the actions needed to be high performing students. This may have occurred for a number of reasons, such as time constraints. It is doubtful that a trendy pedagogical method with flashy online videos can alter such behavior.

Does this mean that the inverted class format should be abandoned? Not necessarily. Although student satisfaction in this limited study is not correlated with student performance student satisfaction is still important and student response was overwhelmingly positive. It is important for professors to learn about innovative teaching methods and try them out for themselves. It is also important to demonstrate to students that the professor wishes to help them learn. If one is already teaching online then the marginal cost of developing an inverted class may be low, and therefore worth trying.

The primary contribution of this study is that it demonstrates the importance of student engagement in the online portion of the inverted classroom. Thus an inverted classroom

should also include some type of enforcement mechanism to ensure students engage the online content. D2L, for example, allows for conditional release and password-protected quizzes. One could set up quizzes so they only release if the student visits relevant online content.   Alternatively, the professor could password protect quizzes, and then imbed the passwords in online videos, this way the student must not only visit the content but also view the content in order to access the quiz. It is important to note that such tools must be used with caution, and that the LMS cannot force good study habits on students (Gardner, et al., 2011). Of course, this can be accomplished in a traditional classroom with a low-tech solution. Regular pop-quizzes based on assigned reading.

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Appendix

Table 1: Variable Descriptions and Summary Statistics

Variable	Mean	Standard Deviation
Grade (Final Course Grade, in Percent)	80.05	11.50
GPA (prior to taking course)	3.01	0.53
Topics (Number of online topics visited, out of 52)	36.51	11.10
I consider myself to be computer literate.	4.18	0.91
I have access to a computer outside of the classroom.	4.39	0.78
I have access to the internet outside of the classroom.	4.33	0.84
The video lectures helped me master course concepts.	4.02	0.73
Watching the videos helped me complete the in class quizzes.	4.06	0.86
I watched the majority of the videos on a timely basis	3.45	1.01
I was able to learn this material without the videos.	2.53	1.06
Working with other students during class helped me learn.	4.22	0.73
I was able to learn more because I could work with my peers during class time.	4.27	0.63
Other students helped me complete quizzes in class	4.04	0.82
I am learning more than I would have if the inverted classroom was not used	3.57	1.15
I feel that my current grade is higher because of the inverted course.	3.82	0.95
I learned more taking the quizzes in the classroom then I would have if I were taking the quizzes on my own.	4.08	1.13
Classroom discussions helped me learn.	4.35	0.69
I was able to learn more because I could ask the professor for help during class.	4.37	0.77
The professor helped me complete quizzes in class.	4.24	0.79
I appreciate that the professor is willing to try new things to help me learn.	4.55	0.83
I think the professor should continue to teach this class as an inverted course	3.88	1.14
I think the professor should invert other courses.	3.82	1.03
I would like to take another inverted course.	3.80	1.20
Other professors should invert a course.	3.76	1.11
I worked on quizzes outside of the classroom.	4.03	0.85
I used the quizzes as a study tool when preparing for exams.	4.49	0.76

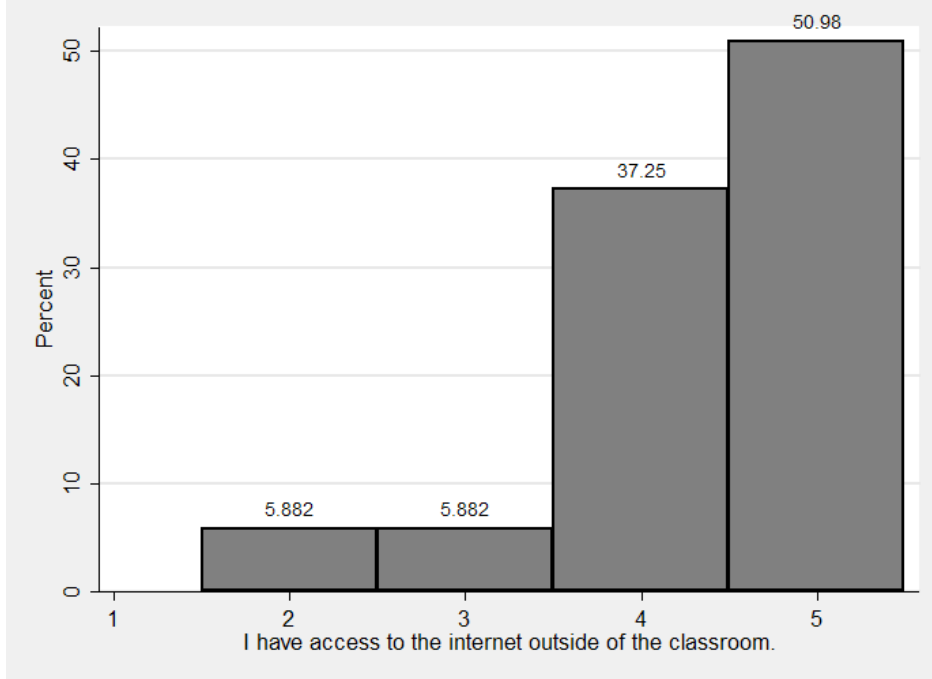**Figure 1: Student Response to "I am Computer Literate"**
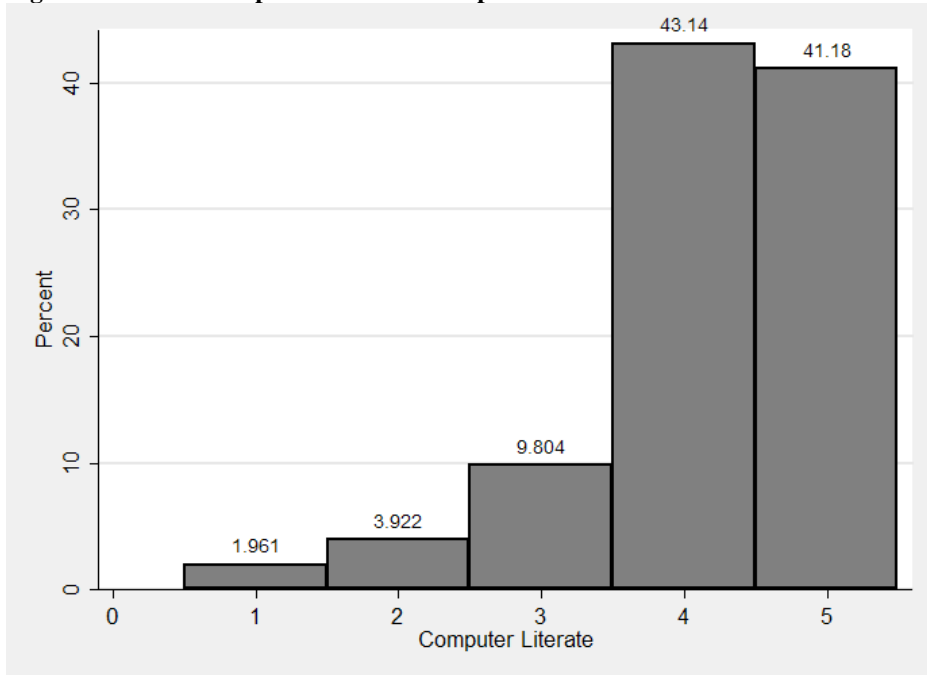
1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 2: Student Response to "I Have Access to a Computer Outside of the Classroom"
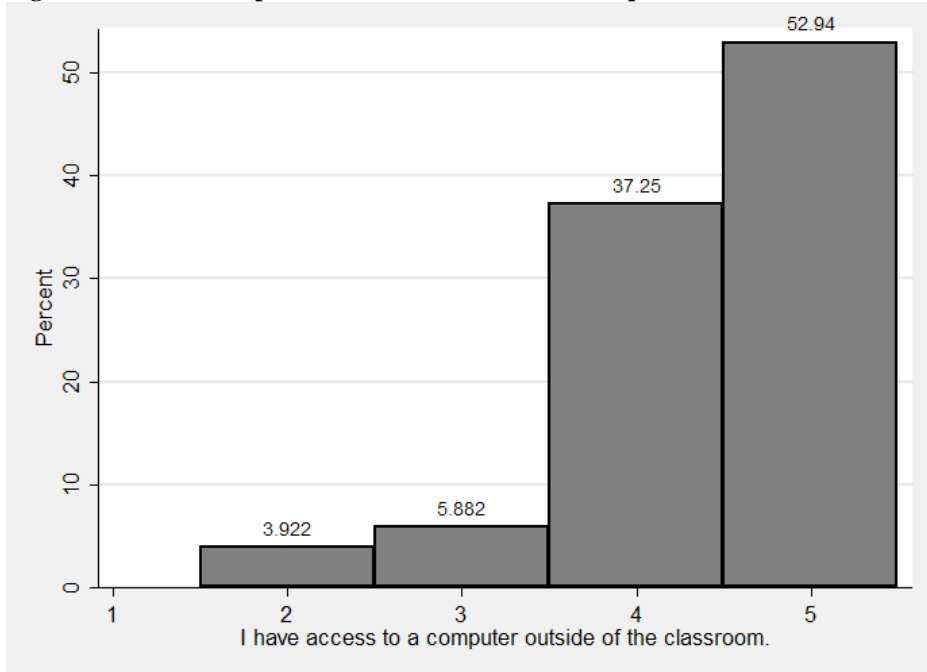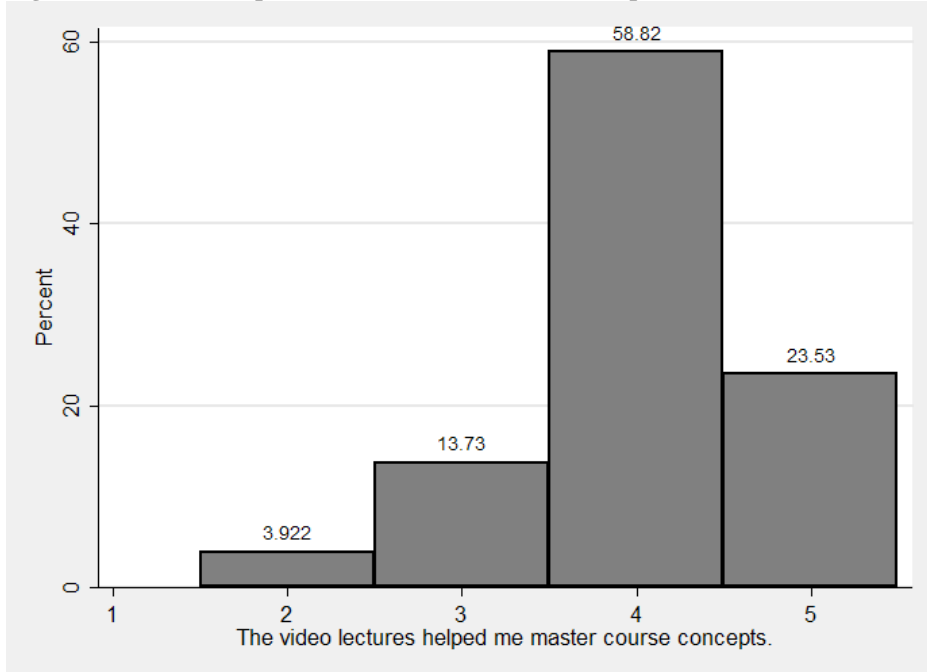

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
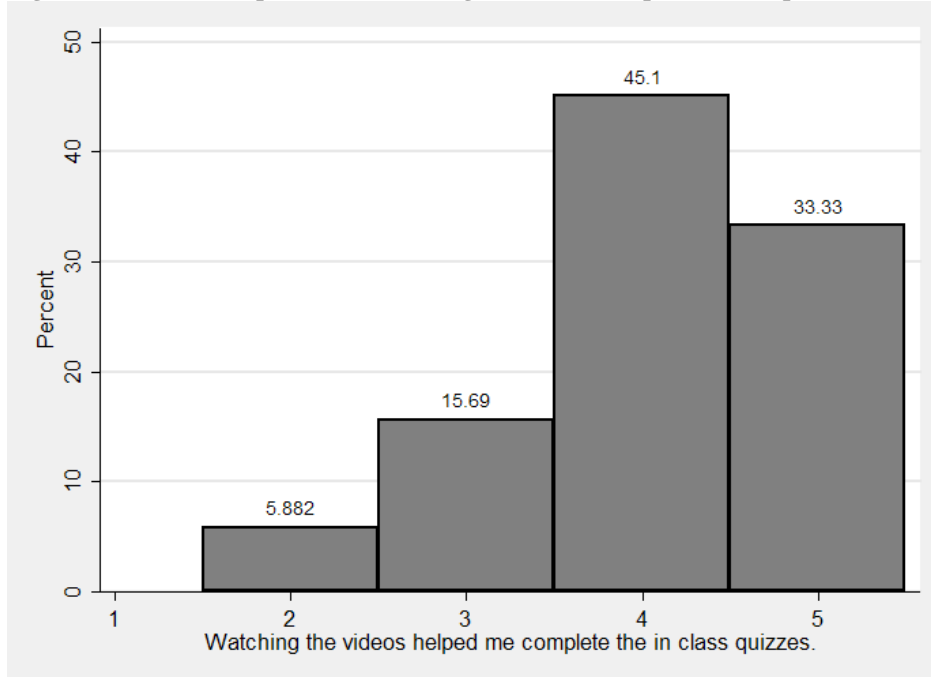4 = Agree, 5 = Strongly Agree

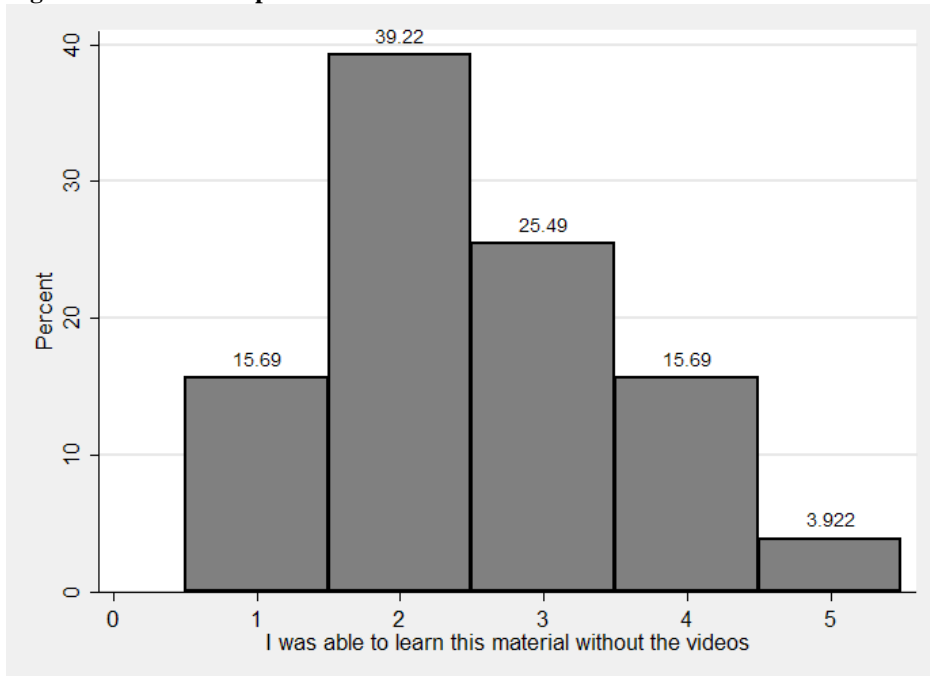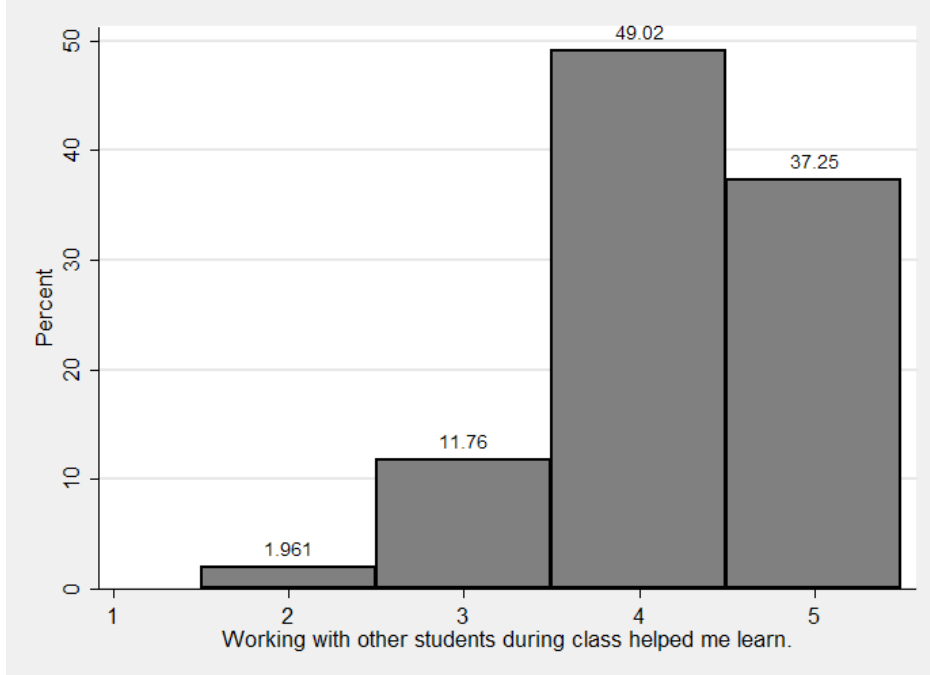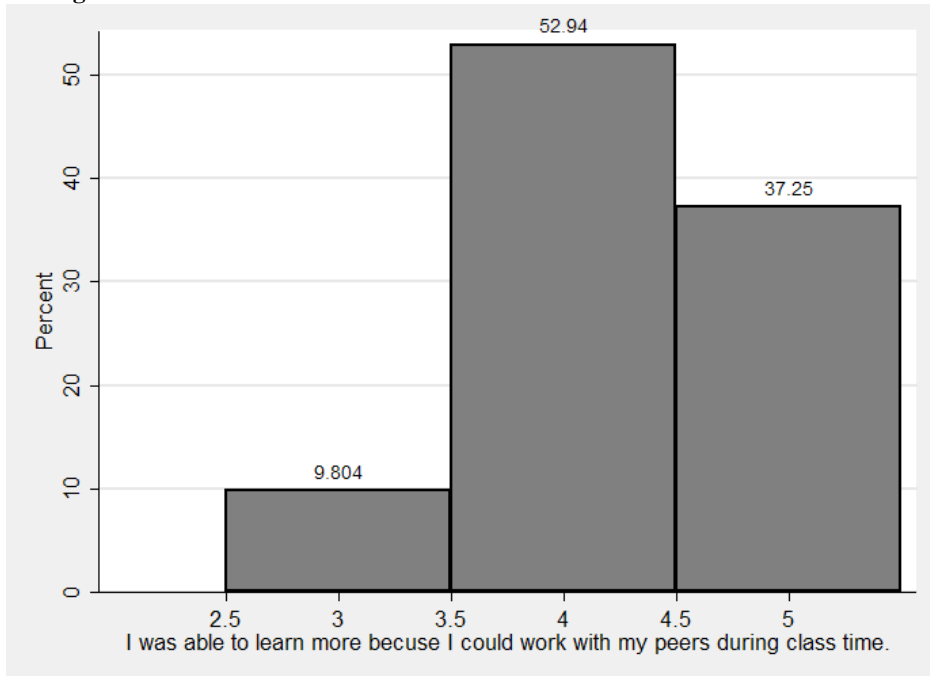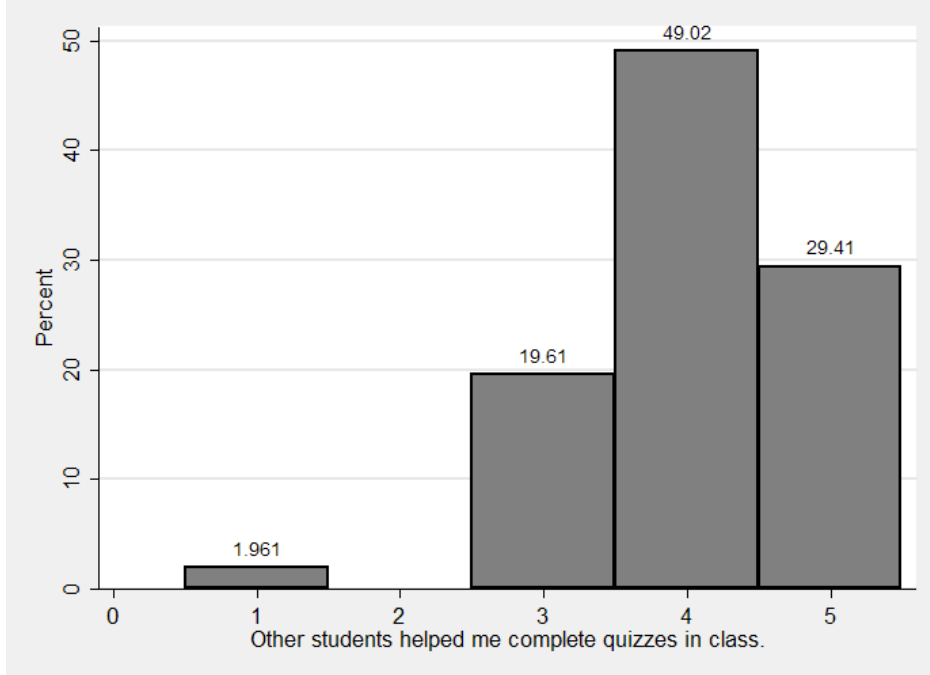**Figure 3: Student response to "I have Access to the Internet Outside of the Classroom"**

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 4: Student Response to "The Video Lectures Helped me Master Course Concepts"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 5: Student Response to "Watching the Videos Helped me Complete the in Class Quizzes"

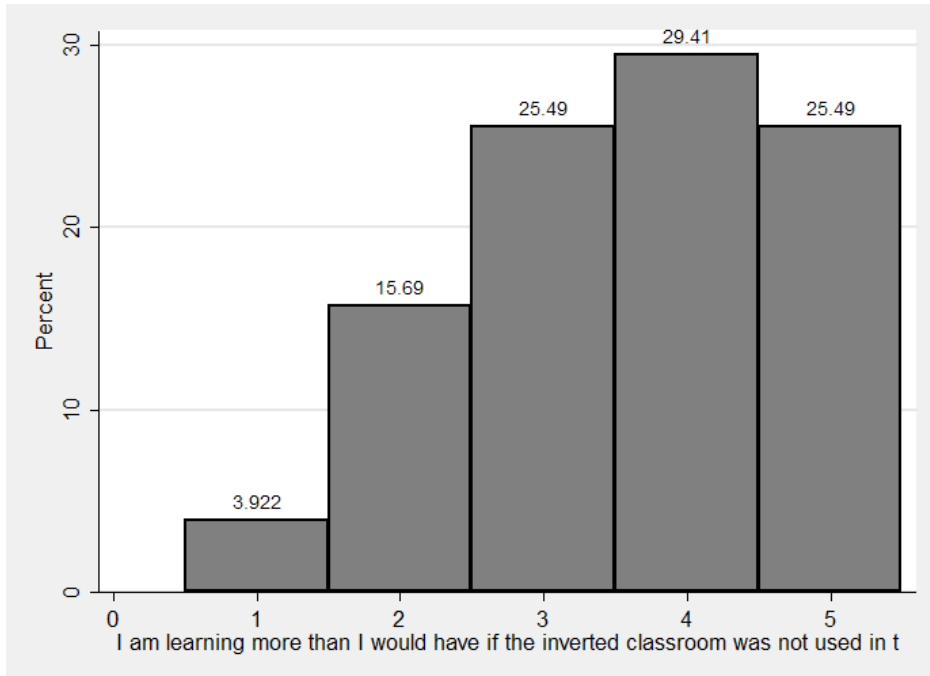

Watching the videos helped me complete the in class quizzes.

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

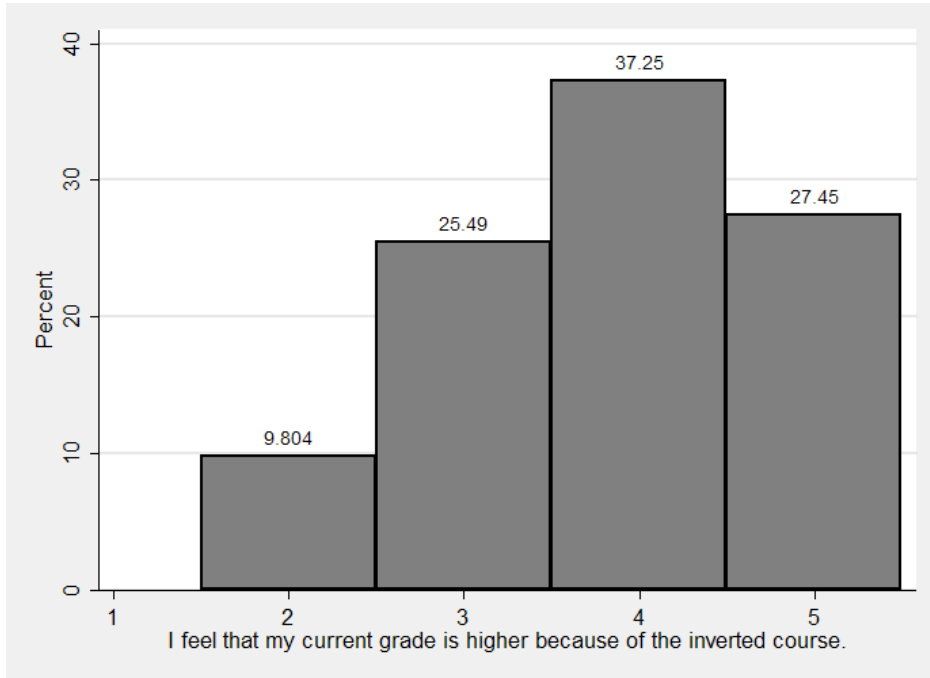**Figure 6: Student Response to "I Watched the Majority of the Videos on a Timely Basis"**
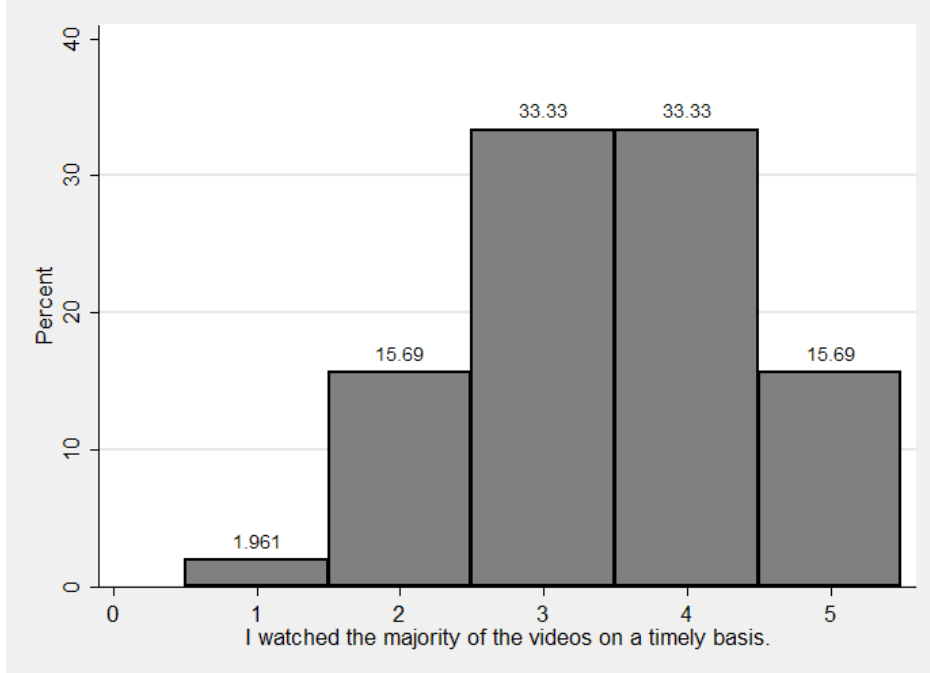
1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 7: Student Response to "I was Able to Learn this Material Without the Videos"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 8: Student Response to "Working with the other Students During Class Helped me Learn"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 9: Student Response to "I was Able to Learn More Because I Could Work with my Peers During Class Time"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 10: Student Response to "Other Students Helped me Complete Quizzes in Class"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 11: Student Response to "I am Learning more than I would have if the Inverted Classroom was not used in this class"
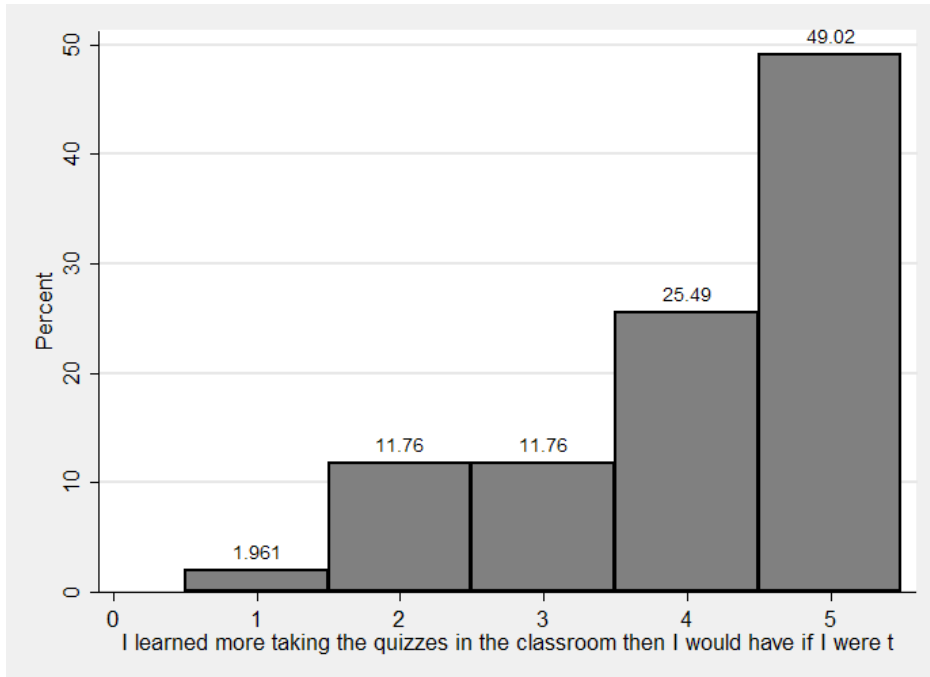

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 12: Student Response to "I Feel that my Current Grade is Higher Because of the Inverted Course"
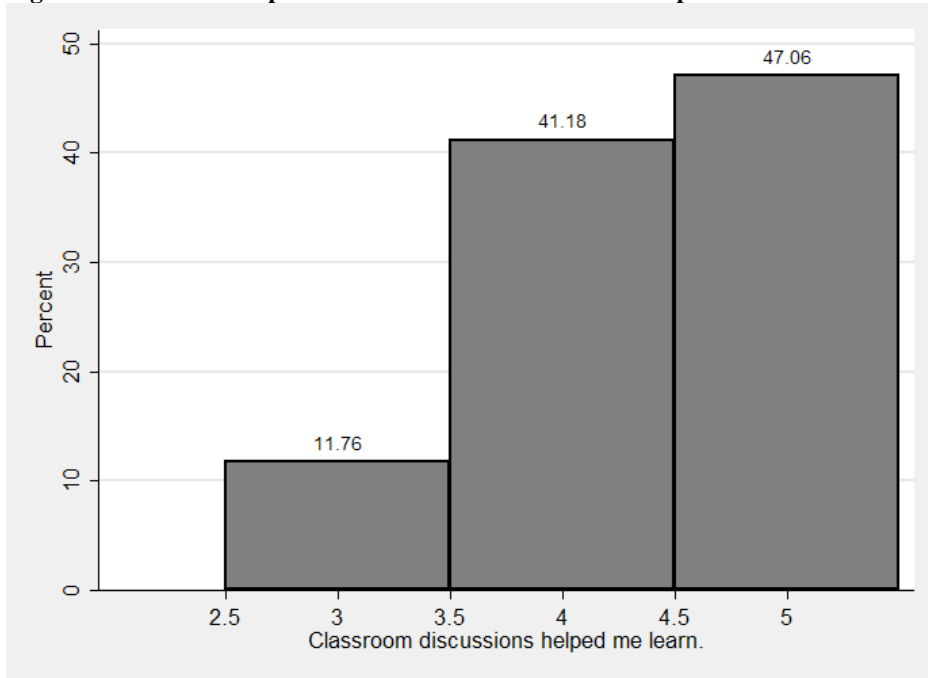

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 13: Student Response to "I Learned More Taking the Quizzes in the Classroom than I would have If this were not an Inverted Classroom"
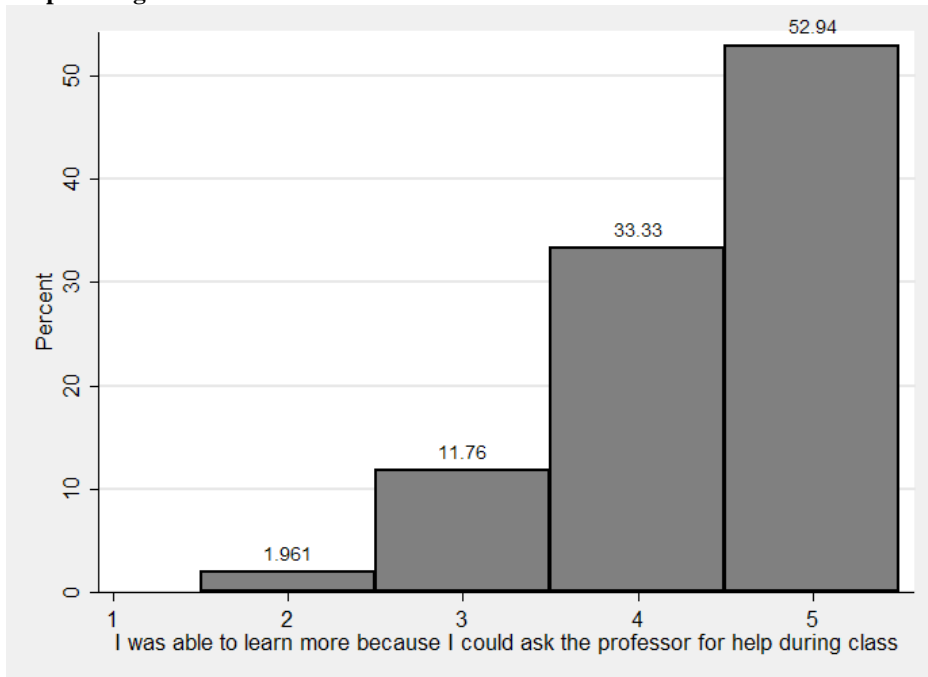

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

19

Figure 14: Student Response to "Classroom Discussions Helped Me Learn"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

**Figure 15: Student Response to "I was Able to Learn More Because I Could Ask the Professor for Help During Class"**

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

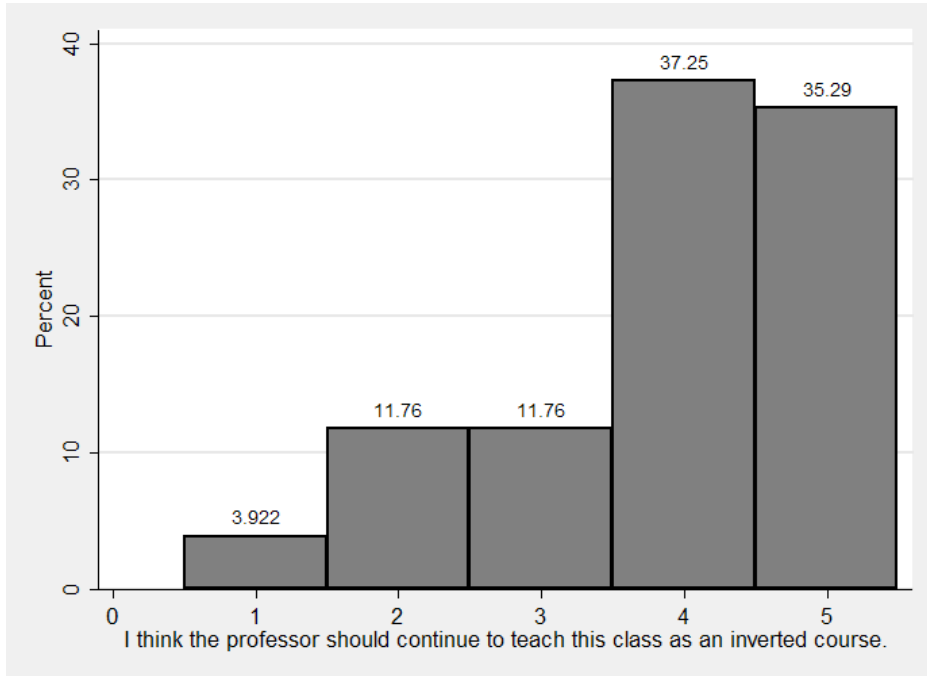**Figure 16: Student Response to "The Professor Helped me Complete Quizzes During Class"**

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

**Figure 17: Student Response to "I Appreciate that the Professor is Willing to Try New Things to Help me Learn."**
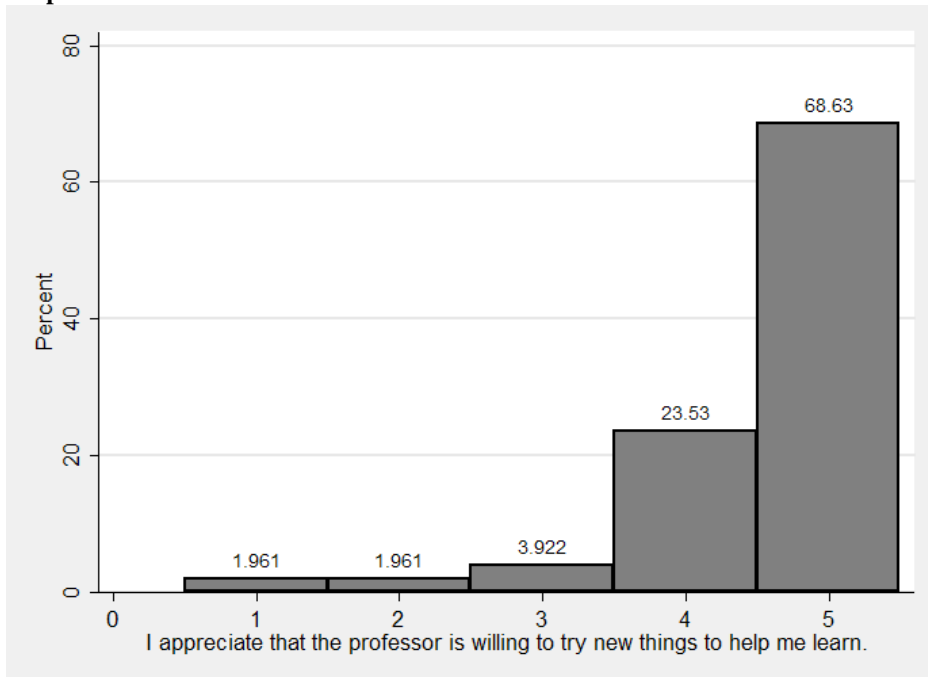
1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 18: Student Response to "I Think the Professor Should Continue to Teach this Class as an Inverted Course"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
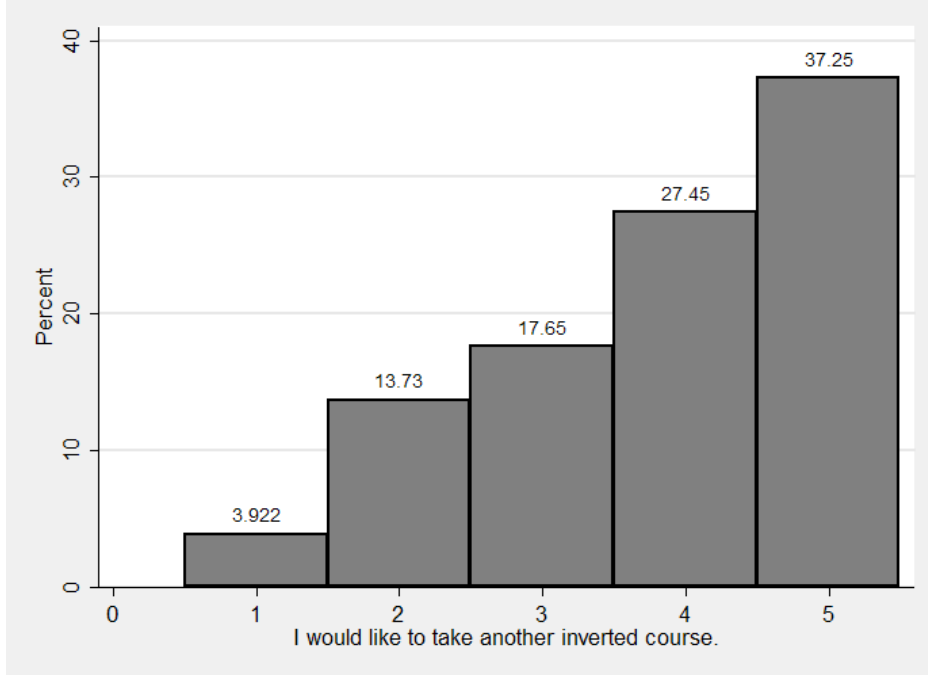4 = Agree, 5 = Strongly Agree

Figure 19: Student Response to "I think the Professor Should Invert Other Courses"
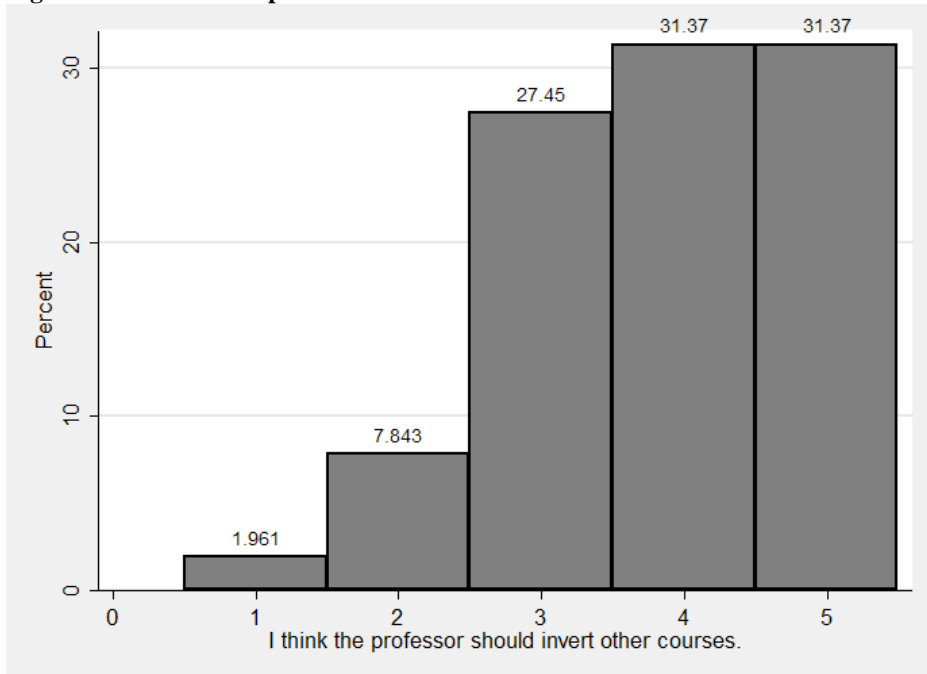
1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
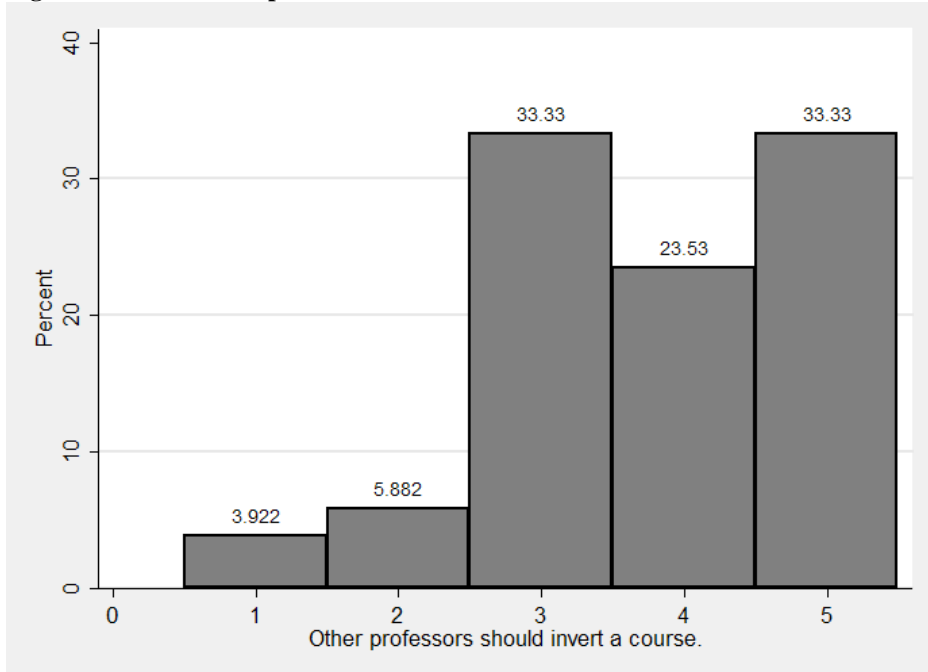4 = Agree, 5 = Strongly Agree

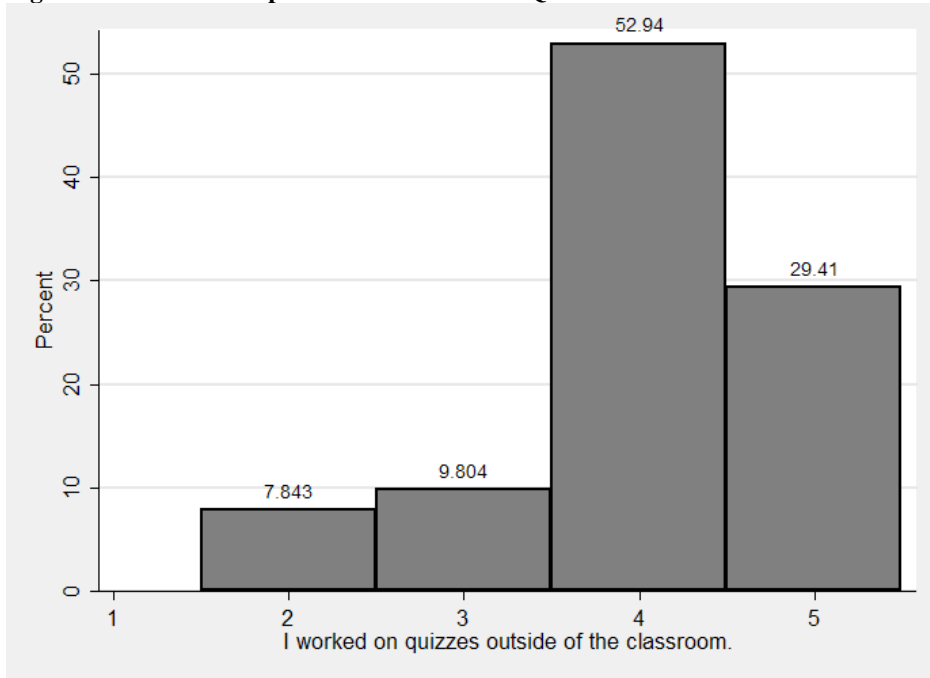**Figure 20: Student Response to "I Would Like to Take Another Inverted Course"**

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 21: Student Response to "Other Professors Should Invert a Course"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

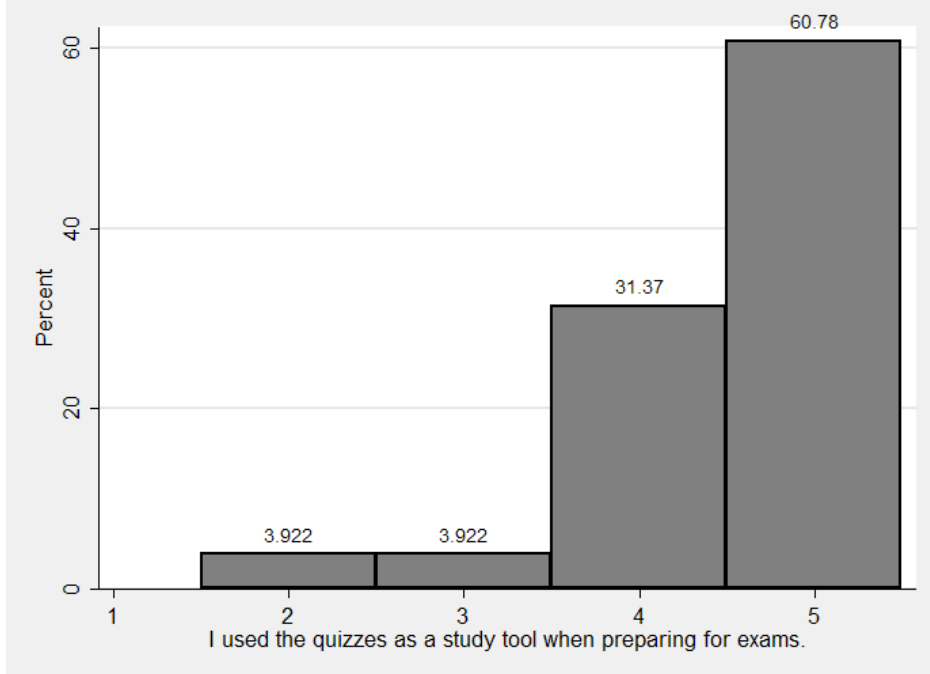**Figure 22: Student Response to "I Worked on Quizzes Outside of the Classroom"**

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Figure 23: Student Response to "I used the Quizzes as a Study Tool When Preparing for Exams"

1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree
4 = Agree, 5 = Strongly Agree

Table 2: Regression Results, Independent Variable = Course Grade out of 100%

VARIABLES	Model 1	Model 2
Topics	0.428**	0.294**
	(0.177)	(0.120)
GPA	6.952*	8.865***
	(3.462)	(2.740)
I am computer literate	2.914*	2.706*
	(1.631)	(1.490)
I have access to a computer outside of the classroom.	10.02***	9.179***
	(3.365)	(2.999)
I have access to the internet outside of the classroom.	-5.070*	-4.483*
	(2.653)	(2.421)
The video lectures helped me master course concepts.	2.884	
	(2.225)	
Watching the videos helped me complete the in class quizzes.	-3.037	
	(1.900)	
I watched the majority of the videos on a timely basis.	-0.714	
	(1.913)	
I was able to learn this material without the videos	1.340	
	(1.540)	
Working with other students during class helped me learn.	-0.406	-1.019
	(2.371)	(2.039)
I was able to learn more because I could work with my peers during class time.	0.0117	1.814
	(3.123)	(2.818)
Other students helped me complete quizzes in class.	-2.853	-2.464
	(2.012)	(1.688)
I am learning more than I would have if the inverted classroom was not used in this course.	0.322	0.141
	(1.203)	(1.107)
I feel that my current grade is higher because of the inverted course.	3.639*	3.536**
	(1.829)	(1.553)
I learned more taking the quizzes in the classroom then I would have if I were taking them on my own.	-1.211	-0.535
	(1.452)	(1.308)
Classroom discussions helped me learn.	4.454	3.113
	(3.312)	(2.557)
I was able to learn more because I could ask the professor for help during class.	-1.347	-2.438
	(3.736)	(3.238)
The professor helped me complete quizzes in class.	3.691	3.375
	(2.494)	(2.395)
I appreciate that the professor is willing to try new things to help me learn.	-3.600	-2.537
	(2.111)	(1.716)
I think the professor should continue to teach this class as an	-0.556	1.207

25

inverted course.

	(2.017)	(1.555)
I think the professor should invert other courses.	4.053	
	(3.138)	
I would like to take another inverted course.	-0.310	
	(3.082)	
Other professors should invert a course.	-5.790*	-3.795**
	(2.918)	(1.633)
I worked on quizzes outside of the classroom.	2.617	1.323
	(2.073)	(1.421)
I used the quizzes as a study tool when preparing for exams.	-1.859	-1.751
	(1.810)	(1.605)
Constant	6.875	11.60
	(16.98)	(14.96)
Observations	51	51
Adjusted R^2	0.623	0.639
F	4.311***	5.667***

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$