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Analysis of CRT Monitors: Do they interfere with learning?

Scientific research is the cornerstone of all academic learning, without which there would be no advancement. Publishing the results of such scientific inquiry is the culmination of said research. It is a way to share the results of these experiments with colleagues and the world at large. Although experiments can be done in many different ways and for many different purposes, the research paper should try to conform to a set of standards to help give the readers a sense of consistency throughout articles in a peer-reviewed journal, peer-reviewed journals in a field, etc. Trochim (2001) lays out these key elements as that of Introduction, Methods, Results, Conclusion, and Style. However, when one looks at different articles, this consistency of structure is not always as easy to distinguish as one might hope. In this paper, I will perform an in-depth analysis of the research article "CRT monitors: Do thy interfere with learning?" by Kate Garland and Jan Noyes published in 2004 in *Behaviour & Information Technology* Volume 23, No 1, pp 43-52. I will not analyze what they researched, but their research paper to see if they had a clear sense of how to write about and organize their research, based on the key elements of Trochim (2001) and lectures by Geisler to the class INF 397C (2006).

Overall, Garland and Noyes's research article was mostly acceptable. Their structure generally followed the proper pattern for a research paper, as mentioned above, even though there were several areas that could have used minor adjustments. In terms of how they laid out what their research methods and analysis, on the whole it appears satisfactory, however there were a few major problems to their internal validity and data analysis, which they either did not discuss at all or tried to gloss over very quickly.

The first section of any research paper is the introduction (Trochim 2001). This section is indented to draw the reader into the study and give them a sense of what the research is about, why it is important, and a context of the specific study within a larger frame of related research. The introduction is generally comprised of a title, an abstract, a statement of the problem, a review of literature, and the proposal of a hypothesis or discussion questions (Giesler, September 19, 2006). The title of the article, "CRT monitors: Do they interfere with learning?", accurately reflects the content of the paper as the authors were testing if people learned better from CRT monitors or from paper material when the material was laid out in the same way (p. 43). They tested for both accuracy of response and the way in which the subjects chose their answers (p. 47).

The abstract of the paper gives a basic overview of the study (Trochim 2001). In the abstract, Garland and Noyes state their basic assumptions before the research started, "screen reading is slower and possibly less accurate than reading from paper," their general methodology, "Six study and test sessions over 10 months examined correct scores and retrieval responses for learning material presented via these two media," and major results, "Correct scores did not differ suggesting that close matching of material can eliminate any decrement in reading speed or accuracy from screens. However, the way in which knowledge was retrieved varied between the presentational formats (p. 43)." All of these are important elements in an abstract (Trochim 2001). However, while they do give their general conclusions and why their results did not match previous assumptions, they also bring up details of CRT monitors, which they barely discuss in the paper itself. This may lead someone researching CRT monitors to believe that the different types of monitor are more important to and discussed more heavily within the paper than they actually are.

The statement of the problem is the most important part of the whole research paper (Creswell 2003). Garland and Noyes's problem statement is the single paragraph, which encompasses the entirety of their section titled Introduction:

> The continuing trend towards computer-based learning makes it important to establish the nature of any differences in learning outcomes between this form of instruction and that achievable from more traditional book/hard copy material. As Martin and Platt (2001) pointed out, the increasing use of electronic material for learning purposes has implications for print versus on-screen consumption. This paper reviews findings reporting differences in specific performance measures (e.g. reading speed, accuracy, comprehension), research reporting comparative learning outcomes between the two media, and examines a long-term memory paradigm that introduces another form of 'learning measure'. We present a longitudinal study that compared closely matched learning material either on a CRT monitor or in book format to examine whether, and in what way, differences in learning outcomes exist when current technologies are used. (p 43).

While the problem statement does lay out a general idea of what the study is, has a brief declaration of why it is important, that some studies have been done already, and what direction the research took, what the authors declare that they tested and the write-up about how the actual tests were done vary to some degree. Furthermore, the abstract is missing a set-up and good declaration of variables, which could have truly made it a strong statement of purpose (Giesler, September 19, 2006). It alludes to a "so what" factor in terms of how when learning material is given over computers, it is important to make sure that people will be able to comprehend it to the same extend that they would comprehend print-based material. I would recommend that the problem statement should read as follows:

> As the technology revolution continues to grow, there is an increasing trend towards computer-based learning modules. Therefore, it is important to establish the nature of any differences in learning outcomes between this form of instruction and that achievable from more traditional book/hard copy material. Although there have been previous studies, such as Martin and Platt (2001), which pointed out that the increasing use of electronic material for learning purposes has implications for print versus on-screen consumption, there have been enough advances in technology that the testing of this subject needs to continue. This study addresses the issue of computer-based (Computer) versus print-based (Print) learning through a longitudinal study which tested for specific

performance measures, mainly accuracy, as well as the nature of long-term memory (or
Know responses as opposed to Remember, Familiar, or Guess responses; see Appendix
for definitions), which is another form of 'learning measure.' We feel that this study is
important when determining how to present material in educational situation, especially
as technology is constantly evolving and many people are becoming more comfortable
with how to use it.

Looking at the problem statement and based on the definitions give in class by Geisler on
September 19, 2006, it can be said that this paper employs applied research. Garland and Noyes
planned take existing research about computer versus paper learning that already exists in the
field and do their own experiment to confirm or deny the previous results.

A number of terms are used throughout "CRT monitors: Do they interfere with learning?"
Although the authors mention in their abstract that CRT stands for cathode-ray tube, they never
repeat that fact in the paper itself, even though they have a whole section in their literature
review on CRT monitor characteristics (p. 44). This could cause some confusion to someone
who does not have an extensive computer background. The authors do declare they will call
computer-based learning Computer and print-based Print (p. 46). The other major terms in the
paper relate to how the subject chose their answers on the tests, or "Memory Awareness". These
terms are first mentioned in the section in literature review on learning (p. 44) and are further
defined on page 45. However, it is only in the methodology section that the authors mention that
the terms are listed in the Appendix (p. 47). The Appendix does, in fact, lay out the three of the
four terms in a clear and concise way, however they define the fourth term "Guess" as "guess"
(p. 52). This is considered to be bad definition practice and could have been prevented if the
authors had just written a simple definition for the word. In terms of consistency, other than the
Appendix, there was no one general section where the terms Garland and Noyes used were
defined, however they were very good at keeping the same definitions throughout the article.

The literature review covers the results of previous studies on the same subject, tests done

just on CRT monitors, and theories of learning and long-term memory and how it has been tested, all of which are relevant to the research problem. By going over previous tests, Garland and Noyes prove that their research is important because of the variety of results the other tests had (p. 43). Also they mention that it is important to repeat the experiment because computer technology has greatly improved (p. 44) and also because many of the studies did not use materials that were closely matched in both the print and screen forms (p. 46). Since CRT monitors are so crucial to their tests, it was important that they touched upon research done on learning just from CRT displays (p. 44). However, they did not spend much time discussing the details of how CRT monitors worked, nor did they include anything about the difference between CRT and flat-panel or LCD monitors; even though this difference is not the focus of their experiment it would have been nice for them to include it as many more people are starting to use these displays. The learning section is the largest section of their literature review and the only section of it that is divided into subsections. This section introduces Tulving's physiological theory about how, "As time passes, this knowledge becomes less distinct, abstract concepts are formed, and the reconstructed memory transfers or shifts into the semantic memory system (p. 44)." In this section they also introduce the concepts of Remember and Know for correlations between episodic and semantic memory and examine other studies that used this methodology to test for learning (pp. 44-45).

The last subsection of the literature review is not a review of previous literature. Instead, it is about a pilot study that Garland and Noyes did, its results, and the questions that arose from it. In this section they also include their hypothesis for this study, which states that while they do not expect a difference between the Computer and Print groups, but that they do expect that the shift from Remember to Know answers to happen sooner in the Print group than the Computer

group (p. 45). Including this information within the literature review is very confusing to the reader and is not conducive to a good writing structure. They should have pulled this subsection into a separate section called "Pilot Study and Hypothesis." In this new section they should have also included the first subsection "design" in their methodology section, because all it contains is a brief discussion of the independent and dependant variables. Another problem, which first shows up in the literature review and continues throughout the article, is that while most of the time their citations are done correctly, when citing a work that has more than two authors, they immediately write "[Author] *et al*" whereas proper citation practices state that the first time the authors are referred to, all of them should be listed with the *et al.* used in subsequent listings (Trochim 2001).

The methods section of an article informs the reader of how the research was carried out both in terms of sample and actual methodology as well as examining both external and internal validity, reliability, and biases that were controlled for or may have happened during testing (Trochim 2001). The methodology that Garland and Noyes chose for their study seems, for the most part, appropriate for their design. Their idea for a longitudinal study is a logical way of not only testing how well people learn material but also how well they retain this knowledge over time. Also, their idea of making sure that the study material was almost identical (p. 46) helps to eliminate one of the problems that they mentioned with previous studies (p. 44) and to make sure that in their study it was not a difference of presentation that affected the results. They discuss in detail each of the sessions in which they had the study's participants review the material, either on a computer or from a booklet, and then take a test on it (p. 47). They were also very careful to use the same type of monitor for the Computer group and to make sure that their sample

groups had the same gender amounts and similar age means (p. 46). By grading the tests, they were able to determine how well the participants of both groups did and if there was any improvement over time. They also asked participants to mark how they chose their answer based on the four terms of Memory Awareness (p. 47). Therefore, the way in which they collected their data seems very straightforward. However, while Garland and Noyes never actually discuss external validity, they do mention that they made sure that their sample had a large proportion of highly computer-literate subjects. This could cause an effect on external validity because learning from a CRT monitor may not be as easy for those people who are not as computer literate as members of their study. However, there is nowhere in their paper where the authors acknowledge any limitations to their methodology. Through my analysis of their paper, I ended up with a few questions about their methods, which I will discuss a little later.

Garland and Noyes discuss their reliability and validity throughout their Discussion and Conclusion sections. Once again there is no general place where they specifically state that they are talking about these concepts. In terms of reliability, the authors mention that they were able to replicate their results from their article published in 2003 (p. 49). However, they also mention that their pilot study gave them different results than their full study (p. 45). Garland and Noyes do give a brief discussion as to prior academic knowledge affecting the scores, however, since it was a longitudinal study, they claim that all the participants had a chance to expand their knowledge. They tested this by administering a second set of questions after the fourth time the participants reviewed the material and answered the first set of questions (p. 47). This second set of questions also helped to address the problem of bias because the participants would not have seen the second set of questions before (Trochim 2001). The authors also discuss how the decrease in correct answers towards the end of the study might be related to the change of

questions, but also might be because of "the reduced number of participants and possibly boredom or poor motivation due to repetition of the same material, rather than learning patterns (p. 49)."

In reading over this research paper, I had a number of issues when looking at the validity and reliability of their research in terms of sampling and methods. First, Garland and Noyes do not mention how they communicated the memory awareness terms to the participants or how well the participants understood each term. Also, they do not discuss how when a subject selected how they chose an answer on the test, it really was due to that type of memory awareness. Without knowing if the concepts were fully and carefully explained to the participants, it is hard to know how well they understood exactly what was being asked of them, especially since there were no interviews or questionnaires to test the subjects' understanding. Second, between the fifth and seventh sessions, the number of participants decreased (p. 47). There was no mention of why this happened, what happened to the number of participants in each group or even if those in session 6 were the same as those in session 7. Although, as mentioned above, the authors do touch upon the idea that some of the change in results could be attributed to this decrease in numbers, they also state that "there were no differences for level of computer experience; similarly, the participant characteristics of age, sex and perceptual style (as measured by the Embedded Figures Test) were found not to influence the results (p. 49)." This, to me, is a major problem with their validity. With an original sample of only 25 members per group (p. 46), a decrease in the sample size could have had a much bigger impact on their study than Garland and Noyes indicate, especially if there were more test subjects in one group than another. If the groups were no longer equal, then can we trust that the data collected is an accurate representation of their original samples? This change in size is one that should have

been very thoroughly examined, however it seems as though the authors were afraid that doing so might invalidate their results.

In the Results section of a paper, the outcome of research is discussed along with an analysis of the data collected (Trochim 2001). As predicted in the hypothesis, "Correct scores did not differ significantly between the two presentation formats in any of the test sessions. Further, measures for improvement in scores and learning did not differ between groups (p. 48)." Also, as predicted, the shift from Remember to Know responses happened earlier in the Print than Computer groups which "suggests that the shift of knowledge from episodic to semantic memory occurred earlier for printed, learning material (p. 49)." In order to come to their conclusions, Garland and Noyes analysis their data in a number of ways and presented it through tables and reliability tests. The first table presents the mean and standard deviation for the correct answers per test group per session. Garland and Noyes run an analysis of variance (ANOVA) test on this data and find that in general, the differences between the groups at the session level was not significant (p. 47). The second table shows the means and standard deviation for the memory awareness answers per test group per session (p. 48). The third one does give the number of Remember and Know responses per group per session as well as the χ^2 test results between these two categories, which in the earlier cases proved to be significant, but not in the later cases (pp. 48-49). Although the authors suggest that this lack of significance means that there was a movement from Remember to Know responses, it could have also been caused by decrease in the study's participants. However, as mentioned earlier, they never clearly address this issue. Furthermore, there did not seem to be any tests run on the Familiar and Guess responses in relation to each other or to the Remember and Know responses. By not addressing this, they are

leaving out the idea that a number of the correct answers may still be obtained by random chance, instead of through any type of learning. This is a real concern that I have about the validity of their argument.

The final section of an article, the conclusion, discusses the "implication of these results" and offers insight into further study (Trochim 2001, Giesler, September 19, 2006). The conclusion of "CRT monitors: Do they interfere with learning?" is that ultimately whether the information is learned from a computer or from print, as long as the material is presented in the same format then people can come up with the same number of correct answers. However, in terms of memory, items move from episodic to semantic in a shorter amount of time when learned from print material. Garland and Noyes infer that this has to do with the characteristics of CRT monitors (p. 50). Both of these conclusions are strongly supported by the data. However, they do not discuss their findings on the Familiar and Guess responses and how these increased or decreased in relation to Remember and Know responses throughout the length of the study. Also within the conclusion the authors bring up an idea for a future study on brain areas in relation to CRT learning (p. 50). However, they do not give any specific ideas for future studies with emerging technologies, such as LCD displays versus CRT displays or print displays, based on their experiences, even though they mention that as technology improves, it is important to continue to do these types of studies (p. 51).

The last element to consider when analyzing a paper is the style (Trochim 2001). Throughout the paper Garland and Noyes' writing style is very clear and precise. There are no biases that can be detected from the authors' tone. However, as noted earlier, some of the

sections do not flow well into each other and they would have benefited from breaking up the reflective inquiry into more sections. Also, they do not give any sort of sample of the material or questions that they used in the test. While they do mention that the material was 22 pages long (p. 46), it would have been helpful to be able to review a snippet of this material in order to get an idea for the level of knowledge it represented. Along this same line, sample questions would also have been helpful. Furthermore, there are no charts in the entire paper. If they had included a chart that showed the close correlation between the correct answers from the Computer and Print groups and another one that showed how the responses shifted from Remember to Know in different time periods for the two groups would have been beneficial to the readers understandings of the data and data analysis.

Overall, I believe that this paper has merit in our field because more and more resources are being placed online every day. As Google.com continues to try to digitize the world, we need to make sure that people will still be able to read and understand the material in front of them. This study proves that while people can learn from CRT displays, the knowledge takes longer to fully process in the human mind. I chose this paper because I noticed that many of the students at the iSchool were printing out the articles they had to read for class instead of reading them on the computer and I wanted to see if any studies had been done about reading online. From Garland and Noyes' paper I learned that while as long as the material looks the same, the medium on which I read it does not matter, but if I want to make sure that I process what I am learning in a deeper way for greater recall, I should probably continue to waste paper by printing things out.

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