Assertion-Evidence versus Traditional PowerPoint: An Investigation of the Impact of Slide Structure on Engineering Students' Cognitive load, Motivation, and Performance

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ABSTRACT

Engineers are typically asked to create slides to present their technical presentations in conferences, classrooms, and meetings. Most slides used by engineers follow a traditional PowerPoint style of a topic-subtopic structure. Contrary to the traditional bulleted PowerPoint, the Assertion Evidence (AE) slide structure replaces default phrase headlines with a succinct sentence, containing the main idea of the slide. While prior research has demonstrated that the AE style of presentations is effective towards audience comprehension of the technical presentation material, there is limited research on the effectiveness of AE slides for the *presenters'* comprehension. The main goal of this study was to examine the impact of slide structure (AE or Traditional PowerPoint) on engineering students' cognitive load, presentation self-efficacy, motivation, and performance. In order to assess this research goal, an exploratory study was conducted with 108 engineering students at Kuwait University where a group of students were asked to design slides using Assertion Evidence style of presentations and another group were asked to design slides using Traditional PowerPoint template. The main findings from this study highlighted that participants in the Assertion Evidence group had a lower perceived cognitive workload than participants that designed slides using the Traditional PowerPoint template. However, slide structure did not impact participants' motivation, self-efficacy, and understanding of the presentation material. The results from this research can be used to drive effective communication of technical engineering presentations.

Keywords: Cognitive Load, Human Factors, Slide Design, Engineering Education

INTRODUCTION

In engineering, presentation slides are often used in conferences, meetings, and classrooms, to communicate key principles, and concepts (Garner et al., 2011). Approximately two-thirds of the slides used tend to follow a topic-subtopic structure, default of Microsoft PowerPoint (Garner et al., 2011). This is where a topic-phrase headline is supported by a bulleted list and in some cases, images may accompany the bulleted list. Currently, this topic-subtopic structure dominates presentations in engineering education, as it owns 95% of slideware market share, extending from presentation projects to teaching slides in engineering classrooms to research conferences (Parker, 2001). Nonetheless, controversy has sparked regarding its effect on audience members' comprehension and violation of cognitive load and multimedia principles (Garner & Alley, 2013). Studies have also shown that the topic-subtopic format represents a poor choice for technical presentations if the goal of the presenter is for the audience to understand and retain information (Alley & Neeley, 2005). Gaskin, co-founder of Microsoft, explained that PowerPoint default template was originally created as an alternative for transparencies (Miraldi, 2021). In this format, users are responsible for the format of their presentations and were expected to alter the template to match their needs, but many users did not do so (Garner et al., 2009) .

Through this controversy, a new form of presentation has surfaced – Assertion Evidence. The Assertion Evidence structure was first created in the 1980s to address communication needs within the context of science and engineering (Garner et al., 2009). The structure composes of a succent statement at the top of the slide and a graphic to support the message of that statement, thereby abiding to the goal of multimedia principles (Fletcher & Tobias, 2005). Previous research reports that individuals tend to learn more effectively when words and pictures are presented simultaneously than words alone (Miraldi, 2021). When compared with Traditional PowerPoint presentations, assertion evidence leads to better understanding of content by audience (Garner & Alley, 2013). An experiment conducted by Alley and Garner (2013) on traditional PowerPoint and Assertion Evidence has been in favor of Assertion Evidence. Assertion evidence slides have not only shown better comprehension but fewer misconceptions and better retention of technical information among participants (Garner & Alley, 2013). The model requires greater reliance on visuals rather than text and has been reported by communication researchers to be a more effective format for technical presentation slides, since it focuses on the message and not the topic, replaces bulleted lists with visual evidence, and generates sentences on spot instead of reading (Miller & Alley, 2017).

While there is a plethora of research demonstrating the effectiveness of Assertion evidence structure for audience members, there is limited evidence on the effectiveness of Assertion Evidence for the presenters' performance (Cooper, 2017a). Specifically, it is yet unknown how slide structure impacts presenters' cognitive load, the amount of information a working memory can hold at a time (Hart & Staveland, 1988). Cognitive load is pertinent to study because it might significantly affect learning outcomes (Kirschner, 2002) given that a vital component of technical communication is the demonstration and organization of skill in technical content (Garner & Alley, 2013). Additionally, it is unknown how slide structure impacts the presenters' self-efficacy, their confidence towards giving a presentation (Bandura, 1977), and their comprehension during presentation creation. This is important since research demonstrates that presenter's knowledge of vital content material-knowledge of ideas, theories, and concepts empowers audience to think effectively (Bransford, 2012). Additionally, self-efficacy is considered an important facilitator of delivering effective presentations because prior research in social–cognitive theory (e.g., (Bandura et al.,1999)) suggests that efficacy facilitates motivation and countless experiments have found that it has positive effects on self-regulatory processes and outcomes such as effort, persistence, goal level, and performance (Bandura & Locke, 2003; Maddux & Gosselin, 2012). Finally, it is unknown how slide structure impacts participants' intrinsic motivation (Walker et al., 2006), the willingness of an individual to perform a task involving standards of excellence (Eccles et.al, 1998). This is important since it may result in satisfaction of a process and in turn increases one's competency regarding academic tasks.

In light of this prior work, the main goal of this study was to investigate the role of slide structure (Assertion Evidence or Traditional PowerPoint) on engineering students' cognitive load, motivation, and performance during the process of slide creation. This study focused on this process due to prior research that discussed the pedagogical value of the process of slide creation in students' knowledge retention (Chen, 2021; Garner & Alley, 2016). The findings from this study can be used to guide multimedia design for effective communication of engineering principles.

RELATED WORK

Since 2001, traditional presentations, known as default Microsoft PowerPoint, have been harshly criticized for violating multimedia learning and cognitive load theories (Garner et al., 2009). Even though, Microsoft PowerPoint is not the only slideware program that exists, the number of users that might be affected is more than 30 million a day and Microsoft owns 95% of the slideware market share (Garner & Alley, 2013). Presentation slides must be sensitive to both intrinsic and extraneous load, however, default PowerPoint settings are unsensitive to both needs. Multimedia principles are assumed to have the ability to improve cognitive processing, learning, and communication of information (Markel, 2009). Mayer's multimedia learning theory on cognitive load upholds six principles consisting of the temporal and spatial configuration of text, auditory narration, graphics, and animations (Mayer, 2001).

PowerPoint topic-subtopic slides prompt a headline and a text box for bullet points. The prompted headline indicates the general topic but not its relation to the other topics (Garner & Alley, 2013), interfering with learners' ability to make connections (Garner et al., 2009). The use of bullet points with detailed information, also makes it difficult to extract topic key points; increasing the risk of not communicating connections between the listed details, especially if no prior knowledge is involved (Garner et al., 2009). Moreover, because the slide contains a lot of text, a presenter, novice in the field, will most likely repeat the same information written in the slides. This allows for redundancy to take place, possibly even rising extraneous cognitive load (Garner et al., 2009). In other words, comprehension suffers when competing language-based information is presented through visual and auditory means (Garner et al., 2009).

Another issue is that text is the default for presenting in Microsoft PowerPoint and placing images is viewed as unnecessary. The purpose of graphics is to promote comprehension and explain concepts. Yet, graphics in the default structure often are chosen to replicate or to depict information already present on the slide (Garner et al., 2011). Large default text box is to blame in restricting available space for graphics. Since presenters must compromise the quality and size of the image, they tend to select ones that represent only a portion of the content. Even though graphics can provide more valuable information, if explained, than just repeat content. The assertion evidence approach to slide design was created to address communication needs within the context of engineering and science that default slides lack.

Assertion evidence slide structure, based on the cognitive theory of multimedia learning, replaces default phrase headlines with a succinct sentence, containing the main idea of the slide (Garner et al., 2011). The absence of topic-subtopic structure is replaced by a statement explicitly emphasizing the most important message or assertion an instructor is aiming to deliver (Garner & Alley, 2013). It serves as a thesis statement where learners get to interpret informational interactivity displayed in the body of the text (Garner & Alley, 2013). Interpreting and synthesizing information into a single phrase relies on being able to select important content and organize it (Garner & Alley, 2013). The body of the slide is then used to visually depict supporting evidence that explains, organizes, and interprets the headline. The main difference between assertion evidence slides and traditional default slides is the absence of bullet lists (Garner & Alley, 2013). In Assertion Evidence graphics, such as diagrams, photographs, drawings, graphs, or maps, are used as evidence to support the assertion phrase and in hand prevent instructors from committing redundancy. This is where the presenter tends to explain the topic instead of repeating slide content, even for novice presenters. Alley (2003) and Markel (2009) affirmed that the type of visual evidence used should depend on the assertion and should be explanatory and practical rather than attractive.

There are multiple ways the design of a slide can affect the success of a presentation from the perspective of the audience. First, the way a presenter designs a slide can affect how attentive a presentation turns out to be. For example, an advantage of Assertion Evidence slides is that a presenter thinks of the presentation in terms of assertions (insights, features, results, and conclusions) rather than topic-subtopic phrases, and is more likely not to include extraneous details (Mayer, 2001). If a presenter continuously reads items from the slide, often happening in presentations with bulleted lists, eye contact with the audience will be lost. Third, the way that slides are designed affects how a listener comprehends a topic (Miller & Alley, 2017).

In the context of Assertion Evidence presentations, Garner and Alley (2013) tested the effectiveness of Assertion Evidence style of presentations on engineering students' immediate and delayed recall of technical information. They found that the group that was presented with assertion evidence had significantly less misconceptions than those with topic-subtopic presentation (Garner & Alley, 2013). The Assertion Evidence slides appeared to have a deeper understanding of the more complex concepts of the presentation. Experimental research has also shown that students who incorporate Assertion Evidence presentations are more likely to be able to call upon that information when answering higher thinking level questions afterwards (Garner & Alley, 2013). However, little is known about how the creation of different presentation styles affect the presenters themselves, specifically regarding their comprehension and processing of topics. It is important to understand how the creation of slides not only affects the audience in learning presentation content but also the presenters, especially those that are new to the topic. While there has been research on the effectiveness of Assertion Evidence slides on audience members' comprehension and performance, there is limited empirical evidence on the impact of Assertion Evidence slides on the presenters' performance, which this research aims to explore.

RESEARCH OBJECTIVES

In light of prior work, the main objective of this study was to examine the impact of slide structure on engineering students' cognitive load, self-efficacy, motivation, and performance. Specifically, the following research questions (RQs) have been devised:

1. Does slide structure impact students' cognitive load?
2. Does slide structure impact students' presentation self-efficacy, motivation and understanding of the presentation material?
3. What are students' perceptions regarding the use of Assertion-Evidence slides of presentations?

Based on prior research promoting the use of Assertion Evidence slides of presentations (Miller & Alley, 2017) , it was hypothesized that participants in the Assertion Evidence group would have a reduced cognitive load and an improved motivation, presentation self-efficacy and understanding of the presentation material compared to participants in the Traditional PowerPoint condition.

METHODOLOGY

To address this research objective, an experiment was conducted with 108 engineering students (18 males, 90 females) who were in four sections of an Engineering Graphics course at Kuwait University. This course was selected since it is a required course that students from all engineering disciplines are required to take in their first two years of college (Christoforou et al., 2003). The experiment was reviewed and approved by the Ethical Review Board before it was conducted. The details of the experiment, including the procedure and data collection instruments are discussed in this section.

Data Collection Procedure

The study was completed over the course of a 2-hour lecture. At the start of the lecture, the researchers presented the study to each of the four sections of the course according to the Ethical Review Board guidelines set forth at the university. Participation in the study was voluntary, and informed consent was gathered prior to the start of the study.

After consent was obtained, the researchers instructed student participants to complete a 1-hour activity involving slide design using Microsoft PowerPoint. First, students were given 10 minutes to read a document about "Additive Manufacturing" (General Electric, 2022). After reading the document, participants were given 50 minutes to design eight slides including a title slide, introducing the topic of Additive Manufacturing to engineering students. Notably, two of the course sections (n = 59) were tasked with creating Assertion Evidence slides while the remaining two course sections (n = 49) were tasked with creating Traditional PowerPoint slides. A time limit of 50 minutes was provided to participants for the purposes of holding a controlled experimental setup between the treatment (AE) and control (Traditional PowerPoint) groups.

Participants were given a brief tutorial (~10 minutes) on creating the slides prior to the start of the activity and were given the opportunity to ask questions about to clarify any confusions. Specifically, Assertion Evidence instructions required students to assert a single caption on each slide, 8 slides, along with visual evidence. Participants needed to make the font size to 28 and no bullet points were allowed (Garner & Alley, 2013), see (Alley, 2022) for detailed examples and templates of AE slides.

Meanwhile, traditional presentation instructions required participants to make an eight-slide presentation with no further instructions. However, an example slide that followed Traditional PowerPoint templates of a title and a bulleted list was given to students. For both groups, participants were asked to pull out images from Google images. Participants were asked to submit their slides electronically.

After the 1-hour activity, participants were instructed to complete a survey that assessed their cognitive load, motivation, comprehension of the material, presentation self-efficacy, and their perceptions on the activity. The next section outlines the survey instruments in detail.

Data Collection Instruments

To study the factors pertinent in addressing the research questions, a survey was completed by students using the following research instruments:

1. Cognitive Load: NASA Task Load Index (NASA TLX) was used to assess participants' perceived subjective workload (Hart & Staveland, 1988). The NASA-TLX involved a series of 5 questions assessing the following subcomponents: temporal, mental, frustration, effort, and performance workload. For each subscale, participants responded to a Likert scale of 1-strongly disagree to 4- strongly agree.

2. Motivation: Participants' intrinsic motivation was assessed using a validated 10-item survey, the student opinion scale, that consists of two subscales: *effort* and *importance* (Tucker & McCarthy, 2001).The wording was slightly adjusted by replacing "test" with "activity". For example, questions on the effort subscale included., "I am giving my best effort on this activity.", and questions on the importance subscale included "Doing well on this activity is important to me."

3. Material Comprehension: To assess participants' level of material comprehension, a 15-question quiz was provided to students. The quiz included multiple choice and true and false questions. Assessment of student participants in this nature was used in previous research in slide structure design (Garner & Alley, 2013).

4. Presentation Self-Efficacy: To determine the impact of slide structure on participants' self-confidence in giving a presentation, participants responded to the following question: "rate how confident you are in presenting the slides you created to an audience of engineering students", on a 5-point Likert scale with 1 being not confident at all and 5 being extremely confident (Preedy, 2010).

5. Open-ended questions: Participants were instructed to respond to the following questions in 2-4 sentences: (1) What new information did you learn from creating the slides?; (2) In general, what is the most difficult part about creating presentation slides? ; (3) Was there anything different in the presentation style used? If so, what was different? Explain. (4) would you use this style of presentation again if given the chance? Explain; (5) Would you like to be taught using this type of presentation or would you prefer another style? Explain; and (6) During today's activity, was the task assigned difficult? Explain.

Content Analysis

An abductive content analysis approach was used to explore participants' responses on the open-ended questions (Timmermans & Tavory, 2012). This technique considers the prior literature on slide design while also being responsive to the nature of the data. The data was coded at the paragraph level. The data was coded by two raters (an Assistant Professor of Industrial Engineering, and an Industrial Engineering Research Assistant) and acceptable interrater reliability (Cohen's Kappa = 0.65) was observed (Landis & Koch, 1977). The data was coded on the following criteria: simplicity of task, temporal demand of task, use of presentation style in future, being taught using presentation style, see (Alsager Alzayed & Alzamel, 2022) for codebook.

DATA ANALYSIS AND RESULTS

In total, 108 participants (18 males, 90 females) participated in the study. To answer the research questions, statistical analyses were computed using SPSS 28.0, and a significance level of 0.1 was used in all analyses. The results are presented as mean ± standard deviation (SD) unless otherwise denoted.

RQ1: Does slide structure impact students' cognitive load?

The first research question was devised to assess the impact of slide design on engineering students' perceived cognitive load. To address this research question, seven independent samples t-tests were computed with the independent variable being treatment condition (Assertion-Evidence, Traditional PowerPoint) and the dependent variables being participants' scores on the (1) overall workload score on NASA-TLX, and the different NASA-TLX subscales: (2) mental demand, (3) temporal demand, (4) performance, (5) effort, and (6) frustration. Prior to computing the statistical analyses, three assumptions were checked. First, the box and-whisker plot (Dawson, 2011) revealed 2 and 4 outliers for participants' scores on the mental and performance subscales, respectively. In order to determine the impact of the outliers on the results, the statistical analyses were conducted with and without the outliers. The outliers did not have an impact on the significance of the results and therefore, the full analysis was used. Second, normality was confirmed by visually inspecting the histograms and quantile-quantile (Q-Q) plots of the scores (Miot, 2017). Third, the Levine's Test for Equality of Variances (Brown & Forsythe, 1974) revealed that the scores on the five subscales did not violate the assumption of homogeneity of variances ($p > 0.1$). However, the overall NASA-TLX workload score violated the assumption of homogeneity of variances ($p = 0.022$). Thus, a Welch t-test (Ruxton, 2006) was computed to assess the differences in overall NASA-TLX scores between the two conditions.

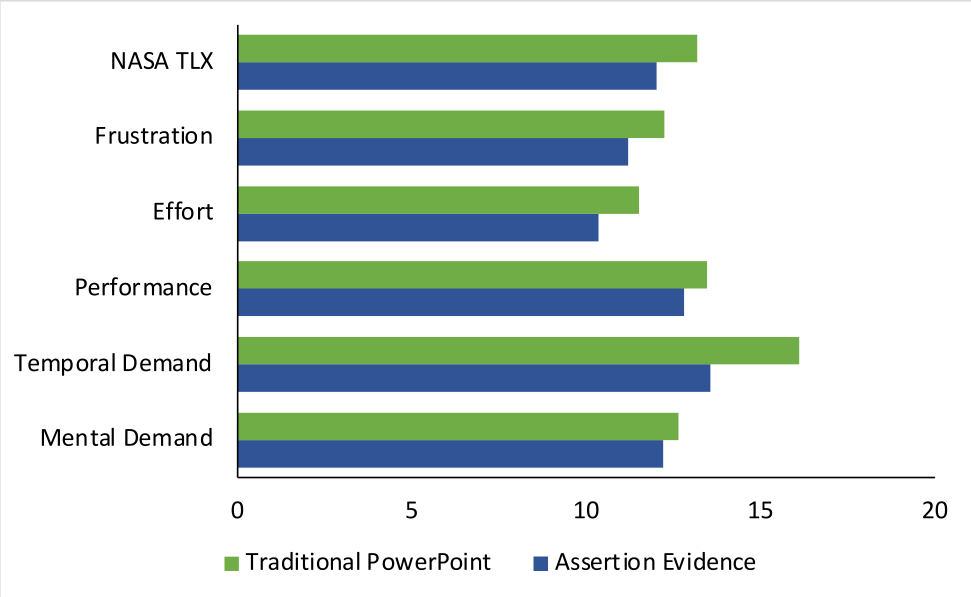

Figure 1. Average workload scores from participants in the two groups

The results from the Welch T-test highlighted those participants in the Assertion Evidence condition had a lower perceived cognitive load (M = 12.02, SD= 3.68) compared to participants in the Traditional PowerPoint (M = 13.20, SD = 2.59) condition, t(103.39) = 1.96, d = 0.32. The observed effect size is considered large (Cohen, 1988). Additionally, the results from the independent sample t-tests indicated that participants in the assertion evidence condition (M = 13.56, SD = 6.16) had lower perceived temporal demand compared to their counterparts in the traditional PowerPoint condition (M = 16.12, SD = 4.82), t(106) = 2.37, d = 0.46. The observed effect size is considered large. However, there were no statistically significant differences between participants in the two conditions on all of the four other subscales, p > 0.1, see Figure 1 for a summary of the statistics. The results from this research question partially support our hypothesis that the assertion evidence style of presentation was helpful in terms of a reduced cognitive load for participants. However, this was only true in terms of the general NASA-TLX and the temporal demand of participants.

RQ2: Does slide structure impact students' motivation, self-efficacy, and understanding of the presentation material?

The second research question was devised to assess the impact of slide design on engineering students' presentation self-efficacy, motivation and understanding of the presentation material. In order to answer this research question, three independent samples t-tests were computed with the independent variable being treatment condition (Assertion evidence, traditional PowerPoint) and the dependent variables being participants' (1) perceived importance of the task, (2) perceived effort on the task, (3) presentation self-efficacy, and (4) score on the comprehension quiz. Prior to computing the statistical analyses, the same three assumptions checked in RQ1 were verified for the data used in RQ2. Since none of the assumptions were violated, the analyses proceeded as planned. The results from the four independent samples T-tests indicated that there were no statistically significant differences between participants in the two conditions on all four measures: (1) perceived importance of the task, (2) perceived effort on the task, (3) presentation self-efficacy, and (4) score on the comprehension quiz, see table 2 for summary statistics.

Table 2. Summary and descriptive statistics for factors studied in RQ2

Category	Slide Structure	Mean	Std. Deviation	t	f	
Importance	Traditional PowerPoint	16.61	3.05	1.08	06	.29
	Assertion Evidence	17.19	2.50			
Effort	Traditional PowerPoint	17.76	2.13	1.14	06	.26
	Assertion Evidence	17.15	3.13			
Presentation Self Efficacy	Traditional PowerPoint	2.94	1.14	0.032	06	.98
	Assertion Evidence	2.93	1.00			
Quiz Score	Traditional PowerPoint	6.67	2.04	0.67	06	.75
	Assertion Evidence	6.97	2.42			

RQ3: What are students' perceptions regarding the use of Assertion-Evidence slides of presentations?
While the first two research questions investigated the impact of slide structure on cognitive load and understanding of participants, the third research question sought to understand participants' perceptions of slide structure on their performance. In terms of temporal demand, participants have found the Assertion Evidence slide structure to pose less temporal demand when compared to traditional PowerPoint slide structure, see Figure 2. For instance, temporal demand was considered when participants mentioned short time in their responses like participant #105 (Assertion Evidence), "there is no difficulty in the subject, but the time is a little short" or participant #35 (Traditional PowerPoint), "the time wasn't enough".

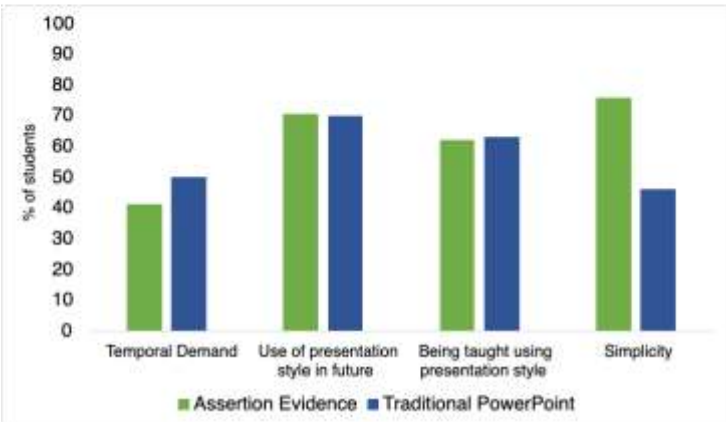

Figure 2. Students' perceptions on the use of Assertion Evidence slides compared to traditional PowerPoint

Second, in terms of using the presentation style in the future, there were no large differences in participants' preferences between participants who used the Assertion Evidence structure compared to Traditional PowerPoint. Participant 104, who used the Assertion Evidence slide structure, mentioned "it is easier and summarizes the topic and includes only the main points". Although there was positive feedback regarding the use of Assertion Evidence in the future, 40% of participants in the Assertion Evidence group did not prefer to use this structure of presentation in the future. For instance, Participant 65 reported that they will not use this structure in the future because they "prefer more explanation and more points in an organised way." Additionally, those who used traditional PowerPoint have also showed both positive and negative preferences about using this structure in the future. For example, Participant 24 mentioned, "Yes it makes perfect sense to use this style as it can achieve the attention of the students and make them learn at a faster pace". However, Participant 23, mentioned that they will not use Traditional PowerPoint in the future because, "No, because it is indirect and incomprehensible and does not encourage understanding."

Third, there were no significant differences in participants' preferences regarding being taught using the Assertion Evidence structure compared to Traditional PowerPoint. The qualitative results indicated that the Assertion Evidence slide structure was equally favourable to the sample of students in this study compared to the Traditional PowerPoint structure. For instance, Participant 27, in the traditional group, mentioned, "Yes, I would like to be taught using this type of presentation. It helps us process the information and understand the topic". Meanwhile, Participant 71, in the Assertion Evidence group, discussed, "Yes, I prefer this method because it helps to develop thought and helps correctly understanding the information."

Finally, the results show a large difference between Assertion evidence responses and those of traditional PowerPoint on simplicity. Specifically, 30% more participants in the Assertion Evidence structure found the structure to be simple compared to the Traditional PowerPoint group. For example, participant 75, in the Assertion Evidence group, reported that "it is easier to access information and more clearly so that it contains a picture that enables the information to be consolidated." Participant 104 also reported on how simple the slide structure was, "it was clear and good, and I loved it". However, Participant 23, who used the traditional PowerPoint structure, stated that they wish not to use again because "it is indirect and incomprehensible and does not encourage understanding".

DISCUSSION & CONCLUSION

The principal goal of this study was to examine the impact of slide structure on engineering students' cognitive load, presentation self-efficacy, motivation, and performance. The main findings from this study are highlighted in this section with respect to the three research questions.

The current study indicated that participants in the Assertion-Evidence group had a lower perceived cognitive workload. Specifically, participants in the assertion-evidence condition had lower overall perceived workload in addition to a lower temporal demand. This finding supports previous research that found that assertion evidence presentations pose lower perceived mental effort than that of Traditional PowerPoint. This indirectly relates to difference in extraneous cognitive load as both groups were given the same material (Garner & Alley, 2013).

The results of this research also revealed that slide structure did not impact participants' motivation, presentation self-efficacy, and understanding of the presentation material. This refuted our hypothesis that Assertion-Evidence style of presentations would be more effective in driving students' motivation, presentation self-efficacy, and understanding of presentation. The lack of difference in participants' motivation could be attributed to the nature of the task since both groups had low mean motivation scores on the importance (Assertion Evidence = 17.23, Traditional PowerPoint = 16.59) and effort (Assertion Evidence = 17.18, Traditional PowerPoint = 17.71) subscales. This could also be the same with participants' mean scores on the quizzes since both groups performed poor on the quiz (Assertion Evidence = 6.97, Traditional PowerPoint = 6.67). Thus, future iterations of this research should compare the influence of Assertion-Evidence presentations with other incubation activities (e.g., traditional classroom lecture on Additive Manufacturing). Finally, participants might be overwhelmed with the number of questions on the survey and thus are not motivated to perform well on the quiz (i.e., survey fatigue) (Porter et al., 2004).

Additionally, participants' presentation self-efficacy was also low for both the assertion evidence ($M = 2.93$, $SD = 1.0$) and Traditional PowerPoint ($M = 2.94$, $SD = 1.1$) group with no significant differences between the two groups. This lack of difference might be due, in part, to the lack of ecological validity (Andrade, 2018) of this study, as participants were not asked to present their slides to any audience. Thus, future research is warranted to ask participants to not only design slides but also present these slides to an audience, and then assess the outcomes of the activity through the survey.

The third finding of this paper was that most participants in the Assertion-Evidence group reported that the slide structure was simple. This is promising as it indicated that the Assertion-Evidence structure of slide design would be positively received by students and would not require extensive instructions. Notably, participants were only exposed to Assertion-Evidence style of presentations for 50 minutes, and thus, any longer-term effects, whether positive or negative, might not be captured in this experimental study. Thus, future work is warranted to evaluate the impact of slide structure on students' performance and perceptions across an entire course semester, and not immediately after an activity.

While the results of this study are promising in support of the promotion of assertion-evidence presentations, there exist some limitations. First, the study was conducted with engineering students at Kuwait University. Future research should extend the findings across engineering professionals in industry and more seminars should be conducted in universities and companies to teach the assertion-evidence approach. Second, participants were given the comprehension quiz immediately after completing the slide design activity. Thus, we cannot conclude if there are longer term effects of slide structure on comprehension of the material. Third, the experimental design in this study had unequal sample sizes between the Assertion Evidence (n = 59) and the Traditional PowerPoint group (n = 54), which leads to an unbalanced statistical analysis. While prior research found that an unbalanced analysis does not impact the results of a single-factor ANOVA (Milhken & Johnson, 1984), future work should seek a more balanced statistical analysis by having an equal number of participants in the two groups. Fourth, while this study had a time limit for participants to create slides, future research is warranted to examine whether students' experiences and performance with the AE style of presentation might be different if there was no time limit to creating slides. Finally, while this paper explored the impact of slide structure on presenters' performance, participants did not actually present the slides. Hence, we cannot determine the impact of slide structure on participants' actual performance in presenting the slides. Future iterations of this research should survey students after the actual presentation of the material and compare those results to the findings presented in this study to ascertain whether the observed benefits of AE can be observed after the actual presentation. Taken as a whole, the results from this study can be used to drive effective communication of technical presentations in engineering.

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