Using Multi-Image Presentations to Enhance Continuing Engineering Education

Dr. Charles E. Baukal Jr. P.E., John Zink Co. LLC

Charles E. Baukal, Jr. has a Ph.D. in Mechanical Engineering, an Ed.D., and Professional Engineering License. He is the Director of the John Zink Institute which offers continuing professional development for engineers and technicians. He has nearly 35 years of industrial experience and 30 years of teaching experience as an adjunct. He is the author/editor of 13 books on industrial combustion and is an inventor on 11 U.S. patents.

Dr. Floyd B. Ausburn, Oklahoma State University

Dr. Ausburn is Adjunct Professor Emeritus, Oklahoma State University. He was previously Assistant Professor, Monash University, Melbourne, Australia and Chairman, Oklahoma International Development Group. Dr. Ausburn has worked in 19 countries and is author/co-author of numerous articles and papers at state, national, and international levels. His primary research interest is virtual reality and digital imagery in technical education.

Dr. Lynna J. Ausburn, Oklahoma State University

Dr. Lynna Ausburn is Professor Emerita of Workforce and Adult Education, College of Education, Oklahoma State University, Stillwater, OK. She holds a PhD in instructional media and technology from the University of Oklahoma. She has more than 30 years of experience in adult and workforce education in 19 countries. She also has an extensive list of publications and conference papers at state, national, and international levels, and has won several major awards and an Oklahoma Governor's citation for research and university teaching. Her current research interests include virtual reality in technical training, adult learning, and instructional strategies. Dr. Ausburn can be reached at lynna.ausburn@okstate.edu.

Using Multi-Image Presentations to Enhance Continuing Engineering Education

Abstract

Research has shown that engineers are considerably more visual than the general population and that engineers prefer more visual multimedia materials for continuing engineering education (CEE). These materials include, for example, photographs, drawings, videos, animations, and virtual reality. Research also has shown that multi-image presentations can enhance learning. Therefore, it is argued that multi-image presentations can enhance CEE.

This paper reviews the relevant literature on multi-image presentations, describes how a multi-image presentation was used in a research study that considered CEE preferences, discusses the potential benefits and problems of using multi-image presentations, and provides some recommendations on how to use multi-image presentations in CEE along with some potential areas for future research.

Introduction

The use of multiple images simultaneously on one or more screens in presentations is referred to as *multi-image (multiple image) presentations* [1]. Biere defined it as "an audio-visual presentation utilizing a synchronized soundtrack and multiple projection devices that display images over one or more screens" [2]. This means there may be more projectors than screens, with multiple projectors per screen where there may be images dissolving in and out or projectors focused only on a particular section of a screen [3]. Some define multiple image specifically to mean multiple projectors [4]. Using multiple screens was popular some time ago but does not appear to be as popular today, except in large rooms where multiple screens are used to permit viewers around the room to better see the content no matter where they are seated. However, true multi-image presentations simultaneously show different related content on different screens, rather than merely duplicating the same content on multiple screens. An alternative format is multiple images presented simultaneously on a single large screen, with each image containing different content. This has sometimes been referred to as "split screen" technique.

Large-scale multi-imagery shows were featured in special films presented at the 1967 World's Fair (Expo 67) in Montreal, Canada. This showcase created interest in multi-image presentations. One early commercial use of the format was the original 1968 film *The Thomas Crown Affair,* in which split-screen multi-imagery was used to add excitement and movement to a polo match and, more importantly, to advance the film's plot by showing simultaneously various aspects of the implementation of a bank hold-up.

During the 1970s, multi-image shows became a commercial entertainment enterprise. The literature on early multi-imagery was extensively reviewed by Ausburn [5]. These shows, which toured entertainment venues nation-wide, were made using 35mm slides and multiple slide projectors with images fading in and out with appropriate synchronization, sometimes on as many as five screens, although two or three were more common. A simple presentation set-up is shown in Figure 1. A complex set-up could include 24 or more projectors and numerous screens. On the potential of multi-image presentations, Mezey ([6], p. 1) wrote, "Multi-image production

is one example of how we can organize and relate aural and visual media in a nonlinear presentation that can reach and teach audiences within minutes of viewer contact."

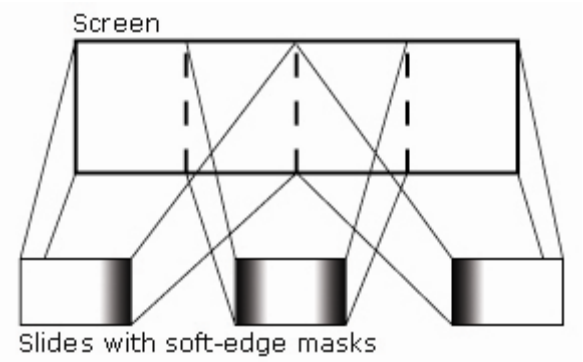

Figure 1. Basic multi-image slide presentation set-up (Source: https://en.wikipedia.org/wiki/File:Multi-Image_PanProjection.png, released for public domain usage).

The slide-based multi-image presentations had synchronized soundtracks. They required complex mechanical apparatuses to switch between projectors and to control the sound-pulse audio equipment. Creating those presentations was expensive and challenging given the available technology and required costly equipment, skilled designers, and large teams of technical specialists. This cost and production difficulty eventually kept multi-imagery from entering the mainstream of technology and from gaining use as a tool for instruction. While it was cheaper than film, it was too expensive and labor-intensive for most educational uses.

Today, however, the technology for creating and presenting multi-imagery is dramatically different. Creating such presentations today is much easier given the ubiquity of computers, digital projectors, and sophisticated but easy-to-use software such as PowerPoint that can be used to control the timing of displaying content. This new computer-based multi-imagery technology opens the door to its use as an instructional tool, including in the field of continuing engineering education.

Stimulus Presentation Methodology

Multi-imagery and other media technologies are examples of what is often termed *stimulus presentation methodology*. Stimulus presentation methodology occurs when organisms are exposed to different types of stimuli to determine their reactions or performance. This methodology has been used in a wide range of fields such as psychology (e.g., [7]), medicine (e.g., [8]), and child development (e.g., [9]). It has also historically been used in multimedia research ([10]). For example, Schmidt-Weigand et al. [11] used this methodology to study visual attention distribution in learning from text and pictures in multimedia learning using system-paced vs. self-paced instruction. In that study, the text for the instructional program on the subject of lightning was either written or spoken (narrated). The results showed that participants spent more time looking at the visualizations with spoken text, compared to written text (where they alternated between reading the text and looking at the visualizations). Another example is the study by Murray and Thomson [12] who used the stimulus presentation methodology to study age-related differences on cognitive overload in an audio-visual word recall test.

Stimulus presentation in education has typically been done *sequentially* where participants view some type of presentation one page, slide, or screen at a time (e.g., [13]). In research using this mode, groups of participants are typically assigned to different treatments and then the group performance means (usually some type of comprehension post-test) for each treatment are compared to each other to determine if one treatment is more effective than another. Another less common type of stimulus presentation research is when two different treatments are compared side-by-side, or *simultaneously*. The latter stimulus presentation methodology was used in a recent study by Baukal and Ausburn of the multimedia preferences of working engineers [14].

Mayer's Cognitive Theory of Multimedia Learning

Regardless of the technology or stimulus presentation mode used, multimedia presentations require good instructional design to be effective. Mayer [15] offered 12 research-based principles for designing effective multimedia presentations which are based on his Cognitive Theory of Multimedia Learning:

1. **Coherence Principle**: exclude extraneous words, pictures, and sounds.
2. **Signaling Principle**: use cues to highlight the organization of the essential material.
3. **Redundancy Principle**: use graphics + narration, rather than graphics + narration + text that repeats the narration.
4. **Spatial Contiguity Principle**: corresponding words and pictures should be located close to each other.
5. **Temporal Contiguity Principle**: corresponding words and pictures should be presented simultaneously rather than successively.
6. **Segmenting Principle**: presentations should be divided into segments rather than in long continuous units.
7. **Pre-training Principle**: present the names and characteristics of the main concepts before the actual multimedia presentation.
8. **Modality Principle**: graphics + narration are better than graphics + text.
9. **Multimedia Principle**: text + pictures are better than text only.
10. **Personalization Principle**: text should be in conversational, rather than formal, style.
11. **Voice Principle**: narration should be in a friendly, standard accent, human voice rather than in a foreign accent or machine voice.
12. **Image Principle**: including a picture of the speaker on the screen does not necessarily improve learning.

Mayer's theory was derived from three other theories: (1) Baddeley's Working Memory Theory, (2) Paivio's Dual Coding Theory, and (3) Sweller's Cognitive Load Theory. According to *Baddeley's Working Memory Theory* [16, 17, 18], humans have a limited capacity to process information in memory channels. This means multimedia designs should not overload a learner's memory channels or learning will be reduced. In *Paivio's Dual Coding Theory* [19, 20], text and graphics are encoded into two different memory channels: verbal and nonverbal. The theory suggests that multimedia designers should use both channels to reinforce concepts for the learner. However, while verbal and visual information can collaborate to enhance learning, they can also compete and reduce learning if not properly designed [21]. According to *Sweller's*

Cognitive Load Theory [22, 23, 24], instructional materials should not overload a learner's mental processing. For example, having a figure on one page and the text describing the figure on a different page increases the mental integration required by the learner which increases the cognitive load that could reduce learning. This theory suggests that multimedia designs should eliminate unnecessary processing for the learner.

Of specific interest here are Mayer's spatial and temporal contiguity principles which state that related materials should be presented as close to each other as possible to aid the viewer in processing the information. A common example where this principle is violated occurs in textbooks is where a figure is on one page and the text discussing the figure is on another page, so the reader has to constantly flip back and forth between pages. Similarly, this occurs in presentations where related content is presented on successive slides. The problem for the viewers is that they cannot go back and forth between slides as the presenter is in control of which slide is being viewed. Multi-image presentations can help mitigate that problem.

Multi-Image Presentations

One type of multimedia presentation is called *multi-image*, which is defined as "simultaneous projection of two or more pictures on one or adjacent screens for group viewing" ([25], p. 392). The Association for Multi-Image (AMI) considered a multi-image program as consisting of an audio tape and three screens of slides or film [26]. It may also include the use of audio synchronization [27]. Various labels have been used to describe this instructional design method including multi-media, multi-screen, wide screen, multiple-image, multiple-screen, and non-linear projection [28]. Multi-image presentations apparently date back to 1896 when Frenchman Claude Autant-Lara used multiple screens for a presentation on gold exploration [29]. Several studies are presented here to illustrate the nature of research on multi-imagery and to provide findings of use to designers of continuing engineering education.

Perrin [30] identified three major factors distinguishing multi-image from the conventional use of single-image media: simultaneous images, screen size, and information density. Simultaneous images are of particular interest here. Ingli [31] experimentally found that college classes assigned to multi-image instruction scored significantly higher than the control classes assigned to traditional single-image sequential instruction methods. Another important finding of the study was the multi-image classes completed the course content in 85% of the time compared to the traditional class, even though only about one-quarter of the course content was converted to multi-image. Therefore, multi-image may be more efficient for learning compared to single-image and is particularly effective for large audiences [32]. Multi-image presentations may also be more motivating for learners [33].

Meyrowitz [34] listed 11 relationships that are potentially present in multi-image presentations: redundancy, cross-modality redundancy, generic/specific, compare and contrast, relationship of interacting variables, parallel messages, analogical messages, temporal relationships, spatial relationships, generic concepts, and ideograms (combining images to form a concept). Dyer [35] identified ten major strengths of multi-image presentations: comparison, contrast, multiple perspectives, sequence, juxtaposition, direct emphasis, sustained emphasis, motion effect, combining motion and still pictures, and the ability to create a panorama. The simultaneous presentation of multiple concepts results in more efficient learning [36]. Bullough [37] similarly identified the comparison capability, but also noted that multi-image can increase information density and make learning more efficient if the presentation is properly designed.

Research on multi-image compared to single image presentations in learning contexts was very popular in the 1960s and 1970s [38]. Multi-image research has traditionally focused on how the images were presented – simultaneously versus sequentially [39]. For example, Travers [40] experimentally found simultaneous presentation to be consistently more effective than sequential. Much research has been done studying how multiple channels can be used to enhance learning (e.g., [41]), where two different screens may be considered as two different channels [42]. The research on whether multi-image presentations enhance learning compared to single-image presentations was generally considered inconclusive [43, 44]. Some researchers argued this was because multi-image had not been properly used because too many senses had been engaged which overloaded the viewer's cognitive abilities to process the information [44].

Jonassen [45] argued that simply having multiple simultaneous images does not necessarily lead to simultaneous mental processing and that there is no way to know exactly how individual viewers will perceive and interpret multiple images. He posited (p. 292), "The structuring of multi-image presentations should be designed by using established cognitive strategies based on existing theory. Multi-image is not a medium; it is a presentation technique that has potential for manipulating visual perception and, subsequently, cognition."

Clark [46] examined multi-imagery's relationship to concept formation. In a meta-data study of research related to concepts, he found that using both positive and negative instances helped students to better understand concepts and that the bigger the difference between the positive and the negative instances the greater the learning. He also found that simultaneous display of four instances of a concept produced the best learning. In their instructional design guide for teaching concepts, Merrill and Tennyson [47] supported Clark's findings and recommended one approach using direct comparisons with dual projectors. They recommended showing the best example of the concept first on the left projector, followed by showing a non-example of the concept on the right projector. If only a single projector is available, they suggested a split-screen technique with the left half of a slide showing the best example and then the right half of the slide showing a non-example.

Burke [48] provided a less positive view of multi-imagery, stating that "The successes of multi-imagery with traditional linear information are limited to young children, underachievers, and tactily-oriented haptic learners" (p. 159). In addition to the increased cost and complexity, Burke listed several shortcomings he believed may explain why multi-imagery was rarely used in educational contexts at that time.

Burke and Leps [49] reviewed multi-image research over a 30-year period and claimed few studies were done and relatively little valid information had been produced. They wrote (p. 184), "very little beyond the level of common sense has been discovered which would serve theoreticians as a foundation for important statements on multi-image design and use." Nearly all of the studies examined by Burke and Leps were limited to full-time students as the subject populations. Additionally, those studies did not follow Perrin's (1969) recommendation for the multi-image presentations to enhance the basic message, but rather merely repeated it across multiple screens. However, some benefits were found in some studies for using multi-image compared to single image. These benefits included enhanced learning for under-achievers, haptics, and media novices, as well as improved retention, although some of the studies could not be replicated.

Multi-imagery was used in a completely different context and methodology by Berger [50] who used a form of multi-images in psychotherapy which he termed *multi-image immediate impact video self-confrontation*. In this technique, the same videos are shown side by side where one screen is unadulterated and the other is deliberately distorted. The purpose is to help patients more freely associate about their past and present self-concepts and introjections, to help them gain greater insights into themselves. The technique was tested on 40 long-term patients where 70% spontaneously recalled memories of the experience in the weeks following the test.

Returning to a learning context, Fradkin [51] studied the effectiveness of cognitive recall after viewing one-, two-, and four-image programs. The participants were 129 tenth-grade students in nine homeroom classes, with three classes assigned to each of the three treatments. The same set of 40 visuals was shown to each class and each visual was shown for the same amount of time. The difference in the presentations was how many visuals were shown at one time. The total number of minutes to show the visuals was four, two, and one, for the one-, two-, and four-image projection tests, respectively. Participants were post-tested on recall immediately after viewing the images, after 24 hours, and a third time after one week. Recall was the best when the images were viewed singly and immediately after the test. Recall declined with more images being viewed simultaneously and with more time after viewing the images. However, this research design did not follow Perrin's [30] recommendations for how to most effectively use multi-images to enhance learning as the multi-image presentations were essentially compressed versions of the single-image presentation.

Trohanis [52] studied the presentation length of audible multi-imagery (AMI) presentations. AMI is a combination of multiple projection screens (three separate but contiguous screens in Trohanis' study) and with a corresponding audiotrack where a control system advances the slides. The primary variable of interest in that study was the program length, where essentially equivalent 10-, 20- and 30-minute presentations on high school psychology were used to study recall and retention. A total of 253 students in 10 classes from two high schools were sampled. The results showed that immediate and delayed (one week) retention were both highest for the 10-minute presentation. The shortest presentation was the most efficient program for learning.

Owens and Coldevin [44] studied the effects of the time that images were shown in a dual-image presentation. The three treatments studied included a visual overlap of three seconds, six seconds, and fully overlapping. In the first two cases, two slides were shown simultaneously for either three or six seconds, after which one slide was removed and replaced with a blank slide. The time the slides were shown simultaneously was controlled to be either three or six seconds. In the overlapping case, two slides were shown simultaneously but one of them was being dissolved out and replaced with another slide so there was a complete visual overlap. Any individual slide remained on the screen for between ten and twenty seconds. Taped narration accompanied the presentations. The results of the three treatments were also compared to a single-image presentation. The presentations were twenty minutes long and the topic was the nation of Zambia. The subjects were eighth graders from 10 classes from a suburban Montreal high school, where two classes were randomly assigned to the four experimental treatments (three multi-image and one single-image) and to a control group (post-test only). Scholastic ability as measured by mean scores on term examinations was used as a covariate. Significant differences were found for males who scored significantly higher than females and for students with high scholastic ability who scored significantly higher than students with low scholastic ability. All experimental treatment groups scored significantly higher than the control group which did not see any presentation. The only significant difference between treatments was the

multi-image complete overlap group scored significantly higher than the three-second overlap group. This suggested that somewhere between a three second overlap and a complete overlap is recommended for optimal learning.

Jonassen [45] experimentally studied the effects on learning of single- and multi-image presentations on plant biology for 362 seventh-grade students in life sciences classes in a suburban junior high school. Presentations on different plant classifications were shown on one, three, and four screens. In the single-screen presentation, 41 slides were linearly sequenced. In the three-screen presentation, additional examples and non-examples were included (a total of 115 different images) compared to the single screen presentation, following the recommendations of Clark [46] and Merrill and Tennyson [47]. In the four-screen presentation, a total of 75 images were displayed including the original 41 slides plus 34 of those original slides repeated, again showing both examples and non-examples simultaneously. Participants were given tests to measure their conceptual style (analytic vs. relational), field articulation (analytic vs. global), and focal attention (scanners vs. focusers). They were also tested on their ability to classify plants after viewing the various types of presentations. The results showed that students' plant classification performance was better for the multi-screen than for the single screen presentation, although it was only statistically better for the four- vs. one-screen presentations. None of the learner styles was a significant predictor of plant classification performance.

Whitley and Moore [53] studied the effects of presentation mode (single-image vs. multi-image) and student perceptual type (haptic vs. visual). Extreme haptics only use their eyes when they have to and use touch and kinesthesis otherwise, as compared to extreme visuals who depend on visual experiences [54]. Whitley and Moore hypothesized that using multi-image presentations would aid haptics who have difficulty mentally retaining visual imagery. The subjects were 40 visual and 40 haptic students selected from a group of 200 English students from a community college in Virginia. Perceptual types were determined using Lowenfeld's Test of Subjective Impressions and Visual-Haptic Word Association Test [54]. The presentations contained 20 groups of pictures, where each group contained three similar pictures from art books. In a post-test, subjects had to select the criterion photo in each group of pictures. The haptic and visual groups were each divided into two groups: single-image and three-image presentations. The results showed that visuals scored significantly higher than haptics regardless of how many images were used and that haptics scored significantly higher when viewing the simultaneous multi-image presentation compared to the sequential single-image presentation. There was no significant difference for visuals viewing the single- or multi-image presentations. This confirmed the results of Ausburn's [55] earlier study of sequential versus simultaneous multiple imagery with visual and haptic learners which found that simultaneous multiple imagery particularly benefitted haptics in quickly and accurately locating a specific item (button, switch, etc.) on complex items of equipment.

Jurgemeyer [56] noted that multi-image research studies produced conflicting results on the ability of multi-image presentations to enhance *learning*. He designed a study to see if multi-image has the capability of changing the *attitudes* of viewers. The topic for the presentations was instructional display boards (bulletin boards) which was traditionally relatively uninteresting for undergraduates taking an introductory audiovisual methods course. Forty-four students from the audiovisual class participated in the research. This study did not compare single-image vs. multi-image presentations as only a three-screen presentation was used. Both an attitudes and an applications test were given to the participants. The results showed that the multi-image format was not very successful for learning performance as only 28% of the students achieved the

desired target of at least 90% correct on the applications test. This result was not compared against how students performed in previous classes which did not use the multi-image presentation. However, the multi-image format was successful in changing students' attitudes to be more favorable toward the content compared to their attitudes before the presentation. Again, this was not compared to students' attitudes in previous classes before and after studying that topic, so it is unclear how students' attitudes after the multi-image presentation compared to those after the traditional single-image presentation.

Leps [57] hypothesized that learners with a more holistic or non-linear cognitive style would learn better with multi-image presentations and that learners with a more serial or linear cognitive style would learn better with single-image sequential presentations. The topic used for the study was photography. Cognitive style was determined using several instruments. The sample consisted of 190 undergraduate students who were randomly assigned to the experimental groups. Pre-test scores were a covariate in the study. The results showed no statistically significant difference in post-test scores so the research hypothesis was not supported. The single- and multi-image presentations were not identical in length or content which could have been confounding variables in the study.

More recently, Kuo, Chang, Hsu, and Yu [58] experimentally compared single-screen and dual-screen presentations where the topic was programming language instruction. The participants were undergraduate students where 23 were randomly assigned to the single-screen and 19 to the dual-screen presentations. The content was identical in both formats; however the material was presented sequentially in the single-screen format and simultaneously in the dual-screen format. The results showed that students had better perception and felt the learning materials were clearer and easier using the dual-screen/simultaneous compared to the single-screen/sequential presentation.

Wiseman and Gordon [59] wrote as a summary of the mixed findings of multi-image research (p. 3), "multi-image provides a further flexible alternative along with other traditional means of large group instruction." This body of early research on the effects of multi-images on learning was clearly inconclusive. Salomon and Clark [10] argued that research on the effectiveness of multimedia in general was inconclusive because the only factor that varied in the gross media comparison research studies was the delivery mechanism because the content was essentially the same. They called for research in more realistic contexts (higher external validity) to study the interaction between the learner and the medium to find the best way to use that medium and under what conditions. No research was found by the present authors on the use of multi-image presentations to enhance learning for adults (i.e., beyond college students), which is of particular interest in CEE.

Benefits

Benefits that may accrue from using multi-imagery are important considerations for designers of engineering education. The most important potential benefit of multi-image presentations is enhanced learning. Another potential benefit is providing a better view for all students in a classroom by better distributing the visual content. Using multiple screens makes it more likely students will be close to at least one of the screens so they should have less difficulty seeing the projected materials. Another benefit is that multiple screens provide an enhanced method to compare and contrast content compared to a single screen. The content can be larger since it is being displayed on more than one screen which usually makes comparison more effective.

Another benefit is that duplication of displays provides a backup in case one of the projection systems breaks down.

Challenges

There are some potential challenges related to using multiple screens. The first is the added expense of having more than one projection system in a classroom. However, technology today is relatively inexpensive so the added cost is typically small. Depending on the shape and configuration of the room (e.g., a narrow room), multiple screens may mean they have to be smaller than a single larger screen to fit into the available space. That means individual images would then be smaller when projected onto multiple smaller screens compared to a single larger screen. The fact that multiple screens are available to view should compensate for the smaller image size. In some cases it may be possible to rearrange the room layout when adding additional screens so larger sizes can be used. Another problem is related to viewability when different content is displayed simultaneously on different screens. If students are sitting on the far side of the room, they may have difficulty seeing a different image being shown on a screen on the other side of the room. This could particularly be a problem for students sitting close to a screen on one side which could make it more difficult to see a screen on the other side of the room. This is only an issue if different content is being displayed on the screens simultaneously. The distance from the closest seat to the screens could be increased to compensate for this viewing angle problem.

Example Multi-Image Implementation

An example is presented here to demonstrate the use of multi-image presentation and research in engineering education.

Stimulus presentation methodology using multi-image presentations was used in a recent research study by Baukal and Ausburn investigating multimedia preferences for working engineers [14]. Two projection screens were used because it allowed participants to directly compare two different types of media. In the conventional single-image sequential presentation format, the participant must hold an image in memory in order to compare it against the image on the screen, unless smaller images are displayed simultaneously side-by-side. According to Lowenfeld [54], keeping images in memory is particularly challenging for individuals with a more haptic perceptual style. Perrin ([30], p. 376) wrote, “Simultaneous images reduce the task of memory and enable the viewer to make immediate comparisons.” As demonstrated by Whitley and Moore [53] and by Ausburn [55], multi-image display enhances perception particularly for haptics. Based on those assertions, a dual-image simultaneous presentation was used and is argued to have produced a generally better environment for comparison of multimedia types than a single-image sequential presentation.

The room layout used in the study of multimedia CEE for working engineers [14] is shown in Figure 2. The viewable area of each screen was 8 ft-8 in. wide by 5 ft-2 in. high. The dual screens are shown in Figure 3. A different presentation was loaded onto each computer, so the proper multimedia types would appear on the left and right screens. The slides were manually advanced by the researcher.

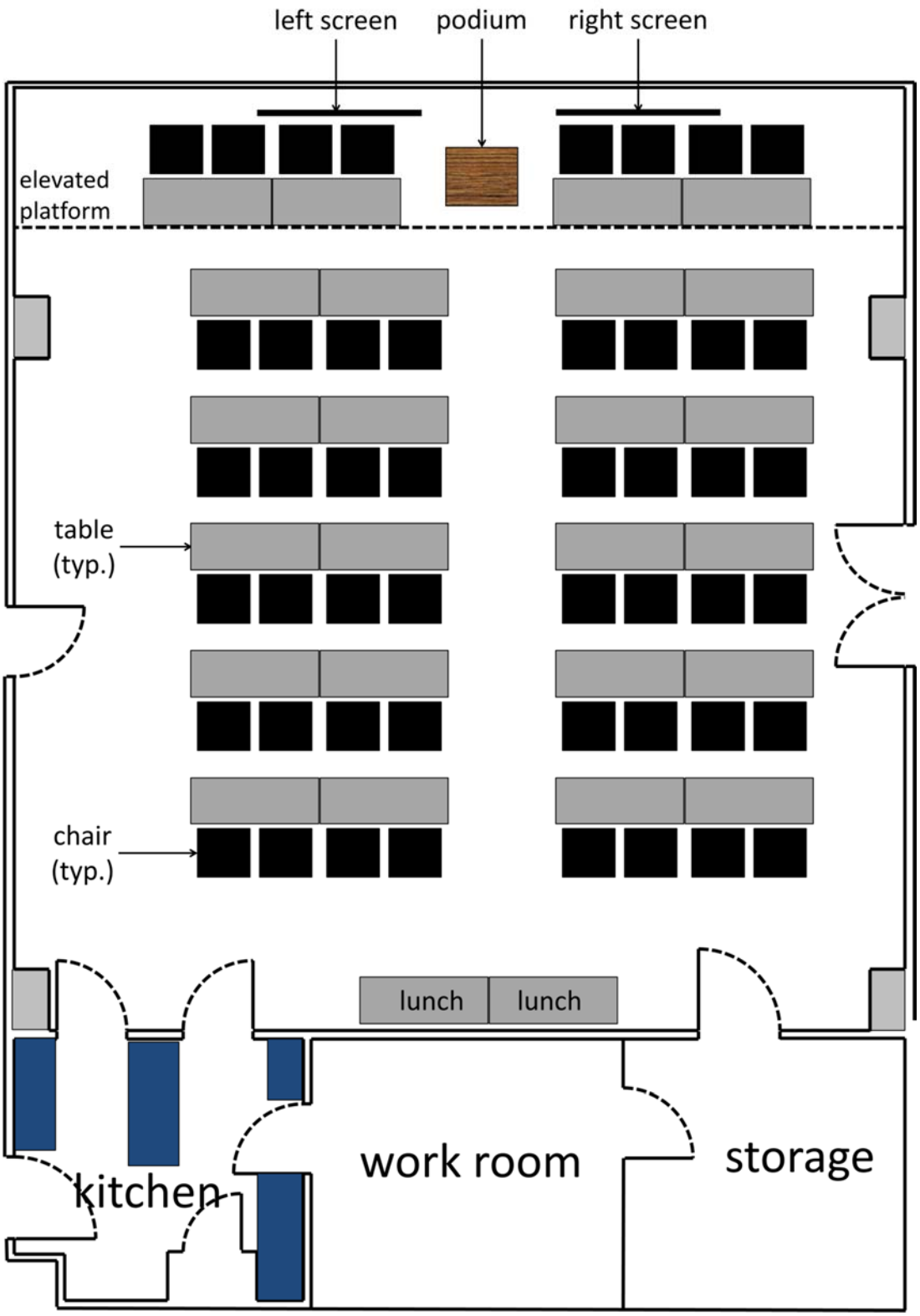

Figure 2. Room arrangement used for the sessions.

Figure 3. Example of a multi-image presentation with a photograph on the left and text on the right.

Eight different types of multimedia were compared in two phases. The first phase compared multimedia types within a given category. The four categories (with the two types in each category shown in parentheses) were: verbal (text and narration), static graphics (drawing and photograph), dynamic non-interactive graphics (animation and video), and dynamic interactive graphics (simulated virtual reality and photo-real virtual reality). The most preferred types in each category from phase one were then compared against each other in phase two. While pairs of multimedia types could have been compared on a single slide and a single projection screen, it was believed to be more effective using dual screens with a single multimedia type on each screen based on previous multi-image presentation research.

The multi-image stimulus methodology used in this study to present the working engineers with media formats or comparison and preference selection was quite successful. The study produced several findings and conclusions that are useful guidelines for instructional designers of CEE [14].

Conclusions and Recommendations

Mayer recommended both spatial and temporal contiguity to enhance learning when using multimedia [15]. Both types of contiguity can be effectively achieved using multi-image presentations. Previous research on how learning is impacted by multi-image presentations is somewhat inconclusive. Some studies have shown improvements in learning while others have not, although in many of the latter cases some of the recommendations for effective use of multi-image presentations, such as showing the best example first on the left projector followed by a non-example on the right screen [47], were not applied. One study found multi-image presentations to be more time efficient where less time was needed to cover material compared

to a single screen presentation [31]. The challenge is not to overload learners with too much material in a given amount of time which could cognitively overload them and actually reduce learning. The only study found related to CEE and multi-image presentations was the study by the authors [14]. However, in that study the purpose was strictly comparison of multimedia types for preferences and not to determine if learning was affected by the use of multi-image presentation.

While multi-image presentations are not as common today as they were in the 1960s and 1970s, they should actually be easier to implement today because the required hardware and software are relatively inexpensive and readily available. The more significant issue is properly designing presentations to utilize best practices such as showing good and bad examples simultaneously for direct comparison and properly timing the displays to show one example first before bringing up the counter-example. This has particular potential for learners who are more haptic [53].

While the current research on multi-image presentations is inconclusive for how learning in CEE is impacted due to the lack of data, past research in other technical disciplines suggests multi-image presentations has the potential to improve learning. Clearly, further research in this area is needed to find out if multi-image presentations enhance learning in CEE and if so, what are the most effective techniques for using this methodology.

References

1. B. Fradkin, *A Review of Multiple Image Presentation Research*, retrieved from ERIC database (ED130680), 1976.
2. J. Biere, *The Guide to Multi-Image*, Munich: Verlag Photographie, 1990, p. 12.
3. J. Lewell, *Multivision*, London: Focal Press, 1980.
4. P. Mezey, *Multi-Image Design and Production*, Boston: Focal Press, 1988, p. 7.
5. F.B. Ausburn, *Multiple versus linear imagery in the presentation of a comparative visual location task to visual and haptic college students,* unpublished doctoral dissertation, University of Oklahoma, Norman, OK, 1975.
6. P. Mezey, *Multi-Image Design and Production*, Boston: Focal Press, 1988.
7. J. Arciuli and I.C. Simpson, Statistical learning in typically developing children: The role of age and speed of stimulus presentation, *Developmental Science*, *14*(3), 464-473, 2011.
8. R.H.S. Carpenter, Express saccades: Is bimodality a result of the order of stimulus presentation, *Vision Research*, *41*(9), 1145-1151, 2001.
9. W.E. Jeffrey, Variables in early discrimination learning: III. Simultaneous vs. successive stimulus presentation, *Child Development*, *32*, 305-310, 1961.
10. G. Salomon and R.E. Clark, Reexamining the Methodology of Research on Media and Technology in Education, *Review of Educational Research*, *47*(1), 99-120, 1977.
11. F. Schmidt-Weigand, A. Kohnert, and U. Glowalla, A closer look at split attention in system- and self-paced instruction in multimedia learning, *Learning and Instruction*, *20*, 100-110, 2010.
12. J. Murray and M.E. Thomson, Age-related differences on cognitive overload in an audio-visual memory task, *European Journal of Psychology of Education*, *26*, 129-141, 2011.
13. P. Goolkasian and P.W. Foos, Presentation format and its effect on working memory, *Memory & Cognition*, *30*(7), 1096-1105, 2002.
14. C.E. Baukal and L.J. Ausburn, Multimedia category preferences of working engineers, *European Journal of Engineering Education*, DOI: 10.1080/03043797.2015.1095161, published online October 13, 2015.
15. R.E. Mayer, *Multimedia Learning* (2nd ed.), New York: Cambridge University Press, 2009.
16. A.D. Baddeley, *Working Memory*, Oxford, England: Oxford University Press, 1986.
17. A.D. Baddeley, *Working Memory, Thought, and Action*, Oxford, England: Oxford University Press, 2007.
18. A.D. Baddeley and G. Hitch, "Working memory," in G.A. Bower (Ed.), *Recent Advances in Learning and Motivation*, New York: Academic, 1974.
19. A. Paivio, *Mental Representations: A Dual Coding Approach*, New York: Oxford University Press, 1986.
20. A. Paivio, *Mind and its Evolution: A Dual Coding Theoretical Approach*, New York: Psychology Press, 2007.

21. J.R. Kirby, Collaborative and competitive effects of verbal and spatial processes, *Learning and Instruction*, *3*(3), 201-214, 1993.
22. P. Chandler and J. Sweller, Cognitive load theory and the format of instruction, *Cognition and Instruction*, *8*(4), 293-332, 1991.
23. J. Sweller, Implications of cognitive load theory for multimedia learning, in R.E. Mayer (ed.), *The Cambridge Handbook of Multimedia Learning* (pp. 19-30). Cambridge, UK: Cambridge University Press, 2005.
24. J. Sweller, P. Ayres, and S. Kalyuga, *Cognitive Load Theory*, New York: Springer, 2011.
25. J.E. Kemp and D.C. Smellie, *Planning, Producing, and Using Instructional Technologies* (7th ed.), New York: HarperCollins, 1994.
26. K. Burke, A pragmatic approach to criticism of multimedia, *Journal of Educational Technology Systems*, *6*(1), 57-75, 1977-78.
27. R. Slawson, *Multi-Image Slide/Tape Programs*, Englewood, CO: Libraries Unlimited, 1988.
28. R.D. Owens and G.O. Coldevin, Effects of varied temporal visual overlapping in multi-image tape-slide presentations, *Programmed Learning & Educational Technology*, *14*(1), 33-42, 1977.
29. R.V. Bullough, *Multi-Image Media*, Englewood Cliffs, NJ: Educational Technology Publications, 1981.
30. D.G. Perrin, A theory of multiple-image communication, *AV Communication Review*, *17*(4), 368-382, 1969.
31. D.A. Ingli, Teaching a basic audiovisual course by the multi-image technique, Proceedings of the Association for Educational Communications and Technology Annual Conference, Minneapolis, MN, 1972.
32. J.A. Benedict and D.A. Crane, *Producing Multi-Image Presentations*, Tempe, AZ: Arizona State University, 1973.
33. J.E. Kemp, *Planning and Producing Audiovisual Materials* (3rd ed.), New York, NY: Thomas Y. Crowell, 1975.
34. J. Meyrowitz, Conceptual relationships in multiple-image instruction, retrieved from ERIC database. (ED126851), 1976.
35. P.E. Dyer, Why we use multi-image presentations, in R.L. Gordon (ed.), *The Art of Multi-Image* (pp. 17-19). Abington, PA: Association for Multi-Image, 1978.
36. C.J. Beckman, Producing multi-image: Getting started, Part 1, *Audiovisual Instruction*, *22*(3), 70-74, 1977.
37. R.V. Bullough, *Multi-Image Media*, Englewood Cliffs, NJ: Educational Technology Publications, 1981.
38. D.M. Moore, J.K. Burton, and R.J. Myers, Multiple-channel communication: The theoretical and research foundations of multimedia, in D.H. Jonassen (ed.), *Handbook of Research for Educational Communications and Technology*. New York: Macmillan, 1996.
39. B.M. Hutchinson, The effect of presentation mode on visual discrimination by visual and haptic college students, retrieved from ERIC database. (ED227837), 1981.
40. R.M.W. Travers, Studies related to the design of audiovisual teaching materials, retrieved from ERIC database. (ED017169), 1966.
41. F.R. Hartman, Recognition learning under multiple channel presentation and testing conditions, *Audio Visual Communication Review*, *9*(1), 24-43, 1961.
42. E.B. Goldstein, The perception of multiple images, *Audio Visual Communication Review*, *23*(1), 34-68, 1975.
43. K. Burke and B. Fradkin, History, theory, and research related to multi-image, in R.L. Gordon (ed.), *The Art of Multi-Image* (pp. 6-16). Abington, PA: Association for Multi-Image, 1978.
44. R.D. Owens and G.O. Coldevin, Effects of varied temporal visual overlapping in multi-image tape-slide presentations, *Programmed Learning & Educational Technology*, *14*(1), 33-42, 1977.
45. D.H. Jonassen, Implications of multi-image for concept acquisition, *Educational Communication and Technology*, *27*(4), 291-302, 1979.
46. D.C. Clark, Teaching concepts in the classroom: A set of teaching prescriptions derived from experimental research, *Journal of Educational Psychology*, *62*(3), 253-278, 1971.
47. M.D. Merrill and R.E. Tennyson, *Teaching Concepts: An Instructional Design Guide*, Englewood Cliffs, NJ: Educational Technology Press, 1977.
48. K. Burke, Theory and evaluation of multi-image, in K. Burke (ed.), *An Anthology of Multi-Image* (pp. 157-172). Abington, PA: Association for Multi-Image, 1980.
49. K. Burke and A. Leps, Multi-image research: A thirty-year retrospective, *International Journal of Instructional Media*, *16*(3), 181-195, 1989.
50. M.M. Berger, A preliminary report on multi-image immediate impact video self-confrontation, *American Journal of Psychiatry*, *130*(3), 304-306, 1973.
51. B.M. Fradkin, Effectiveness of multi-image presentations, *Journal of Educational Technology Systems*, *2*(3), 201-216, 1974.
52. P.L. Trohanis, Information learning and retention with multiple-images and audio: A classroom experiment, *Audio Visual Communication Review*, *23*(4), 395-414, 1975.

53. J.B. Whitley and D.M. Moore, Effects of perceptual type and presentation mode in a visual location task, *Educational Communication and Technology*, *27*(4), 281-290, 1979.
54. V. Lowenfeld, Tests for visual and haptic aptitudes, *American Journal of Psychology*, *58*(1), 100-112, 1945.
55. F.B. Ausburn, A comparison of multiple and linear image presentations of a comparative visual location task with visual and haptic college students, paper presented at the Association for Educational Communications and Technology Annual Convention, Dallas, TX, April 1975.
56. F. Jurgemeyer, The role of multi-image learning materials in changing student attitudes, *Technological Horizons in Education*, *7*(2), 44-45, 1980.
57. A.A. Leps, Visual instructional strategies and cognitive style, Proceedings of the Annual Convention of the Association for Educational Communications and Technology, Denver, CO, retrieved from ERIC database. (ED194108), 1980.
58. F-O Kuo, T-W Chang, J-M Hsu, and P-T Yu, The learning effects of simultaneous dual-screen instructional presentation in programming language instruction, in S.C. Kong, H. Ogata, H.C. Arnseth, C.K.K. Chan, T. Hirashima, F. Klett, . . . S.J.H. Yang (eds.), *Proceedings of the 17th International Conference on Computers in Education*. Hong Kong: Asia-Pacific Society for Computers in Education, 2009.
59. R.C. Wiseman and R.L. Gordon, What is the multi-image presentation?, in R.L. Gordon (ed.), *The Art of Multi-Image* (pp. 1-5). Abington, PA: Association for Multi-Image, 1978.