

**For the Love of Technology:
How Aesthetics define Emotions in a Digital Education Setting**

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WRIT 8505: Professional Practice

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Spring 2021

Abstract

Educators often admit that they are aware that emotion plays a significant role in students' educational success, yet most of the scientific literature measures cognition in education to the exclusion of emotion. This study is intended to be a proof of concept design for future research. Its goal is to assess how an individual's aesthetic value of a product might be a way to gauge emotion in educational settings. Three faculty members at the University of Minnesota were interviewed about their viewpoints pertaining to the product design of a static Canvas page and asked to evaluate its design based on its visceral, behavioral, and reflective beauty. Page orientation and font were used to represent product design. Results of the interviews showed that readability was the most frequently mentioned reason people are drawn to certain aesthetic features of a product's design in digital education, followed by alignment, accessibility, mobile devices, tradition, and font personalities. Additionally, this paper evaluates the participants' valence response; their responses to the design's functionality; and their thoughts on meaningfulness as they relate to Norman's (2007) three aesthetic levels of product design. At the end of the paper, suggestions for how we might use this data to increase productivity in our classes and enhance educational technology are addressed. Future directions for how these results might apply to cognition, emotion, and computation are also discussed.

Keywords: Aesthetics, cognition, emotion, technical communication, technology, education, typeface, font, page orientation, learning, beauty, product design, human computer interaction

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For the Love of Technology:

How Aesthetics define Emotions in a Digital Education Setting

Research in education has shown the importance of cognition in students' learning and behavior, but there has been significantly less research showing the importance of emotions on students' learning and behavior in educational settings despite instructors admitting to being aware that students' emotions influence their learning and behavior in educational settings (Gupta, Elby, & Danielak, 2018). When instructors know how to navigate students' learning through cognitive-affective dynamics in the classroom, situations that may be anxiety-provoking for some students can be reduced. When students feel more secure and supported in their surroundings, they may be more likely to try new things and engage with one another more readily, making learning more enjoyable and meaningful for them. Therefore, if instructors are familiar with both the cognitive and the affective—or emotional—sides of a problem, they can handle classroom situations more adeptly as well as enable students to feel more empowered to move past learning obstacles quickly.

Within cognition and emotion research, there is somewhat of a debate about what constitutes the definition of “emotion,” so for the purposes of this paper, I will use the term “emotion” in reference to the six universally so-called “basic emotions” described by Sauter, Eisner, Ekman, Scott, & Edward (2010): joy, anger, surprise, disgust, sadness, or fear. One way to measure emotions in product design is through aesthetics. If we like the appearance of a digital product, it produces a change in our emotional state which then gets communicated to our cognitive system (Turner, 2017). Norman (2007) says that the aesthetics of product design can be based on three levels of “beauty” or aesthetics: visceral, behavioral, and reflective. He describes them as follows:

1) Visceral beauty: Norman's (2007) first level of beauty is visceral beauty. It is the simplest and stems from the most primitive parts of the brain. It is sensitive to a wide range of genetically pre-determined conditions that have evolved throughout our evolution. All of these conditions are determined by our sensory information system as the visceral system is incapable of reasoning. Rather, the visceral system works through "pattern-matching." We are genetically programmed to gravitate towards situations that make us feel good and comfortable, such as ones that offer food, warmth, and protection. It is how we instinctively know we like or dislike something.

2) Behavioral beauty: The second level of beauty, according to Norman (2007), is behavioral beauty. This level is not as much about the beauty you can see, but the beauty you can appreciate in terms of how well something works. Function, understandability, usability, and "physical feel" are all components of this aesthetic level. Behavioral and reflective beauty are more sensitive to experiences, training, and education than visceral beauty.

3) Reflective beauty: The third and final level of beauty according to Norman (2007) is reflective beauty, and it encompasses how personally meaningful the user experience of a product design is for an individual. It involves message, culture, the meaning of a product, and how that product is ultimately used. Consciousness enters the picture because people often want to understand their actions in the context of past behaviors or future endeavors. For one person, a given experience may trigger a specific memory from the past. For another person, engagement with the same device may trigger a vision of themselves achieving a goal they have set for themselves in the future.

Whether someone feels pleasure or displeasure over a product can make a difference in how they use it, and how they use it can impact the level of their productivity. In this study, I explored the issue of aesthetics of product design in technical communication by first showing

how my overarching key questions on aesthetics, emotions, and education led to my two hypotheses, in the next section, on page orientation and font in technical communication. Then, I reviewed several key ideas in the literature that connects how technical communication connects with aesthetics.

It is important to point out that there is a vast amount of literature on fonts and readability in the field of technical communication. This literature can trace its origins back to the work of Miles Tinker in the 1940s on the legibility of print (e.g., Tinker, 1966) and has grown to include more recent work such as comparing how handwritten versus typewritten font can influence readership of product design (Izadi & Patrick, 2020). This paper does not nearly cover an exhaustive account of all the literature on font and readability studies in the field; but rather it focuses on a select few studies that justify the background for hypotheses that stem from the following key questions.

Rationale

Key Questions

- 1) How do one's aesthetics influence their use of educational technology?
- 2) Will people who work in education (students or teachers) be more productive (e.g. higher grades) if they use aesthetically pleasing educational technology?
- 3) Is the level of productivity or success that people have in education proportional to the level of beauty (visceral, behavioral, reflective) that they hold for the educational product?

Hypotheses:

1. Landscape orientation will be preferred aesthetically by people over portrait orientation.
2. Times New Roman (TNR) font will be more fluent to people and therefore Comic Sans italics font will be easier to read. In turn, people will be more likely to neglect the appearance (or

“attractiveness” in terms of visceral beauty) of TNR for their more functional aesthetic value. In the case of print, the ability to read clearly is predicted to be what people find to be their “more functional aesthetic value.”

Page Orientation

Researchers have shown natural environment scenes to reflect a lower cognitive load than urban scenes using measurements of eye movement and blink rate (Valtchanov and Ellard, 2015). Also, the restorative benefit that many people associate with nature causes people to assign an aesthetic value to natural environments (Hartig and Staats, 2006). For these reasons, it is hypothesized that people will choose landscape over portrait when asked which orientation they prefer aesthetically on a visceral level.

Typeface/Font

When a product design used to sell something is presented to a potential consumer in a way that forces the consumer to really concentrate on the product that they are considering, it becomes more difficult for the consumer to convince themselves not to buy it. Similarly, if people are presented with a disfluent typeface on a piece of educational technology, they will be more likely to evaluate the typeface for its functionality rather than its attractiveness, or visceral appeal, at first glance. Since we are talking about typeface, the functionality is likely how well can they read it.

Good typography allows readers to determine how content is organized on the page as it helps facilitates the rapid retrieval of information (Schriver, 2015). How content is organized is important for teachers because, although students may be drawn to a product’s external appeal, creating content in a way that gets students to focus on the task at hand can be the greater challenge when it comes to getting the job done. Research by Hernandez and Preston (2012) has

shown that when something is presented disfluently and requires more focus, people are more likely to skip past how attractive the presentation is and go right to the second level of aesthetic beauty: how functional is it? Therefore, one of my hypotheses is that when people evaluate the different fonts, they will be more interested in the quality of how well the fonts function (level two of aesthetic beauty) over their attractiveness (level one of aesthetic beauty).

Disfluency is associated with instances when people have to focus harder to get through a task (e.g., reading something). Improved cognitive ability, such as memory, was found to occur in high school students who scored higher on their tests when they were presented with questions in a disfluent font, such as Comic Sans italicized, as opposed to when they were presented with test questions in a fluent font, such as Arial (Diemand-Yauman, Oppenheimer, and Vaughan, 2010). Fluency is something that can be altered through the visual clarity in the text.

Background and Literature Review

Page orientation and font are examples of visual design elements that make learning more productive and students more successful. However, the amount of technical communication literature that associates these design elements with visceral, function, and reflective levels of aesthetic beauty is minimal. To offer a big picture perspective of literature available on the topic of aesthetics in technical communication, Hardesty and Hollinger (2020) performed a literature review of 25 technical communication journals by which they narrowed their search using the keywords “beauty” and “creativity” to understand how those terms related to teaching and training in the field of technical communication. Of the literature they discussed in their review, I further refined my own literature search to match Norman’s (2007) three levels of aesthetics. As a result, I was able to find two studies (Tractinsky, Katz, Ikar, 2000; Zhang, 2016) that described

beauty as visceral, functional, and meaningful to individuals. As such, they demonstrate why aesthetics can be an effective measure for the evaluation of emotions in educational technology.

In one of the two studies, Zhang (2016) found that visual beauty can go beyond the visceral and functional to also satisfy a sense of meaning in people by making an image memorable. To do this, Zhang (2016) compares medical texts from China's Northern Song dynasty with medical texts from previous dynasties. The more recent medical texts incorporated more illustrations with enhanced beauty and usability. Through their improved visual strategies, such as reduced visual clutter and greater accuracy, they appealed to both elite and public audiences and negotiated their way into more press releases, they gained greater circulation, and became more popular in their own right. In other words, because readers liked the way the later medical texts' page layouts looked, those texts were read more often, their information was able to reach and train more people, and the information led to a greater overall sense of productivity.

In the second study by Tractinsky, Katz, and Ikar (2000), the idea of making something memorable—a quality associated with the reflective level of beauty—was also demonstrated in human-computer interaction using individual's perceptions before and after they used an automated teller machine (ATM). Not only did the study indicate a correlation between a computer system's perceived beauty (visceral; level one) and usability (functional; level two), but there was also an indication that a beautiful and practical experience might also make a memorable experience after the event occurred with the ATM. This finding would indicate that a person is having a personally meaningful experience (reflective; level three) associated with the computer product (in this case an ATM—possibly because people feel a strong personal connection to their money). Either way, all three of Norman's (2007) levels of beauty are attained in the experience of engaging with a technological device. This research demonstrates

that aesthetics (i.e. liking the look of something, appreciating how functional something is, and forming a fond memory) can all play a part in defining beauty and can all be linked with an emotional experience related to computer technology. I will now apply a similar idea to education.

Methods

This research project was reviewed by the University of Minnesota Institutional Review Board (IRB) under STUDY00012334, and the IRB determined it is “not human research.” The interview data in this report has been de-identified, therefore any information that would personally identify interviewees has been removed.

I hand-selected three faculty members at the University of Minnesota to interview for this study. Each faculty member I interviewed belonged to one of the following colleges: Liberal Arts, Education and Human Development, or Science and Engineering. Because my interests that formed this study stemmed from my past research work related to math anxiety in physics education, I decided to focus on interviewing faculty rather than students. Faculty viewpoints are also valuable because faculty are familiar with educational technology and classroom performance, and their viewpoints on aesthetics in educational technology can have a positive influence on classroom productivity in the future. In addition, faculty from the University of Minnesota use the learning management system (LMS), Canvas, so they would have some sense of how it functions when asked about its behavioral beauty in reference to a static Canvas screen mock-up, which is used during the interview.

Canvas is a web-based software LMS and data analytics system that educators can use to manage the delivery of their course materials and content (Instructure, 2020). A semi-structured interview style was chosen so interviewees would have the opportunity to expand on their

answers without feeling limited. By conducting semi-structured interviews, interviewees are free to use their own words to reference their experiences, allowing for the most authentic keywords from the interviewees that best express certain personal themes relevant to them. For example, when asking about their thoughts related to the level of reflective beauty—or what they find meaningful—Turner (2017) says that keywords related to past or future times in their life or referencing cultural items could be indicators that those keywords or ideas represent something meaningful in their thought process.

The interview process went as follows:

1. Interviewees viewed two Canvas pages via Zoom (video/audio), and I recorded the sessions with their permission (in advance). Each page displayed either a landscape or portrait view (as shown in Appendix B).

2. Interviewees answered the questions below in a semi-structured interview style.

3. When it was clear which orientation that individual liked better (portrait or landscape), that orientation was selected and two new pages in their selected orientation were shown to them.

Each page had a different font. One page had Times New Roman font and the other had Comic Sans Italics font. The different fonts and orientations are shown in Appendices B-C.

4. Interviewees answered the same questions in a semi-structured style regarding which font appealed to them more.

Note: Although interviewees were shown general knowledge questions on the Canvas pages, they were *not* asked to answer any of the general knowledge questions on the Canvas page. They were only asked to comment on the font or orientation of the page related to the three aesthetic levels below.

Interview Questions:

1. For the visceral aesthetic level questions:

What do you like/dislike about the (font or orientation)? Why?

What do you think a class would like/dislike about its (font or orientation)? Why?

2. For the behavioral aesthetic level questions:

What makes the (font or orientation) functional for you? Why?

Which do you think would be more functional in a classroom? Why?

3. For the reflective aesthetic level questions:

What makes the (font or orientation) meaningful to you (personally)? Why?

What about its (font or orientation) do you think would make it meaningful to a class? Why?

Results

Hypothesis 1: Landscape will be preferred aesthetically by people over portrait orientation.

Results: Two of the three participants preferred portrait and one preferred landscape. Note: three people are not enough to determine a significant result so future research with more participants is needed to determine if these results support or refute the hypothesis. This is the case for both Hypothesis 1 and Hypothesis 2.

Hypothesis 2: Times New Roman (TNR) font will be more fluent to people and therefore easier to read to people than Comic Sans italics font. Therefore, people will be more likely to neglect TNR for what they value on a functional level (usually, in the case of print, the ability to read).

Results: The participant who said that the thing they found most meaningful about the font was its ease of use for reading chose Comic Sans as their preferred font. One of the other participants chose TNR only because he hated Comic Sans. He said, "I hate Comic Sans...I might have a

little bit of a bias, that would be worth accounting for as you do your analysis. I used to be a graphic designer, so I do not like Comic Sans and that family of fonts, I just do not like it! I like the cleaner kind of more traditional fonts, I guess you could say.” And, the third participant did not like either the TNR or Comic Sans font.

Thematic Analysis

For the thematic analysis, I used Braun and Clarke’s (2006) article to guide my framework for how I analyzed my results. They laid out the steps of the analysis process in the following phases:

Table 1. Phases of Thematic Analysis for interviews.

Phase	Description of Phase
1. Become familiar with the data	This phase involved transcribing the data, entering it into NVivo, and reading through as many times as necessary while noting initial ideas both by hand as well as on the computer.
2. Generate initial codes for the data	This includes coding interesting features of the patterns I notice, and collecting relevant data of each code, across data of the whole data set.
3. Search for themes	This is where I turn the codes into themes and gather all relevant data for each theme.
4. Review themes	See if the themes work against Phase 1 above (coded extracts) and Phase 2 above (entire data set) above. This will result in a thematic “map” of the analysis.
5. Define and name the themes	Continue the analysis to refine the specifics of the themes in light of the overall story the analysis is telling. Generate clearer definitions and names for each theme along the way.
6. Produce a final report	Give a once-over of the analysis taking a final opportunity to select vivid, compelling extract examples. Relate those final selected extract examples to the analysis of the research questions for the final write-up.

Source: Table is based on information from Braun and Clark (2006).

After data was collected from Zoom recordings, data was analyzed in a table by hand to find overall themes and patterns between the three participants. Then, transcripts were manually coded from those themes using Notepad and transferred to Microsoft Word for analysis. Words were coded to the themes based on direct match (e.g., “read” = readability) or indirect match (e.g., “not blurry” = readability). Finally, the coded transcripts were analyzed for a third time using NVivo. From NVivo, a Word Cloud (Figure 1) was generated based on the top 50 keywords once extraneous words such as “so,” “but,” or “something” were removed. After the thematic word counts were generated in NVivo, the numbers were transferred to Microsoft Excel and the bar chart (Figure 2) that summarizes the most common thematic phrases was created.

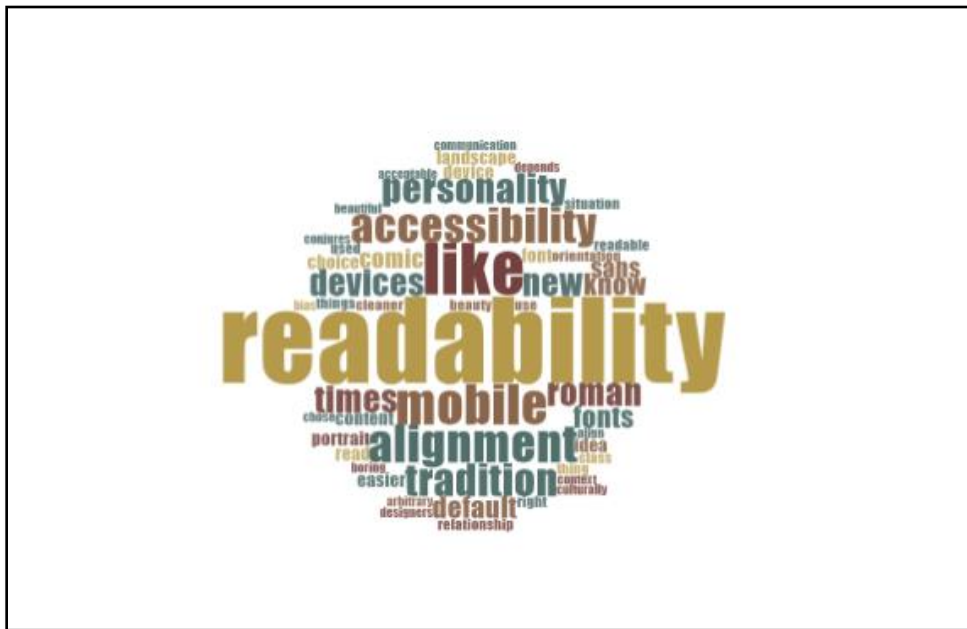


Figure 1. Word cloud based on top 50 keywords from interviews.

Results of the interviews showed that readability was the most frequently mentioned aesthetic reason people are drawn to certain visual design features of product design in digital education followed by alignment, accessibility, mobile devices, tradition, and font personalities. These results are visually depicted in Figure 2.

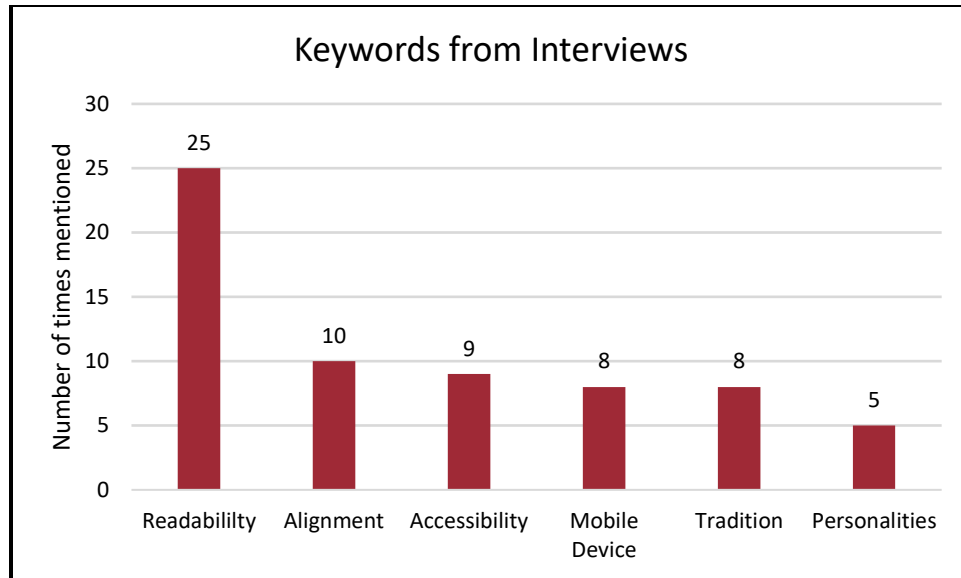


Figure 2. Chart of keywords from interviews.

Readability

Being able to read the screen was the most common reason participants gave for the orientation or font they preferred. They expressed this by directly saying “readability” or “it’s easier to read” as their reason for making the choice they did, or by indirectly using phrases like, “easier on the eyes,” “a little bit less blurry,” or “it’s a little cleaner.” This finding was not surprising given research present in technical communication on the value of good visual presentation through information design. Schriver (2013) points out that information design is about supporting readers’ cognitive and emotional interactions with content to enable the best communication possible. My findings echoed the existing research.

Alignment

The visual alignment was also cited by participants as being a reason they chose either one orientation or font over the other. In the case of orientation, where one long sentence in landscape view was able to stand on its own, the same long sentence in portrait view was required to wrap around to the next line. Interestingly, in terms of aesthetics, one of the three participants found the single line in landscape view to be more aesthetically pleasing, whereas the other two considered the wrap-around text on two lines to be more aesthetically pleasing. In

all three cases, the participants said that they would consider the content being relayed to the students when deciding whether to use landscape or portrait orientation.

Accessibility

Accessibility was brought up by two of the three participants when discussing which fonts they might consider for their classes. Two participants mentioned the importance of using fonts that can aid with visual or cognitive impairments. One participant thought that there might be a font “designed with dyslexia in mind.” The other suggested that since a font like Comic Sans is not one that students are accustomed to seeing every day, it might present an obstacle that could make learning more difficult for them.

Mobile Devices

Another interesting theme that emerged, more so from the presentation of page orientation, was that of how today it is important to consider the frequency with which students view their schoolwork on their phone or mobile devices. In that case, a landscape or portrait view would not make a difference to which orientation one viewed the page. It was mentioned that one of the benefits of using an LMS like Canvas is that you get to put the educational content in, and it can be presented in a variety of different modalities automatically.

Tradition

Portrait and Times New Roman (TNR) were the most frequently chosen orientation and font. The reasons cited were because participants were accustomed to them. Popular responses about TNR font were: “Times New Roman is a very common default.” And popular responses in relation to portrait orientation were: “It’s reminiscent of 8-1/2 x 11 page.” Also, “Culturally, I tend to think that portrait is the default orientation because of the way that I engage with pages.”

Personalities of Fonts

A final theme that emerged from the interviews was that participants talked about the fonts as having personalities. Considering fonts to have their own personalities was an unexpected theme that emerged out of the data analysis only after I coded and looked for the highest number of repeated patterns. I found this theme especially interesting given that people like to identify with giving human qualities to inanimate objects, similar to anthropomorphism. This notion is not surprising, however, given the extent that artificial intelligence has become such a large part of our lives (e.g., Alexa, Google Maps, and other robotic devices that we talk and engage with daily).

These results are consistent with a study conducted by Brumberger (2003) which showed that people do ascribe personality attributes to passages of text. Her research also showed that perceptions of text persona were also shaped significantly by demographics. This is interesting because of the three participants, the two participants from the younger generation identified the texts as having personalities whereas the participant in the older generation did not.

Discussion

How Results Apply to Norman's (2007) Three Levels of Aesthetics

Level 1 of Aesthetics: Visceral Response

How can we use these results to measure emotion?

Emotions can be characterized as one of two subjective states: valence or arousal (Barrett, 1998). As such, valence states were rated as pleasing or displeasing, and emotions were rated as either positive or negative valence responses based on whether the interviewees found the product design pleasing or not. This type of coding has been found to be an effective measure in research in which participants were asked to look at images that triggered either a positive or

negative emotional reaction (Groenewold, Opmeer, De Jonge, Aleman, & Costafreda, 2013). By gauging what participants liked and did not like about the product design, their responses were classified as a positive or negative emotional valence value (positive for favorable response and negative for unfavorable response). If participants did not feel one way or the other about orientation or font (i.e., “neutral”), it was not recorded as a valence response and no keywords were associated with it.

Four favorable responses were assigned a positive emotional valence/value:

- “I think it's beautiful when it works well, there's a beauty in that.”
- “I like the cleaner kind of more traditional fonts.”
- “I like the landscape.”
- “I like the italics one better.”

Two unfavorable responses were assigned a negative emotional valence/value:

- “Honestly, these are potentially my least favorite fonts: Times New Roman and then Comic Sans.”
- “I hate Comic Sans.”

Level 2 of Aesthetics: Behavioral Response

What about a product's functionality makes it beautiful?

Hypothesis 2 was supported by research by Hernandez and Preston (2012) who found that if something is presented disfluently people are more likely to reject attractiveness and move on to the quality of the product. Therefore, one of my hypotheses is that when people evaluate the different fonts, they will be more interested in the quality of how well the fonts function (level two of aesthetic beauty) over their attractiveness (level one of aesthetic beauty).

This research was confirmed in the interviews. When interviewees were presented with the two different fonts and asked the first question about which they found more aesthetically pleasing at first glance, they either gave an answer that negated the question like, “[TNR] 100%. I hate Comic Sans” or they gave an answer that focused on the functionality of whether or not they could read it like, “I don't find that either of them is particularly readable...”

Furthermore, these results also provide an indication to Key Question 3 listed under the “Rationale” section above: “Is the level of productivity or success that people have in education proportional to the level of beauty (visceral, behavioral, reflective) that they hold for the educational product?”

It would appear if people unknowingly bypass the first level of their visceral response and automatically jump to their functional aesthetic response, then their level of productivity would, in fact, be at the level of how they function (perhaps optimally?), at least in the case of something that is presented to them in a disfluent manner. More research would need to be done to determine the relationship between productivity, product design, and aesthetics.

Level 3 of Aesthetics: Reflective Response.

What makes a product design meaningful?

Although the purpose of this study was to work as a proof of concept design and asking participants to reflect on what they like or dislike in relation to the “meaning” of typeface or page orientation may seem like a vague question, the participants still provided insightful answers. Their answers appeared to come down to what they most valued. The following are the participants’ responses to what they found “meaningful” in either font or orientation:

- “Not being distracted by anything you don’t like would allow a student to perhaps derive more meaning from it.” This participant used phrases throughout the

interview that implied they believed it was important that readers not be distracted by the font style. The interviewee used statements such as "...font could distract the person from the content..." and "it's not a font you see every day, so I think it could add a layer of difficulty" which indicated to me that not being distracted was something he valued.

- "The thing that makes it meaningful is that it's easy if it's easy to read." I interpret this participant's statement to say that it means something of value that their life is easier if the product is easier to read. This statement is from the participant who was in the oldest age demographic. Hyun, Lee, and Ihm (2014) researched age demographics and found that people over 50 years old find font size to be of greater importance than people in their 20's and 30's. Vision impairments have been known to become more prevalent as people age (Chubaty, Sadowski, & Carrie, 2009).
- "Times New Roman is the thing that I was told was the only font that was acceptable in an academic context and so to me it conjures up the memory of professors' rules about what academic writing needed to look like. I think the idea behind it is: 'I want to judge the content, not the style; I don't need to waste time playing through all of the fonts.'" This participant's value appeared to focus on what is acceptable in our society and how that can be challenged as educators.

Future Directions

Notes on Aesthetic Level Progression from Visceral to Reflective

As mentioned above, one participant admitted to being biased against Comic Sans font. When asked which of the two fonts he liked best, the participants said, "[TNR] 100%. I hate

Comic Sans.” He explained that he used to work as a graphic designer and acknowledged that he might be a little biased. From that point forward he favored the TNR font on the behavioral and reflective levels of aesthetic beauty.

What is interesting about this participant’s behavior is how their behavior relates to Norman’s (2007) three levels of aesthetics. Norman’s levels of aesthetics are presented as a hierarchy from the visceral (level one) to the behavioral (level two) to the reflective (level three) level. Although Norman is discussing design and not psychology, his model has been compared to the triune brain model proposed by MacLean (1949, 1990) in which the brain is made up of three distinct complexes of neural structures: the reptilian complex (hindbrain), the paleo-mammalian complex (limbic system), and the neo-mammalian complex (neocortex) (Turner, 2017).

Therefore, if an individual is prevented from going forward after the visceral level of Norman’s aesthetic beauty, such as the participant who admitted to hating Comic Sans due to a personal experience, whatever is preventing them from moving forward may present more of a challenge for them to move on to the next two levels of aesthetic beauty: function and reflective beauty. That inability for an individual to progress through the levels of aesthetics might mean more research is needed to evaluate the relationship between productivity and emotion in education. By having a better understanding of how emotions, cognition, and productivity are connected in learning situations, instructors can better understand classroom situations where students who have an adverse reaction to a new experience so they can move past feeling stuck or emotionally “blocked” into a functioning level of productivity. Rather than feeling emotionally defeated, students can reflect on what works or what does not work for them in terms of problem-solving in a supportive classroom setting. This may include neurological and

psychological areas of educational and performance research such as math anxiety, performance anxiety, and/or overload theories, to name a few.

Emotions and Cognition and its role in Cognitive Load

When students become overwhelmed, cognition and emotions cannot engage at the same time, causing increased cognitive load in students who experience greater emotions in a classroom setting. An example of this is when a student experiences math anxiety. The impact of cognitive and emotional overload in math anxiety may be easier to understand when you think of these functions in the context of working memory in the brain: when an individual performs mathematical calculations, it decreases working memory, (a.k.a. short-term memory) (Eysenck and Calvo, 1992) which is a cognitive resource required to complete a mental task, such as a math calculation. If that individual is worried about something, that “worry” uses up some of the working memory space, leaving less to complete the mathematical calculation (Rubinsten, 2017). As a result, some people who may have been perceived as cognitively slow might be high-cognitive functioning individuals who suffer from math anxiety. Evidence of this in brain scans was provided in a study by Artemenkno, Daroczy, and Nuerk (2015) in which they found that for the brain to deal with the anxiety, the areas of the brain associated with emotion remain active during mathematical performance limiting the amount of cognitive capacity available to complete the math task. This, in turn, can lead to impaired performance and less efficient processing, even in very simple mathematical tasks.

Entangled State of Cognition and Emotion in the Brain

Trying to explain how an individual cannot be in two states simultaneously has led to new research by Gupta, Elby, and Danielak (2018) in which they believe emotions and cognition—in the form of epistemological reasoning—to be “entangled states” meaning

emotional and cognitive processes co-occur (Gupta, Elby, and Danielak, 2018). The authors conducted a case study on an undergraduate electrical engineering and physics student, and through the use of video segments, they demonstrated how her emotions and epistemological stances mutually affect each other.

Computational Emotion in Artificial Intelligence

Entanglement is also a concept from quantum mechanics that can be mathematically modeled (Griffiths, 2018). Therefore, one avenue to exploring human emotion might be to first explore it “theoretically” as computational emotion thanks to our understanding of complex systems and our ability to program algorithms in artificial intelligence. If we can write algorithms that can explain emotion in artificial intelligence, perhaps those algorithms can provide future support for understanding human emotions. Studying emotions from a different vantage point such as this may be another avenue that can lend support to learning in a classroom setting.

Limitations of the Study

Time constraints of the semester and the COVID-19 public health pandemic were two limiting factors that prevented me from being able to develop more fully some of the parameters used in the study. For example, it might have been more beneficial to have interactive education technology rather than a static screen image during the interview, since that is closer to what we use in everyday life, but time limitations prevented that from being an option. Also, the COVID-19 pandemic required that interviews were held on Zoom, rather than on campus, limiting the number of people I had access to for whom I could ask to do the study. Interviewing only three participants is a limiting factor in that it makes it difficult to generalize results to a greater population. However, by setting up semi-structured interviews with a small set of individuals I

was able to explore ideas that I might later apply to an experimental design when I begin my dissertation work in a PhD program.

Conclusion

As mentioned, this study was conducted as a proof of concept design for potential research ideas in the future. It utilized information design techniques, such as page orientation and font, to generate discussion about how we can use aesthetics of product design in a digital education environment. It not only gave us direct results of interviewees' interpretation of product design of educational technology in the form of themes, but it also expanded on their responses by applying their thoughts to Norman's (2007) three levels (visceral, behavioral, and reflective) of aesthetics. These results further suggest that the role of information design in technical communication can influence how students respond to their schoolwork viscerally, behaviorally, and the level of value they have for the work they accomplish. In turn, technical communication in education can have implications for how students learn to value themselves—cognitively and emotionally. Therefore, technical communication in education has the potential to increase self-efficacy in students as well increase students' ability to persevere and overcome difficulties by how instructors choose to design their course materials. If we can grow and develop abilities like self-efficacy and perseverance in our students, we can offer more of these strengths and abilities in our world.

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Appendix A

Consent Form

Title of Study: For the Love of Technology: How Aesthetics Define Emotion in a Digital Education Setting

You have indicated an interest in being interviewed for a research study in which you will be asked to provide your thoughts on the appearance of two static Canvas digital webpages.

This study is being conducted by Autumn Brower, Master of Science student in Scientific and Technical Communication at the University of Minnesota - Twin Cities.

Background Information

The purpose of this study is to learn about the role of emotions in learning and performance.

Procedures

If you agree to be interviewed, your participation will consist of an interview about your thoughts and impressions of the differences between two static Canvas webpages. You will be asked a series of questions about what you like and dislike about the Canvas pages in relation to their product design. Your participation will not exceed one hour of your time.

Risks and Benefits

There are no foreseeable risks associated with your participation in this study. Participation in this study may benefit you by encouraging you to think about the ways in which your classroom technology can enhance learning and productivity.

Voluntary Nature of the Study

Your participation is strictly voluntary, and you are not required to participate in this study. You can withdraw from the study at any time. Your decision to withdraw will have no affect on your relationship with the University of Minnesota.

Confidentiality

The records of this study will be kept private. In any sort of report that may be published, no information will be included that will make it possible to identify you. Pseudonyms or numbers will be used in place of your real name to protect your identity. If you agree to participate in interviews, your interviews will be recorded (either audio or video). I will be conducting interviews over Zoom via the University of Minnesota and at the outset of the interview may ask if I can record our session. If I record our session, the file will be stored on my computer until May 4, 2021, after which I will delete any identifiable recordings/videos/information and retain the de-identified transcripts and data files for future use. Only I as researcher will have access to these data.

Contacts and Questions

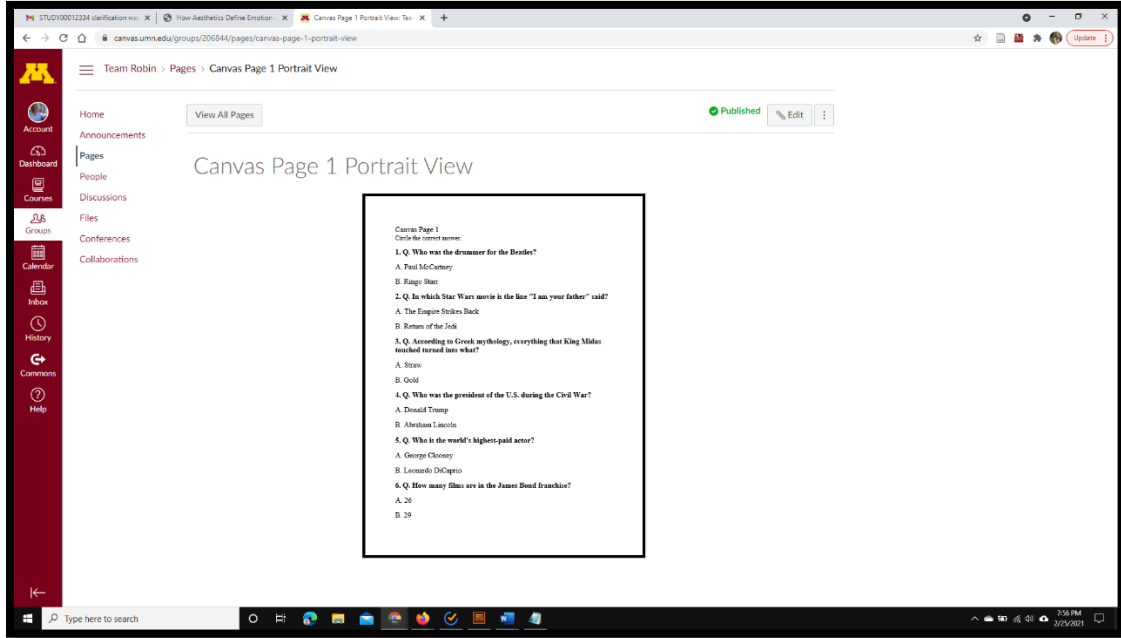
The researcher conducting this study is Autumn Brower. You may ask any questions you have about the study now. If you have questions later, you may contact me through e-mail: browe075@umn.edu

You will be given a copy of this form to keep for your files.

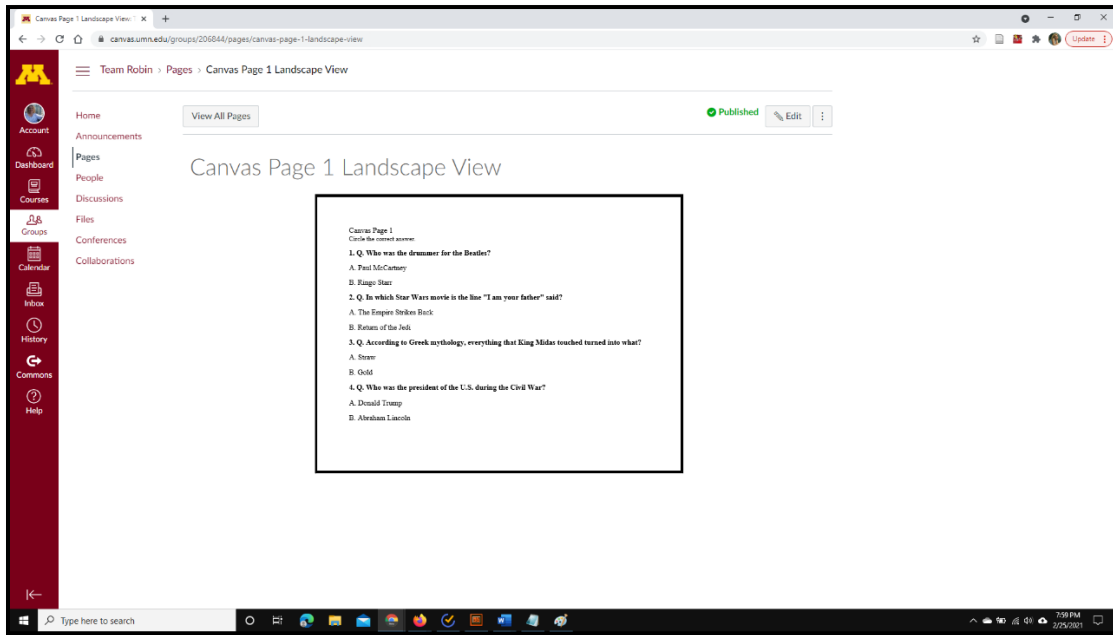
Appendix B

Canvas Screen Page Orientations

A: Portrait orientation (top image)



B: Landscape orientation (bottom image)



Appendix C
Fonts used in study

Canvas Page 1A Portrait TNR

Circle the correct answer.

1. Q. Who was the drummer for the Beatles?

A. Paul McCartney

B. Ringo Starr

2. Q. In which Star Wars movie is the line "I am your father" said?

A. The Empire Strikes Back

B. Return of the Jedi

3. Q. According to Greek mythology, everything that King Midas touched turned into what?

A. Straw

B. Gold

4. Q. Who was the president of the U.S. during the Civil War?

A. Donald Trump

B. Abraham Lincoln

5. Q. Who is the world's highest-paid actor?

A. George Clooney

B. Leonardo DiCaprio

6. Q. How many films are in the James Bond franchise?

A. 26

B. 29

Canvas Page 1B Portrait CSI

Circle the correct answer.

1. Q. Who was the drummer for the Beatles?

A. Paul McCartney

B. Ringo Starr

2. Q. In which Star Wars movie is the line "I am your father" said?

A. The Empire Strikes Back

B. Return of the Jedi

3. Q. According to Greek mythology, everything that King Midas touched turned into what?

A. Straw

B. Gold

4. Q. Who was the president of the U.S. during the Civil War?

A. Donald Trump

B. Abraham Lincoln

Canvas Page 1A—Landscape TNR

Circle the correct answer.

1. Q. Who was the drummer for the Beatles?

A. Paul McCartney

B. Ringo Starr

2. Q. In which Star Wars movie is the line "I am your father" said?

A. The Empire Strikes Back

B. Return of the Jedi

3. Q. According to Greek mythology, everything that King Midas touched turned into what?

A. Straw

B. Gold

4. Q. Who was the president of the U.S. during the Civil War?

A. Donald Trump

B. Abraham Lincoln

Canvas Page 1B Landscape CSI

Circle the correct answer.

1. Q. Who was the drummer for the Beatles?

A. Paul McCartney

B. Ringo Starr

2. Q. In which Star Wars movie is the line "I am your father" said?

A. The Empire Strikes Back

B. Return of the Jedi

3. Q. According to Greek mythology, everything that King Midas touched turned into what?

A. Straw

B. Gold