A Web-based Matrix Organizer for Chunked Multimedia Course Content

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This study presents a web-based matrix organizer that houses multi-media course content, including videos and infographics, for an undergraduate business statistics course. Content is "chunked" into microlessons explaining the "When, What and How" of several statistical techniques. An observational study was conducted to evaluate satisfaction with the tool and how the tool influenced learning. Results show that students felt the tool was easy to use and helped them organize and learn information. Some evidence suggests users have higher perceived learning and grades than non-users. The structure can be used for other courses; recommendations for implementing similar systems are presented.

Keywords: chunking, microlessons, videos, infographics

INTRODUCTION

As technologies have evolved, instructors have explored ways to utilize those emerging technologies to enhance learning. This paper describes the use of a web-based tool to organize videos and other online learning objects. In face-to-face (FTF) settings, instruction is often supplemented with videos and other web-based learning resources to help reinforce concepts, enhance lectures, decrease stress and increase learning. In distance courses, multimedia content is a necessity.

The development of the web-based system for an undergraduate business statistics course was prompted by the instructor's desire to organize multimedia content for easy use in a distance course, as well as to target key course concepts, provide additional resources and enable flipping in a FTF course. Because today's Generation Z college students are considered to have short attention spans (Abromovich, 2015; Micoleta, 2012) and informal student feedback suggested that students may only want to target one or two things they need to learn, the option of recording full-length lectures was dismissed as it was assumed that long recordings would not be well-received.

These observations led to the idea of "chunking" the course content into small, manageable pieces, much like Marzano (2011) proposed chunking content into "digestible bits" to help students interact with new knowledge. Each "chunk" consisted of a topic and a subtopic; topics were statistical methods and subtopics were the When, What and How of each method. For each chunk, a short video was developed utilizing both audio and visual descriptions of the subtopic. In an effort to appeal to more visual learners, an infographic (visual summary) was also created for each chunk.

After listing ten topics that the course covered, each with three subtopics, it was evident that some organizational tool would be needed to display course content. Inspired by the work of Hung and Chao (2007), Hung and Lockard (2007) and Hung and Kalota (2013), a matrix organizer was chosen. The course topics were listed in the left column and three subtopics (When, What and How) were listed across the top row. The content areas (cells) of the matrix each included the chunk of information for that subtopic, allowing students to easily locate the relevant information without trudging through extraneous content.

The remainder of this paper is organized as follows. First, the literature and background regarding chunking and matrix organizers is discussed, then the creation of the content and the web-based organization system is explained. Next an evaluation of the tool is explored, and finally, advice for other instructors wishing to implement a similar system is presented.

LITERATURE AND BACKGROUND

The division of course content into manageable "chunks" is well-supported in the literature. Marzano (2009) defines "chunking" as "presenting new information in small, digestible bites" and includes chunking as one of "Five Avenues to Understanding" when discussing student learning. Chunking is also included as one of 18 content strategies suggested for helping students interact with new knowledge (Marzano, 2011). Cognitive Load Theory suggests that because working memory is limited, instructional design should minimize the load on working memory by removing extraneous information and "chunking" content to facilitate integration into long-term memory (Tempelman-Kluit, 2006).

Guinta (2017) notes that because of Generation Z's short attention span and desire for instant gratification, material targeted toward these learners should be provided in short bursts. In more recent years, microlearning has emerged as a type of technology-enabled chunking (Jahnke, Lee, & Pham, 2019; Major & Calandrino, 2018) and has been applied in online learning environments. Studies have reinforced findings that breaking content into small, manageable bites can improve student learning outcomes (Mohammed, Wakil & Nawroly, 2018; Nikou & Economides, 2018).

Marzano (2009) also refers to "Scaffolding" in the "Five Avenues to Understanding." Scaffolding involves arranging chunks into a logical order, with each chunk leading to the next, setting up a "logical progression to a clear goal." Scaffolding suggests the need to effectively organize chunks for student consumption. Possible formats for organizing and presenting chunks include graphic organizers and more specifically, matrix organizers.

Strangman, Vue, Hall and Meyer (2003) define graphic organizers as "graphic or visual displays that depict the relationships between facts, terms and/or ideas within a learning task" while Ayverdi, Nakiboğlu and Aydin (2014) define them as "teaching and learning tools that show organization of concepts as well as relationships between them into a visual format." Graphic organizers include semantic feature analysis, pyramids, flow diagrams, comparison-contrast matrix, and cause-effect diagrams (Ayverdi, Nakiboğlu & Aydin, 2014). Graphic organizers have been found to improve students' comprehension, performance and motivation in learning (Zaini, Mokhtar & Nawawi, 2010), and to reduce anxiety in distance learning students (Olanrewaju, 2018). Strangman, Vue, Hall and Meyer (2003) cite several other studies that demonstrate that graphic organizers have "benefits that extend beyond their well-established effects on reading comprehension."

The matrix advance organizer utilized in this study is similar to a semantic feature analysis and a comparison-contrast matrix. Semantic feature analysis uses a grid to explore relationships and highlight connections between concepts. A comparison-contrast matrix similarly uses a grid to show how two or more things are similar or different. When designing the matrix to display statistics content, statistical methods were arranged in the left column followed by three columns representing When, What and How. This allows students to see the features of each method and to compare and contrast various statistical methods by exploring when each is used and what is similar or different about the processes.

Matrices are useful in showing a visual overview of materials, interconnections and cross-type relations, displaying hierarchical information and facilitating easy and quick location of information (Hung & Kalota, 2013; Hung, Smith, Harris & Lockard, 2010; Kiewra et al., 1997; Larkin & Simon, 1987). They have been shown to be effective for organizing information and aiding learning (Hung & Kalota, 2013; Hung, Smith, Harris & Lockard, 2010; Kauffman & Kiewra, 2010; Kiewra et al., 1997; Larkin & Simon, 1987).

The web-based matrix organizer developed for this project is modeled after Hung and Chao's (2007) Matrix-Aided Performance System (MAPS). The system uses hypertext technology allowing users to access each "cell" in the matrix by clicking on the link. Similar MAPS systems have been used in other content areas (Chasnoff, 2001; Hung & Kalota, 2013; Hung & Lockard, 2007; Hung, Smith, Harris & Lockard, 2010). Since the content in this system is for statistical methods, it is called STAT-MAPS.

CONTENT DEVELOPMENT

The content contained in STAT-MAPS covers ten statistical methods including confidence intervals, hypothesis testing for one and two populations, Analysis of Variance (ANOVA), chi-square tests for goodness of fit and independence, correlation, simple linear regression and multiple regression. The subtopics for each method include:

1. "When to use / Examples" to describe *when* and in what situations it is appropriate to use each statistical technique;
2. "Concepts / The Idea" which explains *what* is being done and the conceptual idea behind the method; and
3. "Calculations / Details" which explains *how* the method is implemented.

The matrix showing content areas and subtopics is shown in Figure 1. The system is publicly available at https://discovery.indstate.edu/~stat-maps/.

FIGURE 1
STAT-MAPS HOME SCREEN

	When to use / Examples	Concepts / The Idea	Calculations / Details
Confidence Intervals			
Confidence Intervals for One Population Mean	●	●	●
Correlation & Regression			
Correlation	●	●	●
Multiple Regression	●	●	●
Simple Linear Regression	●	●	●
Hypothesis Tests			
ANOVA	●	●	●
Chi-Square Goodness of Fit Test	●	●	●
Chi-Square Test for Independence	●	●	●
Test for One Population Mean	●	●	●
Test for Paired Population Means	●	●	●
Test for Two Independent Population Means	●	●	●

When developing content for STAT-MAPS, several of Mayer's (2009) multimedia principles were used as guidelines. The use of chunking and a matrix organizer are supported by Mayer's Segmenting Principle ("people learn better when a multimedia lesson is presented in user-paced segments rather than as a continuous unit"). Content development was also guided by the Multimedia Principle ("people learn better from words and pictures than from words alone"); Coherence Principle ("people learn better when extraneous words, pictures and sounds are excluded"); and Voice Principle ("people learn better when the narration in multimedia lessons is spoken in a friendly human voice rather than a machine voice," Mayer, 2009).

Content development began by listing only the essential elements of a subtopic. For example, for "when to use" simple linear regression, the four essential elements are:

1. Two quantitative variables;
2. One variable is suspected of influencing or causing an effect in the other;
3. Relationship is assumed to be linear;
4. The question is if a relationship really exists and if so, to describe it.

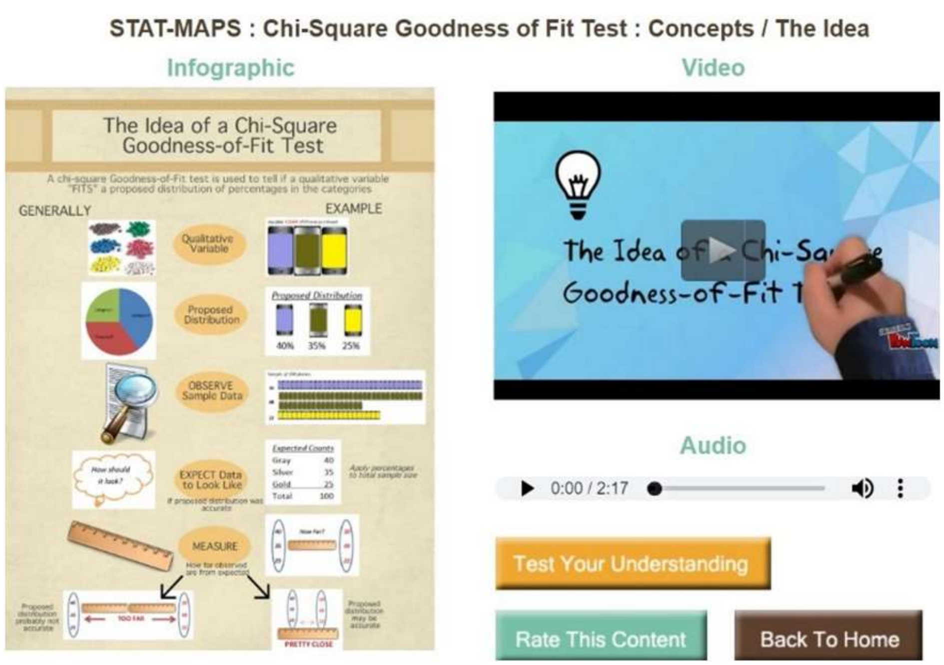
Next, a "script" was written in conversational tone to explain only the essential elements of the subtopic. Care was taken to edit the script so that extraneous information was minimized. Once the script was ready, an audio recording was created and edited using Audacity (Audacity, 2019). The voice recording was used as stand-alone audio content for the subtopic, as well as the voice-over for the video. Most recordings were between two and five minutes.

Next, a visual depiction of concepts and processes was conceptualized. This involved thinking about the building blocks, process, steps, relationships, cause, effect, etc. and then attempting to identify or create pictures that represent each. For example, a population was represented by a picture of many people, and a sample with a picture of a small group. Relationships could be symbolized by arrows, and processes by flow diagrams. The graphics were then compiled in an infographic using easel.ly (Easel.ly, 2018). Words and pictures were used to convey information in a one-page summary. Care was taken to minimize text and extraneous information and to use visual cues to convey concepts. These infographics served as visual summaries for each cell of the matrix.

The audio and visual components were then combined into a video using PowToons (Powtoons, 2019). The animated videos were created by using the audio script as the voice-over and the pictures from the infographic as visuals. Like the audio scripts, videos were generally about two to five minutes long.

In addition to audio, infographic and video, self-test questions were added to each cell under a button called "Test Your Understanding". These consisted of four multiple-choice or true-false questions over the content of the cell. Students were given immediate feedback on their responses, including the correct answer and rationale. An example of one cell (content area) of STAT-MAPS is shown in Figure 2.

FIGURE 2
CONTENTS OF ONE CELL OF STAT-MAPS



The web interface was developed by an academic programmer. The contents are stored in a relational database and dynamically retrieved by a backend program. In addition, a mini-content management system was developed to allow the administrator to add, modify, or delete content by uploading files.

HOW STAT-MAPS WAS USED

The use of STAT-MAPS was voluntary in the FTF sections of the business statistics course observed for this study. Students attended regular lectures, worked on problems in class and had homework and exams to assess their knowledge. Homework assignments were administered through MyStatLab and students were allowed multiple attempts at problems. Exams were in class but students were allowed to use notes, books, and computer resources. STAT-MAPS was integrated into the course as a learning resource in the following ways:

- A link/content area in Blackboard was devoted to STAT-MAPS.
- The instructor often displayed or discussed STAT-MAPS content in class.
- For each topic and course assignment, a STAT-MAPS link referring to relevant content was given on Blackboard.
- Students were commonly referred to and reminded of STAT-MAPS as part of instructor email responses to specific questions.

There were no assignments that specifically required the use of STAT-MAPS. Students voluntarily chose to access the system as one of several tools at their disposal when learning course material and completing assignments.

EVALUATION OF THE LEARNING TOOL

The main purpose of chunking course material and organizing content into the STAT-MAPS matrix was to help students process and learn information. More specifically and consistent with the literature on matrix organizers, the goals were to help students organize information; understand the visual overview of the content; quickly and easily extract information; and understand how content was related. Another goal was to provide a learning tool that students would be satisfied with and perceive as useful and easy to use. Lastly, STAT-MAPS was intended to improve student outcomes in terms of perceived learning and grades.

In light of these goals, five research questions were specified.

RQ1: *How effective is STAT-MAPS in helping students organize and extract information?*

RQ2: *Are students satisfied with STAT-MAPS as a learning tool?*

RQ3: *Does use of STAT-MAPS improve perceived learning?*

RQ4: *Does use of STAT-MAPS improve performance (grades)?*

METHODS

In order to investigate the effectiveness of STAT-MAPS, an observational study was launched to gather information on student usage of the system and performance in the course. The study involved three distinct pieces: a student survey, login information from STAT-MAPS and analysis of students' course grades. This study was exempted by the university's Institutional Review Board and all proper consent procedures were implemented.

Participants

Participants of the study were students enrolled in four sections of the instructor's FTF business statistics course in the fall 2017 and spring 2018 semesters. Students were informed of the study's intent and design, and those who consented to participate were asked to fill out a survey and gave consent for their browsing habits in STAT-MAPS and their grades in the course to be analyzed. Distance students enrolled in the summer 2018 were also invited to participate, but with small enrollment and low response rates, no usable responses were gathered from this group.

Data Collection

The student survey asked participants about their background, work ethic in the course, perceived learning of course topics and attitudes towards STAT-MAPS. Surveys were administered on paper by a third party when the instructor was not present. Perception and attitude questions were measured on a 5-point Likert scale. Students were also asked to rank the usefulness of the different types of content in STAT-MAPS (audio, video, infographics, and self-test questions) and to provide open-ended feedback on what they liked most and least about the system.

For study participants, the academic programmer provided server data showing whether or not each student logged into STAT-MAPS and how long they interacted with the content. Student grades on course assessments, including midterm exams and homework assignments were extracted from the course's learning management system.

Data Analysis

The following methods were used to address each research question. All analyses were done with SPSS V25. To address RQ1 regarding effectiveness of the tool, descriptive statistics from four survey questions were used to gauge student agreement with statements including: STAT-MAPS helped me organize information; presented a visual overview that I could easily understand; helped me get the information I needed quickly and easily; and helped me understand how course content areas were related. Each of these questions was measured on a 5-point Likert scale from strongly agree to strongly disagree. In addition, responses to the survey question: "To what extent do you feel your use of STAT-MAPS helped you learn the content for this course?" were analyzed. Respondents chose from four options: "It helped a lot", "It helped some", "It didn't help much" or "It didn't help at all."

To address RQ2 regarding student satisfaction with STAT-MAPS, descriptive statistics were calculated for five survey questions, including: STAT-MAPS was easy to use; STAT-MAPS was a useful tool in this course; I liked using STAT-MAPS; I am satisfied with the ease of use of STAT-MAPS; and I am satisfied with the content provided in STAT-MAPS. The responses to each of these questions were also recorded on a 5-point Likert scale from strongly agree to strongly disagree. In addition, an analysis of student rankings of usefulness of the four content types (videos, infographics, audio and self-test questions) was also used to evaluate which types of content students found most useful.

To explore RQ3 regarding perceived learning, responses to survey questions asking student perceptions of how well they learned each course topic (e.g. ANOVA, chi-square tests, correlation, regression, etc.) were analyzed. For these questions, there were five possible responses ranging from 5 (very well) to 1 (not well at all). The independent variables of interest were whether or not the student interacted with the STAT-MAPS content for that topic (eight binary variables); eight independent samples t-tests were used to test if use of STAT-MAPS for that content had any influence on perceived learning of that topic.

Also, a "Total perceived learning" variable was created by summing the responses to the perceived learning of individual topics and a Principal Components Analysis (PCA) and test for reliability were conducted to support the creation of this factor. Then regression was used to discern the effect of using STAT-MAPS (for any topic) on Total perceived learning, while controlling for grades, attitudes and work ethic.

To investigate RQ4 regarding the tool's effect on course grades, dependent variables representing scores on overall grades and midterm exams were used. Independent variables included whether or not a student used STAT-MAPS for a topic or topics covered by that assessment. Independent samples t-tests were conducted to determine if scores on midterm Exams 1 or 2 were affected by whether or not a student used STAT-MAPS for any topic covered on that exam, and a chi-square test for independence was used to examine if overall grades were affected by use of STAT-MAPS for any topic in the course. Because students were always allowed multiple attempts on homework, scores on for these assignments were not considered in this analysis. In addition, regression was used to investigate whether use of STAT-MAPS had an effect on grades while controlling for variables such as cumulative GPA, work ethic and attitudes toward the course.

RESULTS

In fall 2017, 72 students were enrolled in two sections of the instructor's statistics course and of those, 57 students (79%) agreed to participate in the study. In spring 2018, 81 (64%) of 127 enrolled students in two sections agreed to participate; however, two students did not provide enough information for their responses to be used. Thus, the data used in this study pertain to 136 (68%) out of 199 students enrolled.

A first step in data analysis required an exploration of STAT-MAPS usage by participants. Of the 136 students, 69 had never logged in to STAT-MAPS (see Table 1).

TABLE 1
TIME STUDENTS SPENT IN STAT-MAPS

Time Logged Into STAT-MAPS	Number of Students	Percent of Students
Not used at all	69	50.7%
Under 1 min	12	8.8%
1 to 5 min	8	5.9%
5 to 20 min	9	6.6%
20 to 40 min	10	7.4%
40 to 60 min	8	5.9%
1-2 hours	8	5.9%
2-4 hours	9	6.6%
More than 4 hours	3	2.2%
Total	**136**	**100%**

Under the assumption that it would take at least one minute for someone to meaningfully interact with contents of a cell, the 12 students who were logged into STAT-MAPS for less than 60 seconds were considered to have not "used" the system. Combined with the 69 students who never logged in, there were 81 students who were classified as "non-users," while the remaining 55 students were considered "users." Only "users" had their survey responses analyzed when measuring perceptions of STAT-MAPS.

Descriptive statistics for personal characteristics, course attitudes and work ethic were compared among users and non-users. Results are shown in Table 2.

TABLE 2
PERSONAL CHARACTERISTICS, ATTITUDES AND WORK ETHIC OF PARTICIPANTS

Respondent characteristics	All Participants (n = 136)	Users (n = 55)	Non-users (n = 81)
Female	50%	46%	53%
Mean Age	21.3	21.4	21.2
Self-reported Mean Cumulative GPA	3.29	3.32	3.28
Mean Attitude Toward this Class *(5 = Very positive, 1 = Very negative)*	4.06	4.13	4.01
Mean Work Ethic (4 = Very Strong, 1 = Poor)	2.91	2.98	2.86

As Table 2 indicates, users and non-users have very similar characteristics, and in fact, tests to compare the two groups using t-tests for means and chi-square tests for independence showed no significant differences in any of these traits. Students were largely of traditional college age and had fairly high grades, which is not surprising since our College of Business has a minimum GPA for admittance and therefore to enroll in this course. Students had fairly good attitudes towards the course but work ethic was more moderate.

Effectiveness of Tool

Descriptive statistics from responses of users were analyzed to address *RQ1: How effective is STAT-MAPS in helping students organize and extract information?* Results are shown in Table 3.

TABLE 3
DESCRIPTIVE STATISTICS FOR ORGANIZATION QUESTIONS

Survey Question *(Scale: 5 = Strongly Agree; 1 = Strongly Disagree)*	n	Mean	St Dev
STAT-MAPS presented a visual overview of the content that I could easily understand	55	4.09	1.01
STAT-MAPS helped me get the information I needed quickly and easily	54	3.93	1.04
STAT-MAPS helped me organize the information I needed to learn	55	3.89	0.98
STAT-MAPS helped me understand how the course content areas were related	55	3.69	0.96

Results indicate that students most strongly agreed that STAT-MAPS presented a visual summary of content that they could easily understand. They seemed to largely agree that the system helped them organize information and get information quickly and easily and, to a slightly lesser extent, understand how content areas were related.

The frequency distribution of the survey question “To what extent do you feel your use of STAT-MAPS helped you learn this content for this course?” is shown in Table 4. Of the 55 students users, 36 (65%) indicated that it helped them a lot or somewhat. Not surprisingly, the helpfulness increased for users who spent more time in the system.

TABLE 4
PERCEPTIONS OF HOW MUCH STAT-MAPS HELPED USERS LEARN COURSE CONTENT SATISFACTION WITH STAT-MAPS

Response	Number of Students	Percent of Users	Time Spent (in Minutes)	
			Mean	St Dev
Helped a lot	17	31%	81.48	86.51
Helped somewhat *	19 (17)	35%	118.3 (59.50)	191.56 (71.91)
Did not help much	14	26%	54.17	58.08
Did not help at all	5	9%	34.75	10.79
Total	**55**	**100%**	**62.81**	**70.42**

** Two students in the "Helped somewhat" category were considered outliers, as they were each logged into one topic for 6 to 10 hours, suggesting that this was not all time spent interacting with the content. The numbers in parentheses are the mean and standard deviation when these two outliers are removed.*

To explore RQ2 regarding satisfaction with STAT-MAPS, descriptive statistics from relevant survey items are shown in Table 5.

TABLE 5
USER SATISFACTION WITH STAT-MAPS

Survey Question *(Scale: 5 = Strongly Agree; 1 = Strongly Disagree)*	n	Mean	St Dev
STAT-MAPS was easy to use	55	4.18	0.96
I am satisfied with the content provided in STAT-MAPS	55	4.15	0.89
I am satisfied with the ease of use of STAT-MAPS	55	4.11	0.98
STAT-MAPS was a useful tool for this course	55	3.98	1.05
I liked using STAT-MAPS	55	3.62	1.05

Results indicate that students thought the system was easy to use and were satisfied with its content. They also appear to largely agree that it was useful, but slightly less likely to indicate that they "liked" it. Users were also asked to rank the four types of content (videos, infographics, audio and self-test questions) from 1 (most helpful) to 4 (least helpful). The average rankings are shown in Table 6.

TABLE 6
RANKINGS OF HELPFULNESS OF FOUR TYPES OF CONTENT

Content type *(Scale: 1 = Most Helpful; 4 = Least Helpful)*	n	Mean	Number of Students Who Ranked "1"
Videos	52	1.90	21
Infographics	52	2.02	23
Questions	51	2.84	7
Audio	52	3.23	1

Rankings suggest that students were most helped by videos, followed closely by the infographics. Overall, these findings suggest students were largely satisfied with STAT-MAPS as a learning tool.

Effects on Perceived Learning

To address RQ3 regarding perceived learning, the relationship between use of STAT-MAPS (binary variables) for each of the eight individual topics and perceived learning for that topic (measured on a Likert scale, 5 = Very well) were explored using independent samples t-tests (see Table 7).

TABLE 7
PERCEIVED LEARNING OF COURSE TOPICS, USERS VS. NON-USERS OF STAT-MAPS

	Users of this Content Area		Non-users of this Content Area		Independent T-test for two means			Bonferroni adjusted critical value (Sig)	Benjamini-Hochberg critical value (Sig)
Course Topic	**n**	**Mean (stdev)**	**n**	**Mean (stdev)**	**T-stat**	**df**	**p-value**		
Correlation	15	4.60 (0.51)	117	4.06 (0.86)	3.52	25.93	0.002	0.013(*)	0.013(*)
Multiple regression	12	4.58 (0.51)	122	4.16 (0.8)	2.54	16.70	0.021	0.013	0.025(*)
ANOVA	28	4.54 (0.64)	106	4.21 (0.78)	2.31	50.39	0.025	0.013	0.038(*)
Simple regression	12	4.67 (0.78)	122	4.16 (0.85)	2.15	13.73	0.050	0.013	0.050(*)
Confidence intervals	42	4.31 (0.72)	93	4.04 (0.75)	1.97	82.79	0.052	0.013	0.063(*)
Chi-square tests for independence	17	4.41 (0.62)	118	4.10 (0.84)	1.84	25.42	0.078	0.013	0.075
Hypothesis tests	32	4.31 (0.78)	103	4.14 (0.75)	1.13	50.35	0.265	0.013	0.088
Chi-square GOF	26	4.23 (0.86)	109	4.14 (0.82)	0.50	36.59	0.621	0.013	0.100

As multiple tests (n = 8) were performed, a Bonferroni adjustment was made using alpha of 0.10, resulting in a 0.10 / 8 = 0.013 significance level for each hypothesis. Results after correction indicate that only the smallest p-value is significant, suggesting that the "Correlation" topic is the only content area of STAT-MAPS for which use of content has a significant effect on perceived learning of that content. However, a more powerful alternative to the Bonferroni adjustment suggested more evidence of significant effects.

The Benjamini-Hochberg (BH) Procedure (Benjamini & Hochberg, 1995) was used to control the false discovery rate of these multiple tests at Q = 10%. The BH critical value was calculated for each ranked p-value (where 1 represents the smallest p-value) using the formula $(i/m)Q$ where i = rank and m = 8 (number of tests). The critical values are shown in Table 7. When p-values are compared to the critical values using this procedure, results suggest that for five of the eight topics (correlation, multiple regression, ANOVA, simple regression and confidence intervals), users of STAT-MAPS for that topic reported significantly higher perceived learning of that topic than non-users. Thus, there appears to be some evidence that users of STAT-MAPS have higher perceived learning than non-users.

Next, to investigate if use of STAT-MAPS affected overall perceived learning while controlling for background factors, a "Total perceived learning" variable was created by summing the responses to the perceived learning of individual topics. The creation of this aggregate variable was justified by a PCA that showed all variables loading on a single factor explaining 71% of the variance. Factor loadings were all above 0.77 and Cronbach's alpha for the 8-item scale was found to be 0.941. The variable ranged from a minimum of 16 to a maximum of 40, with a mean of 33.39 and a standard deviation of 5.41 (n = 132). A regression analysis was conducted with Total perceived learning as the dependent variable, use of STAT-MAPS (1 if a student interacted with any STAT-MAPS content and 0 otherwise) as the independent variable, and cumulative GPA, attitude toward the course and work ethic as the control variables (refer back to Table 2 for details on the measurement of these control variables). Results suggest the use of STAT-MAPS is marginally significant in predicting total perceived learning when controlling for other variables (see Table 8).

TABLE 8
REGRESSION ANALYSIS FOR TOTAL PERCEIVED LEARNING

	B	**Std. Err**	**Beta**	**T**	**p-value**	**Sig.**
(Constant)	10.894	3.447		3.160	0.002	
Cum GPA	1.977	0.822	0.181	2.406	0.018	**
Attitude toward course	2.567	0.534	0.399	4.810	0.000	***
Work ethic	1.728	0.722	0.199	2.392	0.018	**
Used STAT-MAPS (1 = Yes)	1.682	0.894	0.142	1.882	0.062	*

$F(4,116) = 15.78$, $p < 0.001$, R-sq = 0.352; Adj R-sq = 0.330
** Significant at 0.10*
*** Significant at 0.05*
**** Significant at 0.01*

Effects on Grades

With respect to RQ4 regarding effect of STAT-MAPS on course grades, the results for midterm exams 1 and 2 are shown in Table 9.

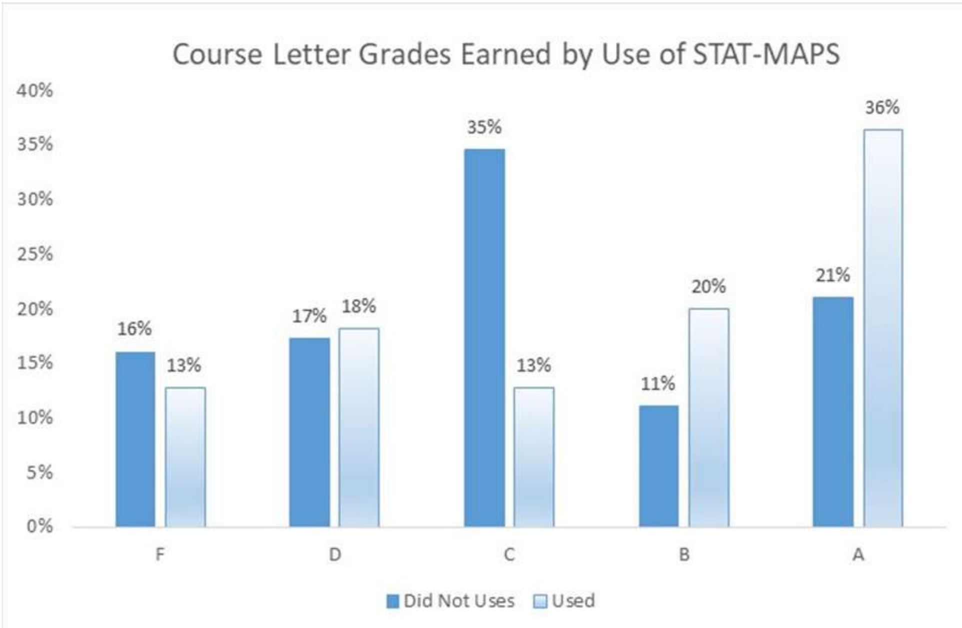
TABLE 9
DIFFERENCES IN MIDTERM EXAM GRADES BETWEEN USERS AND NON-USERS

Assessment	**Used STAT-MAPS for this Content**			**Did not use STAT-MAPS for this Content**		**T-test for means**	
	n	**Avg Time Spent (mins)**	**Mean (st dev) Exam Score**	**n**	**Mean (st dev) Exam Score**	**T**	**p-value**
Exam 1	52	69.1	87.99 (11.83)	84	81.59 (13.72)	2.883	0.005
Exam 2	20	13.9	87.63 (13.05)	116	82.24 (15.95)	1.646	0.110

As Table 9 shows, students who used STAT-MAPS for topics on midterm Exam 1 scored significantly higher than peers who did not use STAT-MAPS by an estimated 6.4%. Use of STAT-MAPS for topics on Exam 2 appears to have no effect on the scores on Exam 2; however, use of the tool appeared to drop off for Exam 2 topics, which might have contributed to this result.

Final course letter grades were also compared among users and non-users of STAT-MAPS. Figure 3 shows the percentages of users and non-users who earned each course letter grade.

FIGURE 3
FINAL COURSE GRADES FOR STAT-MAPS USERS AND NON-USERS



A chi-square test for independence indicated a significant difference between users and non-users ($X^2 = 10.939$, df = 4, p-value = 0.027). It should be noted that these results only show a relationship between use of the tool and final grades and it cannot be concluded that the tool caused higher grades.

Finally, regression analyses were used to determine if grades were affected by use of STAT-MAPS for relevant topics after controlling for variables such as cumulative GPA, work ethic and attitudes. Table 10 shows results for the dependent variable Exam 1 scores (measured as a percentage of possible points). Results suggest that those who used STAT-MAPS for at least one Exam 1 topic scored about 5.3 percent higher than non-users.

TABLE 10
REGRESSION ANALYSIS FOR DEPENDENT VARIABLE EXAM 1 SCORE

	B	**Std. Err**	**Beta**	**T**	**p-value**	**Sig**
(Constant)	29.386	7.903		3.718	0.000	
Cum GPA	11.203	1.898	0.440	5.903	0.000	***
Attitude toward course	4.285	1.270	0.278	3.374	0.001	***
Work ethic	-0.401	1.631	-0.020	-0.246	0.806	
Used STAT-MAPS for this content	5.347	2.033	0.197	2.630	0.010	***
F(4,120) = 15.55, p < 0.001, R-sq = 0.341; Adj R-sq = 0.319 ** Significant at 0.10* *** Significant at 0.05* **** Significant at 0.01*						

Note that even when the non-significant variable Work ethic is removed from the regression, the effect of use of STAT-MAPS is essentially unchanged (B = 5.294, T = 2.629, p-value = 0.010). Results for similar regressions for dependent variables Exam 2 and final course grades did not expose any significant effects on those grades from use of STAT-MAPS after controlling for cumulative GPA, work ethic and attitudes. However, this finding may be due to the significant reduction in time users spent on exam 2 topics compared to exam 1 topics.

Student Comments

An open-ended survey question asked students what they liked most about STAT-MAPS. Fifty student responses were coded according to common themes. The most common responses referred to: (1) Content, information, or examples helped them learn (20 students); (2) easy to use or can quickly get information (19 responses); and (3) infographics/visual displays (11 responses).

Students were also asked what they liked least about STAT-MAPS, and 42 students commented. The most common response was "Nothing" (10 students), followed by three themes mentioned by four students each: (1) Audio, (2) Did not answer all my questions or not enough information, and (3) Confusing.

Students were also asked to provide any additional comments and 22 users responded. Of these, six indicated they wish they had used it more, five left suggestions for improvement and four indicated they learned well enough in class and so did not need to use STAT-MAPS much. Interestingly, seven non-users also indicated that they had learned well enough in class and did not need to use STAT-MAPS at all.

DISCUSSION AND RECOMMENDATIONS

Results of this study suggest that students felt STAT-MAPS was effective in helping them organize information and learn course content. There is also some evidence that those who used the system had higher perceived learning and higher grades compared to non-users.

However, because use of the tool was optional and supplementary, this observational study is not sufficient to show if using the system caused higher grades or if those with higher grades, or perhaps motivation, were more likely to use the system. Future research could attempt to determine characteristics of students who voluntarily use the tool and/or identify types of students such a system would benefit most. Future research should also seek to find more definitive evidence that use of such a system improves course performance.

Because the tool allows flipping of class sessions, future research could explore if that approach is more successful than a traditional FTF course format. Another topic of interest is how the tool is perceived in distance courses. A limitation of this study was that distance students who were invited to participate rarely did. While the face-to-face students were given time in class to respond to the survey, distance students are not a captive audience and it was difficult to secure their consent and participation. Future studies should focus on distance students' perception of the tool and may require incentives to encourage participation.

With some evidence that the system is helpful and easy to use, other instructors may wish to implement something similar. Recommendations for such an endeavor begin with advice to start small and build over time, as creating a full system is a long process. Instructors should begin by selecting a few topics that students find more difficult or which they are asked more questions.

When determining columns of the matrix, common themes that arise in the discipline should be considered. This matrix was done for a statistics course in which When-What- and How are consistent across topics, and this framework may apply in other quantitative and technical disciplines. While not all disciplines will utilize these categories, most have standard approaches to analyzing a problem. For example, in a literature course, the columns might represent Characters, Setting, Plot and Conflict that are to be compared across several works.

When chunking content within a topic, instructors are urged to consider where the natural breaks are and to isolate essential elements. Consider if a chunk containing only vital information be explained in five minutes or less; if not, consider further breaking down the topic. Explaining something simply and concisely may not be as easy as anticipated and multiple attempts might be needed before finalizing a chunk.

When designing content, remember that both audio and visual are preferable. Multiple ways of presenting each chunk may appeal to different students or in different situations. For example, students may watch to videos when exploring a new topic but may prefer infographics when trying to apply concepts to a problem or when reviewing.

There are many tools available for creating videos and infographics other than those discussed here. It is likely that institutions have preferred and supported tools, but there are many publicly available free options. Instructional designers are extremely helpful in guiding choice of tools and training.

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