Analysis of Asynchronous Supplemental Course Modules in Statistical Process Control

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Analysis of Asynchronous Supplemental Course Modules in Statistical Process Control

Abstract
Many engineering and technology departments at the collegiate level have developed extensive online and hybrid (face-to-face and online) course offerings (Bourne, Harris, & Mayadas, 2005). These courses may meet several goals such as increasing access, reducing university costs, providing schedule flexibility, and increasing curriculum offerings. An additional opportunity for computer-based learning is to increase student success by offering asynchronous learning modules to extend content beyond traditional lectures.

Disciplines
Agriculture | Bioresource and Agricultural Engineering | Engineering Education
Introduction

Many engineering and technology departments at the collegiate level have developed extensive online and hybrid (face-to-face and online) course offerings (Bourne, Harris, & Mayadas, 2005). These courses may meet several goals such as increasing access, reducing university costs, providing schedule flexibility, and increasing curriculum offerings. An additional opportunity for computer-based learning is to increase student success by offering asynchronous learning modules to extend content beyond traditional lectures.

The authors analyzed the helpfulness of asynchronous online video modules specifically focused on Statistical Process Control (SPC) chart content. This topic has been historically difficult for technology students enrolled in a large Total Quality Improvement course, offered at a mid-west university. The intent was to better understand how helpful do students perceive these online modules in learning to construct and interpret SPC charts. The authors proposed the following research questions:

1. How helpful do students, who view at least one unique module, perceive video modules in learning to construct Statistical Process Control (SPC) charts?
2. Does the number of unique modules viewed positively affect the level of perceived helpfulness to students who view at least one unique module?
3. Does the proportional viewing duration to overall module length positively affect the level of perceived helpfulness to students who view at least one unique module?

Background

The use of the Internet as an educational tool has significantly increased in the last decade. Students appreciate the use of supplemental course modules provided over the Internet (Freeman & Field, 2004). Many courses and classes are being offered that contain online or hybrid units of instruction that combine classroom and online components. One qualitative study of students participating in hybrid and online courses reports that students identified benefits of each type of content (El Mansour & Mupinga, 2007).

DeNeui & Dodge (2006) report student satisfaction with online instructional materials that included interactive demonstrations and video lectures. Their study found “…a significant positive partial correlation between overall usage and their exam scores” (DeNeui & Dodge, 2006, p. 256). Another study concluded that most students preferred a hybrid course to a traditional course (Mosca et al., 2010, p.10).
Hybrid Learning

There are several studies that help guide the development of successful hybrid course materials (Babb, Stewart, & Johnson, 2010; Hensley, 2005; Potosky, 2014). Hensley (2005) makes some specific points with regard to such course content and design:

- You should clearly convey objectives/learning outcomes in the syllabus and in each module.
- Make sure content is available to students in manageable segments (modules).
- Prepare to present the content in a logical, sequential manner.

As part of a comprehensive discussion of faculty and the development of hybrid courses, one group of authors noted a good activity for creating a hybrid course is, “Develop new learning activities that capitalize on the strengths of the online and face to face learning environments” (Kaleta, Skibba, & Joosten, 2007, p. 138). In general, faculty members may not be using online learning management systems to their full potential (Woods, Baker, & Hopper, 2004).

Statistical Process Control Charts

There are many topics covered within a Total Quality Improvement course. One common component, SPC chart creation and analysis, is “a powerful problem-solving technique used for monitoring, controlling, analyzing, managing and improving a process using statistical methods” (Antony, Balbontin, & Taner, 2000, p.242). Additionally, “a control chart is a powerful tool for identifying out-of-control situations in the presence of assignable or special causes of variation” (Antony, Balbontin, & Taner, 2000, p.246).

Many people often relate SPC applications primarily to manufacturing. However, there are other opportunities for students to apply these valuable tools and techniques. Individuals and institutions are using SPC charting techniques to monitor healthcare clinical practice (Smith, Rivers, & Brighouse, 2014), and changes in other health care delivery services (Benneyan, Lloyd, & Plsek, 2003). Understanding the popularity of SPC techniques in fields as disparate as health care and manufacturing will allow students to better appreciate the value of this topic (Woodall, 2006). There are many charting techniques that are available for a variety of situations. Providing students with real-world examples outside of the classroom better equips them to apply this technical problem-solving tool in future endeavors.

Observational Sample

The authors chose an observational sample of 145 students from a department required junior-level technology course.

Methods

The focus of this IRB designated exempt study was to determine how helpful do students perceive supplemental video modules towards learning to construct and interpret SPC charts. To that end, nine video modules were generated and made available to students to view in preparation for an exam that covered this content. To
understand how these students perceived the helpfulness of these asynchronous modules, data were collected from two sources. The first was a Likert scale survey that measured student's perceived helpfulness of each supplemental video module after viewing and the second was online access data for each module, as tracked by Panopto (Panopto, Inc.) video capture software and database. After these sources of data were collected, the results were analyzed to understand the connection between perceived helpfulness verses number of unique modules viewed and proportional overall viewing duration for students. A sequential flow of research activities, including module administration, data collection, data analysis, interpretation, and dissemination is illustrated in Figure 1. Additionally, this figure depicts the parallel activity structure used to align with the course's schedule and content. The following sections detail each of these research activities in detail.

### Figure 1. Parallel structure of research activities (orange) and course content (blue).

#### Asynchronous Video Modules

<table>
<thead>
<tr>
<th>March-25</th>
<th>March-30</th>
<th>April-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data/Chart Types</td>
<td>Xbar-R charts</td>
<td>Interpreting Charts</td>
</tr>
<tr>
<td>Rational Subgroups</td>
<td></td>
<td>np-chart</td>
</tr>
</tbody>
</table>

#### Supplemental Modules

Nine supplemental video modules formed the educational foundation of this research. These videos were generated specifically for this project to reinforce the lecture content and made available to students on an asynchronous schedule. Each video was released directly after its corresponding content was discussed in lecture, with the last being released two days before the exam. The staggered release, as depicted by Figure 1, was intended to allow the modules to parallel the course content. These videos were made available to all class members, but not required as part of a graded course assignment. The module content pertained to solving SPC charts similar to those covered in the lecture. Additionally, the videos were framed in a way to cover material from diverse real-world scenarios. Students were encouraged to use the videos to reinforce class lecture content and as preparation resources for the exam. In this way, students were incentivized to engage with the asynchronous modules.
An expert review committee that included the current course instructor validated the content of the video modules and five quality professionals from industry with an estimated combined level of experience of over five decades in quality and statistical process control. Their employers ranged from small manufacturing companies to a Fortune 500 corporation. Two were the Quality Managers of their organizations, one was a Corporate Quality Systems Lead, and two were Lean Consultants within their respective organizations. All agreed that the modules were suitable for the undergraduate students in the course and one expressed specifically the potential benefit if their employees had the opportunity to view the modules. After industry review and module updates, the faculty member responsible for the course for the past three years provided a final review and approved the modules for release to the students. A two-week window was allotted for this validation process, which allowed for adequate review time for the expert committee.

**Data collection**

A paper survey instrument was administered to students at the beginning of the exam to collect responses on how many modules they watched and how helpful they were. Responses were recorded with standardized bubble sheets. The timing of the survey administration was intended to allow for a maximum response rate from class participants. Students were asked to rate (on a 5-point Likert scale: 1 strongly disagree to 5 strongly agree) how the modules helped them to understand the SPC content, as illustrated in Figure 2. This survey was used to answer research question 1.

In tandem with the paper survey, data was also collected with Panopto's viewer statistics tool and specifically included the number of unique modules viewed by each student and the total viewing duration for each module by each student. This data was combined with the survey results to answer research questions 2 and 3.

*Figure 2. Survey instrument administered to students*
Data Analysis

Data from both the paper survey and the online viewing statistics were analyzed to answer the research questions. This statistical analysis included descriptive statistics, Chi squared tests ($\chi^2$), Pearson correlation coefficients ($r$), and fitting of individual simple linear regression models for the relationships between the response variable of student perceived helpfulness and the explanatory variables of the number of unique modules viewed and proportional viewing duration. The response of perceived helpfulness was coded 1 (not helpful) through 5 (helpful) in question two of the survey (see Figure 2). Furthermore, the self-reported explanatory variable of unique modules viewed was coded 0 (a) through 9 (j) in question one of the survey (see Figure 2). These responses were further validated using Panopto’s viewer statistics to guard against false responses. The explanatory variable of proportional viewing duration was calculated as the duration of all modules viewed divided by the total duration of all nine modules (58.22 minutes) and was tracked by Panopto. Table 1 indicates each variable, its source, the sample sized used, and which research question it was used to answer. Finally, the data points for respondents who viewed and/or reported zero unique modules viewed were removed from all data analyses, as they were philosophically inappropriate to answering the research questions of this study.

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Response Variable</th>
<th>Explanatory Variable</th>
<th>Source</th>
<th>Sample Size (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Helpfulness</td>
<td>–</td>
<td>Self-reported Paper Survey</td>
<td>71</td>
</tr>
<tr>
<td>2</td>
<td>Helpfulness</td>
<td>Unique modules viewed</td>
<td>Self-reported Paper Survey &amp; Panopto Viewer Statistics</td>
<td>71</td>
</tr>
<tr>
<td>3</td>
<td>Helpfulness</td>
<td>Proportional viewing duration</td>
<td>Self-reported Paper Survey &amp; Panopto Viewer Statistics</td>
<td>59</td>
</tr>
</tbody>
</table>

Limitations

The observational nature of this study requires that conclusions may only apply directly to the course and students involved. Any association to a broader population of students or courses is cautioned. This does not in anyway diminish the conclusions of this study, but only tempers them. Other institutions and faculty can draw benefits from these results in as much as they relate to their specific situations. In contrast, the ancillary purpose of improving the teaching within the course discussed is not adversely affected by the observational design of this study. Inferences about this course and its student population can be robustly made from the conclusions of this study by way of supporting continuous improvement efforts internal to this course.

Results

Descriptive Statistics

The survey instrument was administered to 138 of the 145 students enrolled in the course. Of these responses 117 were considered for purposes of data analysis, with the other 21 being dropped due to missing and/or inconsistent responses. Out of the 117 responses considered for data analysis, only 71 students watched one or more of the modules. Hence the number of responses valid for answering the first two research questions was N= 71. Even so, a very high 49% response rate from the entire class was achieved.
Thirty-nine percent of the participants stated they did not watch any of the modules, while 28% of students stated they watched all nine modules. Close to 45% responded they watched five or more modules. The complete distribution of modules watched is shown in Figure 3.

Figure 3. Number of unique modules viewed by student population

Research Question One

The first research question investigated student’s perception of the helpfulness of asynchronous video modules in learning to construct SPC charts. To answer the research question, the authors analyzed student’s self-reported responses to the survey question: “The SPC modules helped you to understand this content” (see Figure 2). Students responded by selecting one option from a 5-point Likert’s scale ranging from 1 (strongly disagree) to 5 (strongly agree). Out of the 117 participants, only 71 students stated that they watched at least one module. The distribution of these responses is shown in Figure 4 and illustrates that 18% of the students who watched at least one module either strongly disagreed or disagreed with the statement that the online modules helped them understand the concepts related to SPC. Approximately, 41% of the students neither agreed nor disagreed and 41% of the students agreed that online supplemental videos helped them understand more about SPC. Furthermore, it should be noted that none of the students stated that they strongly agreed that online supplemental videos helped them understand more about SPC.
Overall, the proportion of students who found the online modules helpful was higher than the proportion of students who did not. A Chi-squared test was used to validate the hypothesis and results showed that the proportion of students who agreed was significantly different (p-value < 0.05) from the proportion of students who strongly disagreed or disagreed. The results of this test are shown in Table 2.

Table 2. Chi-square test to validate research question 1

<table>
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<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-squared test statistic value</td>
<td>6.4</td>
</tr>
<tr>
<td>Degrees of freedom</td>
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</tr>
<tr>
<td>p-value</td>
<td>0.01</td>
</tr>
</tbody>
</table>

α = 0.05; N = 71

The result indicates there was a significant difference in the proportion of students who perceived the helpfulness of asynchronous video modules in learning to construct SPC charts. The proportion of students who perceived the video modules as helpful was significantly higher than the proportion of students who perceived the video modules as not helpful.

Research Question Two

The second research question explored if there is a significant relationship between number of unique modules viewed and the level of perceived helpfulness of students who watched at least one module. Correlation and regression analysis were used to validate the hypotheses. Correlation coefficients between the number of unique modules viewed by student and their perceived helpfulness are depicted in Table 3.
Table 3. Correlation between self-reported unique modules viewed and perceived helpfulness

<table>
<thead>
<tr>
<th>Unique modules viewed</th>
<th>Perceived helpfulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique modules viewed</td>
<td>-</td>
</tr>
<tr>
<td>Perceived helpfulness</td>
<td>0.27*</td>
</tr>
</tbody>
</table>

*P < 0.05; N = 71

The moderate correlation between the number unique modules viewed and students perceived helpfulness indicates a positive relationship between the two variables. Simple linear regression was used to further validate the relationship between unique modules viewed and students perceived helpfulness. In the regression analysis, the number unique modules viewed was the explanatory variable, while students rating of helpfulness was the response variable, as shown in Table 4.

Table 4. Regression self-reported unique modules viewed and perceived helpfulness

Data analysis indicates there was a significant linear relationship between the number of unique modules viewed and perceived helpfulness for students who watched at least one module. The value of the regression coefficient for number of unique modules viewed indicates a positive relationship between number of unique modules viewed and the student perception of helpfulness.

Research Question Three

The final research question explored if there is a significant relationship between the proportion viewing duration and the level of perceived helpfulness of students who watched at least one module. Again, correlation and regression analysis were used to validate the hypotheses. Table 5 contains the correlation values between proportion viewing duration and perceived helpfulness.
The correlation value between the proportion viewing duration and student’s perceived helpfulness indicates a weak positive relationship between the two variables. Simple linear regression was used to further validate the relationship between the proportion viewing duration and perceived helpfulness. In the regression analysis, the proportion of time viewed was the explanatory variable, while student’s rating of helpfulness was the response variable, as shown in Table 6.

Table 6. Regression model of proportion viewing duration and students perceived helpfulness

<table>
<thead>
<tr>
<th>Proportion viewing duration</th>
<th>Perceived helpfulness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion viewing duration</td>
<td>–</td>
</tr>
<tr>
<td>Perceived helpfulness</td>
<td>0.1700*</td>
</tr>
</tbody>
</table>

*P <0.05; N = 59

Regression analysis indicates there is a significant linear relationship between the proportion of time viewed by the students and their perceived helpfulness of the video modules in learning to construct SPC charts. The value of the regression coefficient for number of modules watched indicates a strong positive relationship between proportion of time viewed and the student perception of helpfulness.

Conclusions

The following conclusions, organized by research question, were drawn from this study:

- Research Question One: This question looked at student’s perception of helpfulness of asynchronous SPC video modules. From the analysis it was found that students who reported watching at least one module (N = 71), 41% perceived online video modules to be helpful. Furthermore, 41% perceived the modules as neither helpful
nor unhelpful, with 18% responding that they were not helpful. A Chi-square test ($\chi^2 = 6.4; p\text{-value} = 0.01$) for this case showed that the proportion of students who found the video modules helpful was significantly different ($\alpha = 0.05$) from the proportion of students who did not find them helpful. Therefore, answering research question one, it was found that a large amount (41%, $N = 71$) of students who watched the video modules perceived them to be helpful.

- **Research Question Two**: This question looked at the relationship between helpfulness and number of unique modules viewed. A moderate positive correlation of 0.27 ($p\text{-value} < 0.05$) with significant linear relationship ($p\text{-value} < 0.05, N = 71$) was observed. This indicates that when more modules were viewed students’ perception of how helpful they were increased. From the regression analysis in Table 4, the average student response at one unique modules viewed was 2.44, while at nine it was 3.16. This resulted in a range of 0.72 in perceived helpfulness. Thus, answering research question two, it is clear that the number of *unique modules viewed* positively affects the *helpfulness* as perceived by students.

- **Research Question Three**: This question examined the extent to which the proportional viewing duration effected student’s perception of helpfulness. To answer this question, only students who watched more than 50% of the total viewing duration were analyzed. Looking at this sub-population ($N = 59$), a weak positive correlation of 0.1700 ($p\text{-value} < 0.05$) with significant linear relationship ($p\text{-value} < 0.05$) was observed. This also indicates that as viewing duration increased so did perceived helpfulness. Therefore, answering research question three, it was found that the proportional viewing duration positively affected student’s perception of helpfulness.

- From these results, it can be concluded that students who watched video modules perceived them to be helpful in learning to construct SPC charts. Furthermore, the number of unique modules viewed and proportional viewing duration were both positively associated with the level of perceived helpfulness. These results support the use of asynchronous video modules to help students construct SPC charts and aligns well with the notion that online supplemental content can extend student learning beyond the classroom.

**References**


