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Study Guide Generation in Chemical Engineering Thermodynamics: A Comparison Between Individual and Group Preparation

William Brown
wgb5@uakron.edu

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**Study Guide Generation in Chemical Engineering Thermodynamics: A
Comparison Between Individual and Group Preparation**

Chemical Engineering Honors Research Project Report 4200:497:002

To: Williams Honors College

Author: William Brown

Date: 4/28/2022

Executive Summary:

Learning is essential to the success of a professional and it is of importance to attempt to develop the best learning practices to ensure for ample learning to occur whenever possible. This study explores ways to improve learning in the classroom by postulating on the value of using group generated study guides relative to individually generated study guides. Literature has shown that in collaborative environments, students tend to learn more information (Sofroniou & Poutos, 2016), and that study guide construction is a setting in which students learn (Visco et al., 2007) consistent with the constructivist's learning theory (Simons & Linden, 2007).

In order to determine whether construction method of a study guide affects study guide usage on exams, students were to use individually generated study guides for exam 1 and group generated study guides for exam 2. Individual study guides were constructed independently and not in class, while group study guides were constructed in teams of 4 in the classroom two days prior to the exam. Students were requested to bring a list of preprepared topics that they would like to see on their group study guide. This list of preprepared topics would serve as a guide for each person for what topics to discuss in the group and what they would like to see go on the study guide.

Four questionnaires were sent out to students in 4200:220 at the University of Akron during the Spring 2022 semester. Each questionnaire was composed of 5 statements where students could answer how much they agreed with each statement on a Likert scale of 1-5 where 1 was strongly disagree and 5 was strongly agree. Statements were set up where the desired outcome would be a high value on the Likert scale. Likert data was compared by subtracting matched exam 1 responses from matched exam 2 responses. Data was then given a "direction" of either positive change, negative change, or no change. Questionnaires also contained 1-2 free response questions. Responses were analyzed for codes and themes in order to develop an overview of

study guide strategies and approaches. Questionnaires were sent out via email before exam 1, after exam 1, before exam 2, and after exam 2.

Students' Likert responses reflected that they heavily favored individual study guides when compared to group study guides. Nearly all Likert responses changed negatively, which would imply that students agreed less with the statements for group study guides compared to individual study guides. Students' free responses backed this claim, as the majority (75%) of responses to the question "Which of the strategies to prepare the study guide (individual or group preparation) was most helpful to your learning and why?" resulted in the students favoring individual study guides.

It was hypothesized that usage of the group study guide would decrease relative to the individual study guide due to increased understanding of information on the study guide. Results show that while the students reported that their usage of the study guide decreased when using the group study guide, students also felt like they did not have enough time to finish the exam when using the group study guide. Students feeling like they did not have enough time on the exam could come from lack of understanding of material and needing more time to think.

This project allowed me to develop technical skills such as survey design, Likert data analysis, and coding and theming data. Analysis of the coding and theming data was performed independently and then in unison with Dr. Visco, which also allowed me to gain experience in critically thinking with others. Survey work and Likert data analysis was performed independently which allowed me to gain a sense of independence, along with a sense of improved confidence. Dr. Visco and I had meetings weekly which allowed me to gain experience in communication of projects.

In order to improve this research in the future, I recommend that students be given more time to construct the group study guide, as a major reason why students preferred the individual study guide to the group study guide was that they did not have enough time to properly construct a study guide. It may also be of benefit to make sure students come with a preprepared sheet of concepts which would allow them to create a group study guide more effectively.

Introduction & Background:

Exploring how students learn is a key component in implementing new practices into the classroom. One theory used to describe student learning in the classroom is constructivism (Candra & Retnawati, 2020). Constructivism explains learning occurring both individually and through social interactions based on experiences (Candra & Retnawati, 2020). “Shuell (1988) formulated the main characteristics for good learning: “... (constructive) learning is an active, constructive, cumulative and goal directed process.... It is active in that the student must do certain things while processing incoming information in order to learn the material in a meaningful manner. It is constructive in that new information must be elaborated and related to other information in order for the student to retain simple information and to understand complex material. It is cumulative in that all new learning builds upon and/or utilizes the learner's prior knowledge in ways that determine what and how much is learned. It is goal oriented in that learning is most likely to be successful if the learner is aware of the goal (at least in a general sense) toward which he or she is working and possesses expectations that are appropriate for attaining the desired outcome.”(p277-278) “(Simons & Linden, 2007).

Research has shown that collaborative environments improve student learning (across a wide range of variables – HS vs college, non-STEM vs. STEM). For example, first-year engineering students working on collaborative tutorials in a calculus course showed a statistically significant increase in learning the subject material relative to a control section. These students reported that the group work was helpful via a survey instrument and these impressions were corroborated by exam performance (Sofroniou & Poutos, 2016).

Instructors in all grade levels, from early childhood education (Tal, 2018) to advanced graduate courses in quantum physics (Porter & Heckler, 2020), utilize group work in a wide variety of ways. However, not all of these approaches have been explored with the same frequency.

On the other hand, the literature is silent on the evaluation of teaming toward the creation of a study guide (a.k.a “cheat sheet”). As study guides are a common practice at some universities, it would be interesting to learn about how construction of a study guide in a team compares to that created by an individual.

The research on study guide construction is limited. In comparison, information on study guide effectiveness as well as study guide anxiety reduction (Gharib et al., 2012, Özer, 2021) is readily available. Analyzing the study guides once they have been constructed has also been performed (Capaldi, 2019) to determine whether density, correctness, number of equations, and number of definitions on the study guide has any effect on the students’ academics, but it has been difficult to find much research on the process of constructing the study guide.

One of the main papers focused on study guide construction is *Interpreting Student-Constructed Study Guides* by Visco et al (2007). This paper covers what 10 students put on their study guides and why they chose to do so. Students were asked interview questions following exams and their responses to the interview questions were recorded. The main findings of this study were that students tend to rely on their approximation of instructor emphasized material rather than using their own judgement and that students claimed construction of a study guide helped them learn the material. All study guides in that paper were generated individually.

The “typical” approach for students to generate a study guide is to review their notes individually and create their study guide while looking back through material covered during the semester, also known as the “individual study guide” preparation method. Alternatively, given the support

for benefits of teamwork in STEM fields (Sofroniou & Poutos, 2016), students could take time during class to work in small teams from a self-prepared list of topics to construct a team study guide for use on an individual exam, also known as the “group study guide” preparation method. Accordingly, the research question proposed is “Does the construction method of a study guide affect study guide usage on exams?” This is an interesting question worth exploring because literature has shown that in collaborative environments, students tend to learn more information (Sofroniou & Poutos, 2016), and that study guide construction is an environment in which students learn (Visco et al., 2007), consistent with the constructivist’s learning theory (Candra & Retnawati, 2020). Combining these two concepts, one would expect that group work would increase the amount of learning during the construction of study guides and thus, due to the timed nature of exams, it is hypothesized that usage of the study guide will decrease on the exam when group work is introduced.

Experimental Methods:

Thermodynamics is one of the most essential topics in the chemical engineering curriculum. The content learned in this class is used repeatedly throughout the remainder of the chemical engineering coursework. Accordingly, it is important for students to leave their thermodynamics courses with a good understanding of the relevant concepts.

There are many equations and rules that are used in thermodynamics, and they are often complex and use subtle concepts from math, physics, and chemistry. To assist students with using these equations and recalling rules on exams, students are often permitted a “study guide” to use on the exams. Study guides allow students to avoid rote memorization on exams, thereby helping them to focus on the conceptual material being tested. Study guides can go by many names including: “crib notes,” “equation sheets,” and “cheat sheets”.

How students use study guides on exams varies from student to student. Since exams are timed in this course, a student who spends much of the exam looking at their study guide is in danger of not completing the exam in its entirety. Therefore, the study guide often serves as a “safety blanket” that allows the student to avoid some rote memorization.

This research paper will analyze how students use study guides in a thermodynamics course, especially trying to discriminate between usage and value of a self-constructed study guide relative to one developed by a team of students.

This study was implemented in 4200:220, Introduction to Thermodynamic Processes. Dr. Visco was the professor of this course. Students were placed in teams of four (and one group of three) at the beginning of the semester using a group organization method (info.catme.org, 2021).

These teams worked together on in class problems, group homework assignments and projects.

The course had three midterm exams as well as a final exam. Data was collected over the first two exams only due to time constraints with later exams and William Brown’s Honors Research Project.

DATA COLLECTION:

The University of Akron Institutional Review Board (IRB) approved the use of questionnaires for this study. Students had the ability to opt out of answering any or all questionnaires involved in this project. Students were provided with a consent form at the beginning of all questionnaires that were sent to them (Appendix 1). No portion of this research project was used as a grade for any student in 4200:220. Students were required to use only individual study guides on exam 1 and only group generated study guides on exam 2 as part of this project.

Exam 1:

Exam 1 was given on February 11th, approximately during week 5 of the semester. This exam

was performed with the students working independently for study guide generation outside of class. Prior to the exam, but after study guide generation, the students were asked to fill out a pre-questionnaire (Appendix 1) via email on their study guide. Post-questionnaires (Appendix 1) were sent out via email following the completion of the exam.

Prior to the week of Exam 1, Dr. Visco sent out the following reminder to all students: "you will also be able to use a one-page (two-sided, 8.5" x 11") study guide **that you create**. The study guide can have *anything* you would like to include on the sheet -- the choice is yours. Please create a study guide of your own to use on the upcoming exam. I would encourage you to create your study guide sooner rather than later.". While it is impossible to force students to work alone outside of the classroom, this reminder heavily emphasizes that students should be working alone and be the sole creator of their own study guide.

Collection of pre-questionnaires occurred between February 9th and February 11th, and collection of post-questionnaires occurred between February 11th and February 14th. Responses were recorded using Qualtrics. During the collection period reminders were sent once a day to students that did not complete the questionnaire.

Exam 2:

Exam 2 was given on March 16th, around week 10 of the semester. This exam was performed with the students working in their teams to construct their study guides.

Students were told on the previous Friday to bring a list of preprepared ideas/concepts and that they would be working in their teams to develop one study guide that all four of the students will use on the following exam. Students generated the study guides in the classroom for approximately 50 minutes on the following Monday. Prior to the exam, but after study guide generation, the students were asked to fill out a pre-questionnaire (Appendix 1) via email on their

study guide. Post questionnaires (Appendix 1) were sent out via email following the completion of the exam.

When study guides were being constructed in class, it was observed that most students were actively participating in their respective groups working towards the common goal of constructing a study guide. Periodically, the professor would walk around the classroom and ask students how things were going. All groups had no problems at the time of talking with the professor.

Once the construction period was over, students handed in their group constructed study guides. The study guides were then scanned and emailed to the groups that constructed them within an hour of completing the class that day. Giving the students the scanned study guides allowed for the students to use the study guides when they did their studying for the upcoming exam. Due to time constraints, groups were permitted to make their study guides out of 2 fronts of individual sheets of paper. The two sheets of paper allowed students to work efficiently through the 50-minute construction window. The two fronts were scanned and turned into 1 study guide .pdf file that was distributed to the respective group. One group constructed their study guide on the computer and emailed the file to Dr. Visco following the construction period. On the day of the exam, students were given fresh copies of their study guides to ensure that only ideas prepared in the presence of the group were on the study guide.

Collection of pre-questionnaires occurred between March 14th and March 16th, and collection of post-questionnaires occurred between March 16th and March 19th. Responses were recorded using Qualtrics. During the collection period reminders were sent once a day to students that did not complete the questionnaire. Exam 3 and the final exam were not analyzed due to time constraints of the honors research project.

Questions Asked in Pre-Questionnaire:

Questions/statements for this study were developed by determining what aspects best cover study guide construction and study guide usage on exams. Questions/statements for the Pre-Exam questionnaires can be found in **Table 1**. Statement 1 was designed to make sure the student felt like they did not leave any information out of the study guide prior to the exam. Statement 2 was designed to measure the student's opinion on study guides to see if their opinion changes over the construction of both study guides. Statement 3 was designed to make sure that students reviewed information prior to study guide generation. Statement 3 was important for Exam 2 because students needed to bring a list of preprepared topics for the study guide generation in class. Statement 4 was designed to determine students' opinions on group work and to determine whether opinions change after constructing a study guide with their team. Statement 5 was designed to determine if the length of construction time in class was enough for the students to feel confident in their study guide.

Table 1: Displays Likert statements and the Free Response question for the Pre-Exam questionnaires.

Likert Scale	1- disagree, 5- agree
Statement number	statement
1	I was able to fit all needed information on to my study guide.
2	Constructing a study guide helps me learn.
3	I studied my notes prior to making this study guide.
4	I prefer to study in groups.
5	I had an appropriate amount of time to construct a study guide.
Free Response 1	How did you decide what to put on the study guide?

Questions in Post-Questionnaire:

Questions/statements for the Post-Exam questionnaires can be found in **Table 2**. Statement 1 was designed to measure whether the student’s organization on the study guide changed depending on the method of generation. Statement 2 was designed to measure overall usage of the study guide on the exam. Statement 3 was designed to determine how much students used their study guide to follow examples. Statement 4 was designed to determine whether the content on the student’s study guide had all the needed equations. Statement 5 was designed to determine whether the student had enough time to finish the exam; this may be a telling sign that the student was using the study guide too much.

Table 2: Displays Likert statements and Free Response questions for the Post-Exam questionnaires.

Likert Scale	1- disagree, 5- agree
Statement number	statement
1	I was able to find all needed information on my study guide in a timely manner.
2	I used my study guide extensively during the exam.
3	I followed examples on my study guide during the exam.
4	I had all equations and information I needed for this exam on my study guide.
5	I had enough time to finish the exam.
Free Response 1	What was most helpful about having the study guide available during the exam?
Free Response 2 (only Post-Exam2)	Which of the strategies to prepare the study guide (individual or group preparation) was most helpful to your learning and why?

Once all questionnaire data was collected through Qualtrics, the data was matched using a project specific code for each participant in the questionnaire. The data was then separated into Likert data and free response data. Likert data was analyzed for frequencies and direction of change, while free response data was analyzed for codes and themes within the responses.

Data Analysis:

The Likert data from questionnaires was matched by respondent. If the respondent answered both Pre-Exam questionnaires or both Post-Exam questionnaires their response was recorded as either Pre-Exam matched data or Post-Exam matched data respectively. Once these two groupings were constructed, each question on the questionnaire was separated to determine the matched N for that question, as some participants elected not to answer all Likert scale questions on their questionnaire response. Responses were then matched to create a “Delta” response grouping for each question, where the exam 1 response would be subtracted from the exam 2 response. This data set would show how students opinions changed on each question depending on construction method. Each question had a matched N ranging between 13 and 20, with most questions being in the high teens. Questions were then analyzed on frequency of response and direction of change. Positive change meant the question was given a higher response for the group study guide construction method.

Free response data was analyzed inductively by reading each response in each data set (Pre1, Post1, Pre2, Post2 Q1, and Post2 Q2), and then developing codes of each response (SAGE, 2019). The goal of the codes was to create a shortened response to reflect the actual response based on key ideas conveyed in the actual response. These codes then were condensed into themes, with each theme normally taking up greater than one code. The goal of the themes was to collect codes into groupings that shared an overarching idea. For example, a list of codes for the theme of Key Points / Examples (K/E) would be as follows: conversions, graphs, examples, lecture notes, homework problems.

Coding and theme generation was performed independently by Dr. Visco and William Brown. Both then came together to discuss what themes they had come up with. After discussion, themes for each question were decided upon and themes were reassigned to each response. The procedure of coding and theming data was performed using *Thematic Analysis of Survey Responses From Undergraduate Students* (SAGE, 2019) as a reference.

Data & Results:

Likert Data for Pre-Exam:

As seen in **Table 3** students' responses varied widely between Pre-Exam1 and Pre-Exam2 surveys. Frequencies of change in response are shown in **Table 3**. Direction of change is recorded in the bottom three rows of the table. With a positive change in response agreeing more with the statement in the questionnaire when relative to group study guides. 33% of students reported that they were able to fit all needed information on their individual study guide more than their group study guide, while the majority (50%) of students did not change their response for statement 1.

26% of students reported that constructing a study guide helped them learn less in a group environment when compared to an individual environment, while the majority (63%) of students did not change their response for statement 2.

37% of students reported that they studied more before group study guide construction relative to individual study guide construction. The majority (37%) of students changed their response favoring group study guide construction for statement 3.

46% of students reported that they did not prefer to study in groups once they were exposed to group study guide construction. The majority (46%) of students changed their response favoring individual study guide construction for statement 4.

89% of students reported that they did not have an appropriate amount of time to construct their group study guide compared to their individual study guide. The majority (89%) of students changed their response in favor of individual study guide generation for statement 5.

Table 3: Displays data from the Pre-Exam questionnaires.

CHANGE	I was able to fit all needed information on to my study guide.	Constructing a study guide helps me learn.	I studied my notes prior to making this study guide.	I prefer to study in groups.	I had an appropriate amount of time to construct a study guide.
+1	17%	11%	21%	0%	0%
+2	0%	0%	5%	15%	0%
+3	0%	0%	11%	0%	0%
+4	0%	0%	0%	0%	0%
0	50%	63%	32%	38%	11%
-1	28%	21%	21%	31%	11%
-2	6%	5%	11%	15%	33%
-3	0%	0%	0%	0%	33%
-4	0%	0%	0%	0%	11%
N:	18	19	19	13	18
Positive Change	17%	11%	37%	15%	0%
No Change	50%	63%	32%	38%	11%
Negative Change	33%	26%	32%	46%	89%

Likert Data for Post-Exam:

As seen in **Table 4** students' responses also varied widely between Post-Exam1 and Post-Exam2 questionnaires. 78% of students felt they were not able to find information as quickly on their group constructed study guide compared to their individually constructed study guide. The majority (78%) of students changed their in favor of the individual study guide for statement 1.

60% of students reported that they used their study guide less during the exam when using their group study guide compared to when they used their individual study guide. The majority (60%) of students changed their response to favor the individual study guide for statement 2.

69% of students followed less examples on their group study guide when compared to their individual study guide. The majority (69%) of students reported that they used examples more on their individual study guide for statement 3.

50% of students reported that they did not have all the equations and information needed for the exam on their group study guide when compared to their individual study guide. The majority (50%) of students changed their response to favor their individual study guide for statement 4.

82% of students reported that they did not have enough time to finish the exam while using the group study guide when compared to using the individual study guide. The majority (82%) of students changed their response to reflect that they did not have enough time to finish exam 2 (group study guide) for statement 5.

Table 4: Displays data from the Post-Exam questionnaires.

CHANGE	I was able to find all needed information on my study guide in a timely manner.	I used my study guide extensively during the exam.	I followed examples on my study guide during the exam.	I had all equations and information I needed for this exam on my study guide.	I had enough time to finish the exam.
+1	0%	10%	15%	6%	18%
+2	0%	10%	0%	0%	0%
+3	0%	0%	0%	0%	0%
+4	0%	0%	0%	0%	0%
0	22%	20%	15%	44%	0%
-1	44%	40%	15%	11%	47%
-2	22%	15%	23%	28%	12%
-3	6%	5%	23%	6%	24%
-4	6%	0%	8%	6%	0
N:	18	20	13	18	17
Positive Change	0%	20%	15%	6%	18%
No Change	22%	20%	15%	44%	0%
Negative Change	78%	60%	69%	50%	82%

Pre-Exam Free Response: Inclusion Criteria

As seen in **Table 5**, twenty-five students answered the question “How did you decide what to put on the study guide?” in the Pre-Exam1 questionnaire. Categories of responses emerged and codes and themes for each response were developed. The themes that were identified for Pre-Exam1’s responses were: study guides are for formulas, key points / examples, material that was struggled with, and prediction of what will be on the exam. Study guides are for formulas appeared 36% of the time in responses, key points / examples appeared in 96% of responses, material that was struggled with appeared in 28% of responses, and prediction of what will be on the exam appeared in 12% of responses. This differs from the responses recorded in the Pre-Exam2 questionnaire, as seen in **Table 5**. When asked the same question, twenty-one student responses generated similar themes, but with the addition of group involvement appearing. Study guides are for formulas appeared 43% of the time in responses, key points / examples appeared in 91% of responses, material that was struggled with appeared in 19% of responses, prediction of what will be on the exam appeared in 19% of responses, and group involvement appeared in 43% of responses.

Table 5: Displays the frequencies of each theme for the Pre-Exam questionnaire free responses.

Themes:	Frequency (n=25)	Frequency (n=21)
	Pre-Exam1	Pre-Exam2
Study guides are for formulas	36%	43%
Key Points / Examples	96%	91%
Material that was struggled with	28%	19%
Prediction of what will be on the exam	12%	19%
Group involvement	0%	43%

Post-Exam Free Response: Most Helpful Aspects

As seen in **Table 6**, twenty students answered the question “What was most helpful about having the study guide available during the exam?” in the Post-Exam1 questionnaire. The themes that were identified for this set of responses included formulas, examples, organization of book, and that it was unnecessary to memorize information on the exam. Formulas appeared 55% of the time in responses, examples appeared in 45% of responses, organization of book appeared in 10% of responses, and unnecessary to memorize appeared in 30% of responses. Responses for the same question in the Post-Exam2 questionnaire yielded different results, as seen in **Table 6**. Most of the same themes reappeared from the responses of Post-Exam1, but no response

mentioned using their study guide to organize their book. A new theme of benefit of construction also appeared in this data set. Formulas appeared 40% of the time in responses, examples appeared in 24% of responses, organization of book appeared in 0% of responses, unnecessary to memorize appeared in 20% of responses, and benefit of construction appeared in 8% of responses.

Table 6 : Displays the frequencies of each theme for the Post-Exam questionnaire free responses.

Themes:	Frequency (n=20)	Frequency (n=25)
	Post-Exam1	Post-Exam2
Formulas	55%	40%
Examples	45%	24%
Organization of book	10%	0%
Unnecessary to memorize	30%	20%
Benefit of Construction	0%	8%

Post-Exam2 Free Response: Preference & Explanation

Twenty-Four students answered the question “Which of the strategies to prepare the study guide (individual or group preparation) was most helpful to your learning and why?” in the Post-Exam2 questionnaire. Categories of responses emerged and codes and themes for each response were developed. Responses were classified into 4 categories individual positive, individual

negative, group positive, and group negative. Within these categories themes were developed and frequencies of each theme were determined. Individual negative only had one theme, Unsure of Content, which appeared in 4% of the responses. Individual positive had three themes, Construction, helps me learn, and time of preparation, which appeared in 33%, 29%, and 8% of responses respectively. Group negative had three themes that were identified, time of preparation, compromise, and poor group dynamics, which appeared in 38%, 33%, and 17% of responses respectively. Finally, Group positive had one theme identified, benefit of group construction, which appeared in 21% of responses. Overall, 75% of respondents said they preferred individual study guides, 13% preferred group study guides, 4% had no preference, and 8% did not identify their preference.

Discussion & Analysis:

Students that responded to the survey made it clear that they preferred the individual study guide more than the group study guide, as evidenced by a negative change in nearly all categories in the Likert data. When students were asked the question directly of “Which of the strategies to prepare the study guide (individual or group preparation) was most helpful to your learning and why?” the vast majority (75%) of students responded that they prefer individual study guides. The main reasons that students gave for this decision was that they did not have enough time to prepare the study guide in groups.

This method of group study guide generation could see improvement to get clearer results in this study. Students widely reported that they did not have enough time to prepare the study guide in class, so perhaps allowing students to have more than one class period to construct a study guide may be a good idea. Also, it is unlikely that all students prepared a list of concepts to bring into

the group study guide generation class period. This could perhaps be fixed by making the list of concepts worth a participation grade of some sort. Using that method, students may feel more compelled to perform the necessary prep-work to construct the group study guide more effectively.

Based on survey results it seems that the most helpful thing to students about study guides are that study guides carried formulas and examples for them on exams. This result would match a similar conclusion to Visco et al. (2007) where it was found that student's reported that the helpfulness of the study guide was determined by the content on the study guide and how it matched the content that was found on the exam.

While students did not list that construction of the study guide was the most helpful thing to them about the study guide like Visco et al. (2007), students did respond that construction of the individual study guide helped them learn more than the construction of a group study guide. This concept appeared in the second Post-Exam2 question's free responses, where 29% of students cited that individual study guides helping them learn was a reason why they would choose an individual study guide over a group study guide. Likert data also reflected this sentiment as most of the change that occurred on the statement "Constructing a study guide helps me learn" was negative change (26% changed their response negatively). However, the majority of students (63%), reported no change in response with this statement, which seems to counter the responses from Post-Exam2.2's free response.

When asked "How did you decide what to put on the study guide?" in the Pre-Exam1 questionnaire, students seemed to answer in one of two ways. Students would answer the question with planned usage in mind (key points / examples and formulas) or answer the question with a strategy in mind (material that was struggled with and prediction of what will be

on the exam). Similarly, when asked this question in the Pre-Exam2 questionnaire, students also answered with planned usage (key points / examples and formulas) or a specific strategy in mind (material that was struggled with and prediction of what will be on the exam). However, in the Pre-Exam2 questionnaire, students added group involvement as a common theme which would also fall into strategy.

When asked “What was most helpful about having the study guide available during the exam?” in the Post-Exam1 questionnaire, students answered the question in three potential ways.

Students would answer the question with actual usage in mind (formulas and examples) or answer the question with a strategy in mind (organization of book) or answer with a perceived value of the study guide (unnecessary to memorize). Similarly, when asked this question in the Post-Exam2 questionnaire, Students also answered with either actual usage in mind (formulas and examples) or answered the question with a perceived value of the study guide (unnecessary to memorize). However, students did not list a strategy of how they used the study guide in their responses for the Post-Exam2 questionnaire. In the Post-Exam2 questionnaire students did add the value of benefit of construction to their responses.

Based on the free response questions of the Pre-Exam and Post-Exam questionnaires, it appears that usage and construction of the study guide changed depending on the method of construction.

While the concepts of usage of the study guide remained relatively constant, students did not mention a strategy that they used the study guide for on exam 2 (group study guide preparation).

Figure 1 shows this idea visually. This could be due to change in construction method, or time to prep the study guide, as it is impossible to separate these two variables. Students’ decision of what to put on the study guide that they constructed remained relatively constant but did see the addition of group involvement as one of their methods of input.

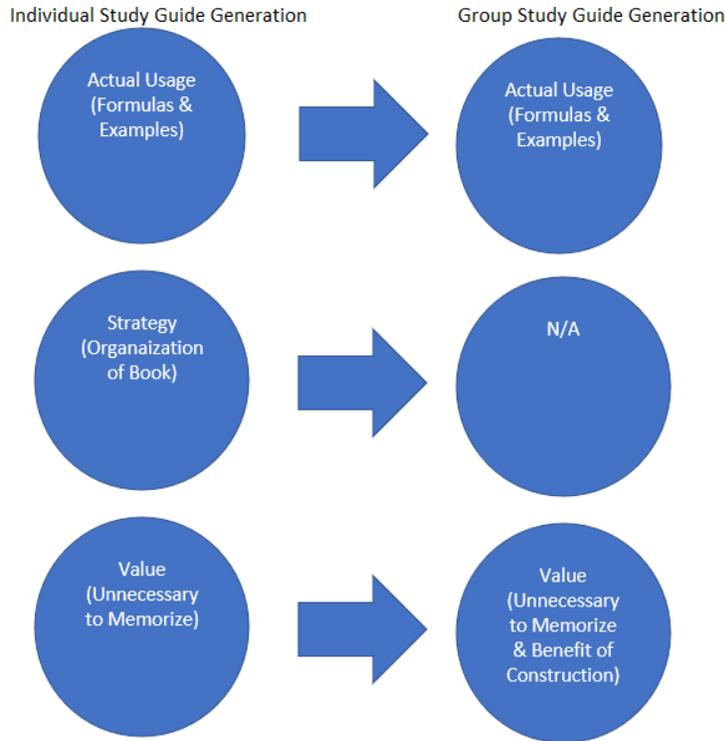


Figure 1: Figure 1 displays groupings of themes and whether they appear in each study guide generation method.

Likert data shows that students used the group study guide less on their exam when compared to individual study guides. However, students reported that they also felt like they did not have enough time to finish the exam when using the group study guide. While usage decreasing appears to agree with the hypothesis that usage would decrease while using a group constructed study guide, it was hypothesized that students would not feel worse about time management on the exam.

In conclusion, using group study guide generation did change the students' reported usage of their study guides on the exam. However, the change was not positive, as many students reported feeling like they had less time on the exam when using a group constructed study guide.

Furthermore, students were not able to maximize the utility of their study guide. While students

prioritized equations on their group study guides, they did not prioritize a strategy of how to use their group study guide on the exam. Even with equations as a priority for the group study guide construction, students still reported that they did not have all equations they needed on their group study guide relative to their individual study guide. It is possible that these changes are linked to changes in construction time rather than construction method, as these two variables are difficult to decouple.

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Appendix 1: Questionnaires

Pre-Exam1 Survey:

Use the slider to show how much you agree with each statement. Where 5 is strongly agree and 1 is strongly disagree.

	Strongly Disagree	Neutral	Strongly Agree		
	1	2	3	4	5
I was able to fit all needed information on to my study guide.	<input type="range" value="1"/>				
Constructing a study guide helps me learn.	<input type="range" value="1"/>				
I studied my notes prior to making this study guide.	<input type="range" value="1"/>				
I prefer to study in groups.	<input type="range" value="1"/>				
I had an appropriate amount of time to construct a study guide.	<input type="range" value="1"/>				

How did you decide what to put on the study guide?

Post-Exam1 Survey

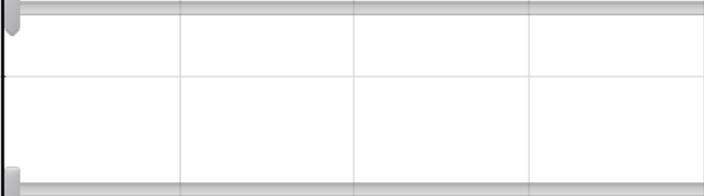
Use the slider to show how much you agree with each statement. Where 5 is strongly agree and 1 is strongly disagree.

	Strongly Disagree	Neutral	Strongly Agree		
	1	2	3	4	5
I was able to find all needed information on my study guide in a timely manner.					
I used my study guide extensively during the exam.					
I followed examples on my study guide during the exam.					
I had all equations and information I needed for this exam on my study guide.					
I had enough time to finish the exam.					

What was most helpful about having the study guide available during the exam?

Pre-Exam2 Survey:

Use the slider to show how much you agree with each statement. Where 5 is strongly agree and 1 is strongly disagree.

	Strongly Disagree	Neutral	Strongly Agree		
	1	2	3	4	5
I was able to fit all needed information on to my study guide.					
Constructing a study guide helps me learn.					
I studied my notes prior to making this study guide.					
I prefer to study in groups.					
I had an appropriate amount of time to construct a study guide.					

How did you decide what to put on the study guide?

Post-Exam2 Survey

Use the slider to show how much you agree with each statement. Where 5 is strongly agree and 1 is strongly disagree.

	Strongly Disagree	Neutral	Strongly Agree		
	1	2	3	4	5
I was able to find all needed information on my study guide in a timely manner.					
I used my study guide extensively during the exam.					
I followed examples on my study guide during the exam.					
I had all equations and information I needed for this exam on my study guide.					
I had enough time to finish the exam.					

What was most helpful about having the study guide available during the exam?

Which of the strategies to prepare the study guide (individual or group preparation) was most helpful to your learning and why?

Appendix 2: IRB Approval



Office of Research Administration
Akron, OH 44325-2102

NOTICE OF APPROVAL

Date: 2/3/2022
To: William Brown
From: Kathryn Watkins, Associate Director and IRB Administrator
IRB Number: 20211208
Title: Study Guide Generation in Chemical Engineering Thermodynamics: A Comparison Between Individual and Group Preparation
Approval Date: 2/3/2022

Thank you for submitting your Request for Exemption to the IRB for review. Your protocol represents minimal risk to subjects and qualifies for exemption from the federal regulations under the category below:

- Exemption 1** – Research conducted in established or commonly accepted educational settings, involving normal educational practices.
- Exemption 2** – Research involving the use of educational tests, survey procedures, interview procedures, or observation of public behavior.
- Exemption 3** – Research involving the use of benign behavioral interventions in conjunction with the collection of information from adult subjects through verbal or written responses (including data entry) or audiovisual recordings, and subjects have prospectively agreed to the intervention.
- Exemption 4** – Research involving the collection or study of existing data, documents, records, biospecimens specimens, pathological specimens, or diagnostic specimens.
- Exemption 5** – Research and demonstration projects conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine public programs or benefits.
- Exemption 6** – Taste and food quality evaluation and consumer acceptance studies.
- Exemption 7** – Research involving the use of a broad consent for the storage or maintenance of identifiable information and/or biospecimens for future research.
- Exemption 8** – Research involving the use of a broad consent for the use of identifiable information and/or biospecimens for future research.

Annual continuation applications are not required for exempt projects. **Any changes made to the study design or procedures require a change application be submitted to the IRB for acknowledgment and/or approval before the changes may be implemented.** If the IRB determines the change(s) pose an increased risk to subjects, and/or include activities that do not fall within the approved exemption category, a new application must be submitted.

Please retain this letter for your files. This office will hold your exemption application for a period of three years from the approval date. If you wish to continue this protocol beyond this period, you will need to submit another Exemption Request. If the research is being conducted for a master's thesis or doctoral dissertation, the student must file a copy of this letter with the thesis or dissertation.

Approved consent form/s enclosed

Approved
University of Akron
Institutional Review Board
Exempt 1 2/3/2022

Student Consent form – Included in Qualtrics Survey

**Study Guide Generation in Chemical Engineering Thermodynamics: A Comparison
Between Individual and Group Preparation**

Dear student,

You are invited to take part in a research study conducted by University of Akron Senior in Chemical Engineering, William Brown.

- The purpose of this study is to determine if the construction method of a study guide affects study guide usage on exams. This study will provide additional insight into what methods are best for study guide construction.
- You will be asked to fill out electronic surveys. Each survey will take about 10 to 15 minutes to complete. Each survey will ask you for information about study guide generation and study guide usage on exams.
- You can refrain from answering any or all questions. There are no risks associated with this study. Your decision to participate in this study has no impact on your grades.
- Data collected from this project will remain confidential and will be stored on password protected university computers. Your email will be used to link pre and post survey data, and the email will subsequently be deleted and replaced with a project specific identification number that is not linked to your identity. Data will only be reported in aggregate form, so that your responses will not be linked to your name.
- The data will be used in William Brown's honors research project for the Williams Honors College and may be used in future conference presentations and/or publications. Any publications associated with this project will present data in aggregate and will contain no information that would identify specific students.
- You may direct questions about this study to William Brown via email at wrb5@uakron.edu. This project has been reviewed and approved by The University of Akron Institutional Review Board. If you have any questions about your rights as a research participant, you may call the IRB at (330) 972-7666, or irb@uakron.edu

To begin the survey, click the arrow at the end of this page. By clicking the arrow, you indicate that you have read the information provided below and voluntarily agree to participate in the study.