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A Comparison of the Effectiveness of a Spreadsheet Matrix vs. a Digital Concept Map in Improving Student Annotated Bibliography Entries and Literature Reviews in AP Research

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**A Comparison of the Effectiveness of a Spreadsheet Matrix vs. a Digital Concept Map in
Improving Student Annotated Bibliography Entries and Literature Reviews in
AP Research**

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Capstone Project: An Action Research Project

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Abstract

AP Research students often find writing the literature review for their thesis papers challenging due to struggling to see connections between sources, leading to difficulty in establishing a gap in the literature. However, incorporating the use of an organizational tool can help students with these challenges and lead to a more thorough and interconnected annotated bibliography entries. With limited research into how well spreadsheet matrices and concept maps help AP Research students improve their writing of these entries, this action research project aimed to further the conversation of how best to help AP Research students approach writing a literature review. In a pre/post-intervention quasi-experimental design, one section of 20 AP Research students were asked to utilize a spreadsheet matrix and one section of 19 AP Research students were asked to utilize a digital concept map. Student annotations were evaluated before and after the intervention using a rubric. A chi-square test for association revealed a significant increase in proficient scores after interventions were implemented, but no significant difference in post-intervention scores between the two test groups. These findings suggest that the use of either a spreadsheet matrix or a digital concept map can lead to better proficiency in writing their annotated bibliography entries, both overall and specifically for interconnecting sources. The implication is that AP Research teachers should train students to use either a spreadsheet matrix or a digital concept map to help improve their ability to write an annotated bibliography, see connections between sources, and ultimately write their literature review.

Keywords: spreadsheet matrix, concept map, annotated bibliographies, AP Research

Table of Contents

Abstract.....	1
Introduction.....	4
Literature Review.....	7
Methods.....	16
Research Question	16
Variables	16
Research Setting.....	16
Participants.....	17
Intervention	17
Data Collection	18
Measurement Instrument	18
Process and Timeline	18
IRB Approval.....	19
Findings.....	20
Data Analysis	20
Chi Square Results	21
Discussion.....	26
Summary of Major Findings.....	26
Limitations of Study	27
Further Study	28
Conclusion	30
References.....	31
Appendix A.....	35
Appendix B	40

**A Comparison of the Effectiveness of a Spreadsheet Matrix vs. a Digital Concept Map in
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AP Research**

AP Research is a course that is part of the AP Capstone program where students “deeply explore an academic topic, problem, or issue...by designing, planning, and investigating a yearlong investigation to address a research question” (College Board, 2022, para. 1). One challenge for high school students conducting original research is their ability to properly evaluate the credibility of online sources. Many students have trouble judging the quality of what they find online and accidentally plagiarize often due to the ease with which students borrow from others’ work (Purcell et al., 2012). Further, once students establish credibility of their sources, there are several common mistakes made when conducting a literature search and writing a literature review, the most relevant being mission creep, selection bias, lack of comprehensiveness, and treating all studies as equally valid (Haddaway, 2020).

The purpose of this research is to determine whether utilizing a spreadsheet matrix or a digital concept map is more helpful to students in improving their annotated bibliography entries and their overall literature reviews. The findings of this study can help AP Research teachers improve their practice by determining which organizational tool leads to better student writing, leading to a potential increase in project quality and student learning. Further, this could free up more time for students to collect data and analyze it, and would allow for more individualized attention, potentially leading to higher quality projects and papers. While research has shown the benefits of using a spreadsheet matrix for organizing literature review sources (Bartram et al., 2022; Broman & Woo, 2018; Clark & Buckley, 2017; Younas & Ali, 2021) and the benefits of using concept maps to organize information and improve student understanding and

conceptualization (Amin & Hina, 2018; Choudhary & Bano, 2022; Conner & Browne, 2013; de Ries et al., 2021; Hartmeyer et al., 2017; Kaddoura et al., 2016; Reiska et al., 2018; Uygur, 2019; Wachanga et al., 2018), no studies in the last 10 years have compared the two tools. This study aims to fill the gap by evaluating the effectiveness of each tool in the context of a high school AP Research course.

Resources for this action research study were compiled from the DeWitt Library at Northwestern College. To be considered for inclusion, studies must have been published in a peer-reviewed journal within the last 10 years. Studies regarding the following were reviewed: best practices when writing literature reviews, concept maps as organizational and assessment tools, synthesis matrices as organizational and/or writing tools, the problems encountered with using spreadsheets and concept maps, and improvements in student achievement understanding and learning from the use of a spreadsheet matrix or a concept map. Ultimately, 20 sources were selected based on relevance and support given to the present study. Studies were used to understand the current knowledge base, as well as identify existing gaps, in organizational tools used for writing literature reviews.

Overall, both the use of a spreadsheet matrix and a digital concept map improved student annotated bibliography entries and literature review quality. There was no significant difference ($\alpha = 0.05$) seen between the two organizational tools, but both were significant between the pre- and post-test.

The following literature review first discusses the importance and necessity of AP Research students conducting a literature search for their topics, as well as writing a scholarly literature review. Second, findings from studies that examined the impact of spreadsheet usage

on data and information organization will be discussed. Finally, findings from studies that examined the impact of concept map usage on organizational skills and student achievement will be discussed.

Review of the Literature

Currently, AP Research students need assistance with organizing sources from their literature search to help them write their annotated bibliography entries, which they ultimately use to write their literature review. Two methods of organization will be compared: a synthesis matrix using a spreadsheet vs. a digital word/concept map using Coggle.

Challenges for High School Students When Writing Literature Reviews

One struggle high school students tend to experience while conducting original research is their ability to properly evaluate the credibility of online sources. A survey of over 2000 middle school and high school teachers found that many students have trouble judging the quality of what they find online and accidentally plagiarize often due to the ease with which students borrow from others' work (Purcell et al., 2012). However, in a study surveying 1,742 high school AP teachers, Rainie et al. (2020) found that students do learn to hone these skills over time during high school, particularly as juniors (when students can take AP Seminar) and seniors (when students can take AP Research), so it appears that this credibility issue does diminish some over time.

However, once students are able to establish credibility of their sources, there are several common mistakes made when conducting a literature search and writing a literature review. In a systematic review of other researchers' literature reviews, Haddaway et al. (2020) found eight common problems when conducting a literature search and writing a literature review: lack of stakeholder relevance, mission creep, lack of transparency or reliability in the review methods, selection bias, lack of comprehensiveness, the exclusion of grey literature, treating all studies as equally valid, and inappropriate synthesis methods. While some of these issues are not as relevant to high school seniors conducting original research, mission creep, selection bias, lack

of comprehensiveness, and inappropriate synthesis methods are the most glaring issues students struggle with while conducting their literature searches and composing their literature reviews (Haddaway et al., 2020). A systematic review conducted by Broman and Woo (2018) support these findings, showing that students conducting research tend to lose focus on their original research question while finding relevant sources and also struggle to synthesize the findings of multiple studies together into a coherent literature review. Based on these findings, it appears that students need better training on finding relevant sources for their research question and on how to connect these sources together to create a synthesized literature review that identifies a clear gap.

In the fall semester of the AP Research course, the majority of the time is spent helping students formulate a reasonable research question, conducting the literature search, and writing the literature review. The literature review is of particular importance because it defines the topic for the reader, identifies the major findings in the field, and ultimately identifies the gap in the literature that justifies the research question (Pautasso, 2018). A common technique found by Conner and Browne (2013) to be effective in helping to begin writing a review of the literature is to annotate one's sources and organize them into themes or subtopics. They conducted an experiment with 50 undergraduate students where three organizational methods were evaluated: a keywords matrix, a visual word wheel (similar to a concept map), and a cascading sequence of search terms. Compared to the control group, students who used an organization tool were able to use more search terms to find more sources and had an easier time organizing their findings into themes. However, research has shown that even when students are can be proficient at finding relevant sources and summarizing them (Rainie et al., 2020), they tend to struggle when it comes to synthesis and finding connections between relevant sources (Baker, 2016). A proper

literature review does not merely summarize, but rather analyze the findings of multiple sources, put them in conversation with each other, and then synthesize the primary argument made by those sources (Baker, 2016).

This action research will focus on this specific issue: helping students organize their sources to help them see the connections better in order to write a proper synthesized (not merely summarized) literature review. It is important that students properly synthesize a review of the literature so that they can provide a comprehensive overview of the research on their topic, thereby providing clarity and comprehension to their readers, and to identify a gap in the literature to justify the necessity of their research (Baker, 2016). To address the shortcomings that students have in this area, two possible solutions have been found that are supported by research: creating a synthesis matrix in an Excel spreadsheet or using a digital Coggle concept map to connect studies together. While research has shown the benefits of using a spreadsheet matrix for organizing literature review sources (Bartram et al., 2022; Broman & Woo, 2018; Clark & Buckley, 2017; Younas & Ali, 2021) and the benefits of using concept maps to organize information and improve student understanding and conceptualization (Amin & Hina, 2018; Choudhary & Bano, 2022; Conner & Browne, 2013; de Ries et al., 2021; Hartmeyer et al., 2017; Kaddoura et al., 2016; Reiska et al., 2018; Uygur, 2019; Wachanga et al., 2018), no studies in the last 10 years have compared the two tools. This study aims to fill the gap by evaluating the effectiveness of each tool in the context of a high school AP Research course.

Synthesis Matrices as Organizational Tool for Literature Reviews

One common technique for organizing one's sources while preparing to write a literature review is a synthesis matrix, defined as a spreadsheet or table "that helps a writer plan a literature review [by showing] how the articles relate to one another and how the research articles relate to

the common themes found in the literature” (Clark & Buckley, 2017, p. 355). Synthesis matrices can help students more easily identify the theoretical frameworks and methods of a source, identify strengths and limitations of an article, and determine potential trends in themes, as evidenced by Younas and Ali’s 2021 systematic review. Broman and Woo (2018) confirmed these findings, revealing in a systematic review that when a spreadsheet is utilized as an organizational tool, students showed improved comprehension of large amounts of information or data and found it easier to explain how various sources of information or data points were related to each other. These findings suggest that the use of synthesis matrix leads to a more efficient researcher because it helps them organize their information quickly and still allow them to visualize connections between sources.

Organizing the literature this way is helpful because it aids the researcher in synthesizing the literature rather than simply analyzing or discussing it. A study conducted by Bartram et al. (2022) involving 12 US data workers found that the physical architecture of their data tables allowed them to quickly analyze data and make more immediate conclusions compared to other visualization methods. A systematic review by Clark and Buckley (2017) confirmed these findings, showing that when experimental groups utilized a synthesis matrix to organize a large number of research articles, the user was better able to combine conflicting and diverse findings in way that accurately described the current state of the body of knowledge surrounding a topic. However, a 2012 study by Chambers and Scaffidi found that among a sample of 400 teacher users of spreadsheets, new users commonly experienced frustration navigating Excel, especially when trying to use specific features they had trouble finding. These shortcomings of using a spreadsheet were also found in a 2017 study by Caulkins et al. They interviewed 45 executives and senior analysts who regularly used spreadsheets for organizational purposes and found that

57% of them expressed strong concern about consequences of spreadsheet errors and another 20% were at least somewhat concerned. These problems encountered when using spreadsheets were confirmed in a 2014 quasi-experimental study by Poon et al. (2014) involving non-technical users of Excel. In their study, five spreadsheets containing natural faults were given to five non-technical users, defined as users who use spreadsheets as part of their job but not trained as a formal IT professional, and asked them to identify errors and correct them appropriately. Overall, they found that while users could identify most errors in the spreadsheet, they found correcting them to be cumbersome and time-consuming.

The findings of these studies suggest that although spreadsheets can be a useful organizational tool, spreadsheet errors do occur and inputting information can be overwhelming for new and inexperienced users, which most AP Research students would classify as. One possible alternative to a spreadsheet matrix is the use of digital concept maps, which will be discussed in the two subsequent sections.

Concept Maps as Effective Formative Assessment Tool

Concept maps were first introduced by Novak and Gowin (2008) as a way to activate prior knowledge and create connections between ideas. Since then, many have found that concept maps are beneficial for a number of reasons, including as a formative assessment tool. In a 2022 study, Choudhary and Bano conducted a six week pre-/post-test experimental study with 46 9th grade biology students to determine if the use of a concept map could be used as a formative assessment to gauge student understanding, predict their performance on the summative assessment, and if it helped students perform better on that summative assessment. They found that the students who were in the intervention group (i.e. used the concept map) were able to more effectively show relationships between different concepts, which led to better

performance on the summative unit assessment (Choudhary & Bano, 2022). Further, teachers were able to gain better insight into student thinking and reasoning when they were using the concept map, which allowed for better remediation of misconceptions. These findings were supported by Reiska et al. (2018), who found that among 182 9th and 10th grade students across 44 high schools, students who used a concept map in an intervention study were better able to demonstrate their understanding of interdisciplinarity to their teacher and were able to create more high-scored propositions compared to the control group. However, a systematic review of nine studies found that in order for concept mapping to be an effective formative assessment, they must be utilized by teachers consistently on multiple occasions, be used individually to help elicit personal understanding, and be low-directed, meaning minimal assistance given by the teacher in the form of a word bank, line template, etc. (Hartmeyer et al., 2017). These findings suggest that concept maps can effectively be used to gauge student understanding of content due to being better equipped to make connections between topics, which ultimately leads to better summative assessment scores, but only if students are given many individual opportunities to create them.

Concept Maps as Effective Organizational Tool to Improve Student Literature Reviews

Concept mapping is also helpful in “recogniz[ing] a logical way to order and link the various sections of a review” (Pautasso, 2018, p. 3), which is something many students struggle with, especially as they annotate more and more sources and are starting to write the actual literature review. Furthermore, concept maps are effective in organizing information into meaningful categories, thinking creatively about a topic, developing an understanding of a body of knowledge, and thinking about the big picture and seeing the connections between concepts (Reiska & Soika, 2015). In a review of 21 studies that evaluated the impact of concept maps, de

Ries et al. (2021) found that all studies showed an increase in learning gains or conceptual growth amongst subjects when students utilized concept maps properly. Furthermore, they found that the more nodes a student included and the more structurally complex the concept map was, the higher the learning gains and the stronger their conclusions (de Ries et al., 2021). These findings are supported by a 2016 study by Kaddoura et al. involving 83 first-year nursing students preparing for a critical thinking exam. The experimental group was trained on using concept maps and developed one concept map a week for 14 weeks, receiving feedback along the way, then took a standardized, nationwide critical thinking exam. The mean scores of the concept map group improved significantly from pre- to post-test and students showed significantly higher critical thinking skills compared to the control group (Kaddoura et al, 2016). These findings suggest that if students are trained on using concept maps, they are better able to organize their information, leading to better connections between concepts and ideas and therefore better critical thinking skills related to the topic of the concept map.

Student Motivation

Another primary reason concept maps are effective organizational tools is that proper usage of concept or mind mapping can help motivate students in the classroom. Wachanga et al. (2018) conducted a study with 202 Biology II students split into four groups: two control groups (one pre-tested, one not) and two experimental groups (one pre-tested, one not). The experimental groups received collaborate concept mapping instruction while the control groups received traditional instruction (i.e. lecturing) and then took a student motivation questionnaire to assess their interest in learning biology. The results of an ANCOVA revealed that students who participated in concept mapping had significantly higher levels of interest and motivation than those who received traditional instruction. Amin and Hina (2018) found similar results in their

study with 600 social science students who were asked to use a mind mapping technique while studying. The t-test analysis showed a significant ($\alpha = 0.01$) increase (30%) in student motivation for both female and male students. The findings of these two studies demonstrate that teachers should be utilizing concept or mind mapping strategies in their classrooms to help better engage with and motivate their students

However, both studies (Amin & Hina, 2018; Wachanga et al., 2018) emphasized that the most significant differences were seen when teachers were well-trained on the concept mapping technique, a finding confirmed by Uygur (2019). In Uygur's (2019) study, students ($n = 44$) who were properly trained on using a digital concept map compared to students ($n = 43$) who created their own concept map with pencil and paper had higher levels of engagement with the lesson, found learning to take place more easily, and had higher levels of achievement on the end-of-unit assessment. The findings of these three studies suggest that concept maps are effective motivational tools and lead to higher levels of academic achievement, but only if students receive proper instruction on how to use them from a teacher who has been trained on how to utilize this instructional strategy effectively.

Research Gap

Both synthesis matrices and concept maps are efficient and research-supported methods to help prepare and write a literature review. As discussed, they both aid the researcher in identifying the themes and subtopics in their research, organize the sources in a logical way, and, most importantly, synthesize the sources together rather than just summarizing separate sources. However, no research from the last 10 years was found that evaluated their effectiveness in high school research classrooms, nor any research that compared the two methods. Therefore, this

action research project aims to evaluate both methods to determine which is the more effective organizational tool to help improve students' abilities to write their annotated bibliographies and their literature reviews for their individual AP Research projects.

Methods

Research Question

The method described below aims to answer the following research question: Is utilizing a synthesis matrix spreadsheet or utilizing a Coggle concept map more helpful to students in improving students' annotated bibliography entries in terms of discussing connections and relevance between sources?

Variables

The independent variable in this study is the organization tool used by each student. One class section will utilize the Coggle concept map and the other section will use a synthesis matrix spreadsheet. These tools will be used to organize their sources in preparation to write their literature reviews.

The dependent variable is student scores on the annotated bibliography rubric (see Appendix A). This rubric evaluates student annotations in terms of the citation format, source summary, source credibility, discussion of method, and discussion of the source's relevance to the student's topic of inquiry, including connections to other sources. Each column is scored out of a possible five points, giving a maximum total of 25 per annotation. Overall annotation scores will be compared as well as the individual sub-score for the "relevance to inquiry" column. Students will ultimately annotate 20 total sources in preparation to write their literature reviews.

Research Setting

This action research project will be conducted at Science Hill High School in Johnson City, TN. The school has a population of about 2300 students, which is broken down demographically as 69.3% White, 11.6% Hispanic, 9.9% Black, 5.0% two or more races, 3.9%

Asian, and 0.2% American Indian/Alaskan Native (US News, 2022). The school has a student-to-faculty ratio of 16:1, a 92% graduation rate, is eligible for Title 1 Funding (38.5% of students received free/reduced meals), an AP participation rate of 40% (meaning 40% of students take at least one AP course), and is ranked #17 out of 402 Tennessee high schools (US News, 2022).

Participants

Two sections of a year-long AP Research course participated in this study. AP Research is a senior-level course in the AP Capstone program, taken after students pass AP Seminar their junior year. There are 39 students total in the course; 19 in section 5A and 20 in section 6A. Of those 39 students, 79.4% are White, 15.4% are Asian, 2.6% are Black, and 2.6% are Hispanic. Students were 59% female and 41% male.

Intervention

Two organization tools were compared: a spreadsheet synthesis matrix using Excel and a digital concept map using Coggle. The 20 students in section 5A used the Excel spreadsheet matrix and the 19 students in section 6A used the Coggle concept map. The spreadsheet consists of the sources listed in the first column with the subsequent columns being used for each theme or subtopic identified by the student. Each cell will then be populated with a summary of the applicable information from each source related to that subtopic. If a source does not discuss a subtopic, the students were instructed to leave that cell blank. For the concept map, the student's research question was placed in the center with the three to five subtopics branching off to surround that question. Students then added branches to each subtopic containing relevant information from each source. As students annotated more sources, they continued to add to their spreadsheet or concept map.

Data Collection

Measurement Instrument

The annotated bibliography entry rubric (see Appendix A) was used to score student annotations. This rubric evaluates student annotations in terms of the citation format, source summary, source credibility, discussion of method, and discussion of the source's relevance to the student's topic of inquiry, including connections to other sources. Each column is scored out of a possible five points, giving a maximum total of 25 per annotation. Overall annotation scores were compared as well as the individual sub-score for the "relevance to inquiry" column.

This rubric has been vetted by the AP Research online community, comprised of thousands of AP Research teachers, readers (those who score the official student submissions in May of each year), and leaders, and is used throughout many AP Research classrooms. The researcher has used this rubric for many years in the AP Research classroom as well. To minimize bias, student names were hidden while assigning grades to prevent the researcher from knowing which organizational tool was used by the student. Further, to ensure accurate ratings are applied, the AP Literature co-teacher (who is also trained in AP Research) scored one annotation from each students' set of five submissions. An inter-rater reliability percentage was calculated to ensure at least 80% agreement in scores.

Process and Timeline

After students decide on an approved research topic, they began conducting their literature search using techniques discussed in class. They used the AP Research annotated bibliography template and instructions to write their first set of five annotations. These annotations were written during week 1 before introducing the organizational tool intervention.

During week 2, students were assigned on organizational tool and instructed on how to use it. After each student group was assigned an organizational tool and instructed on how to use it, they began organizing their first five sources in that tool. After utilizing the tool, students began their annotations again. Every subsequent week (weeks 3, 4, and 5), students submitted a set of annotations comprised of five entries each. Students did not receive scores on these, but the researcher did use the annotated bibliography rubric to monitor student scores. The researcher also provided feedback to help improve student writing, but this was done in whole class instruction. At the end of the five-week study, students should have completed 20 total annotated bibliography entries.

Storage and Security

All student annotations were submitted through the district's learning management system, Canvas. The digital rubric software was used on Canvas to assign scores to each student submissions. These scores remained hidden from students. Only the researcher has access to these submissions and scores. At the end of the school year, the individual scores on these assignments will be deleted to secure them from any future data leaks or breaches.

IRB Approval

This action research project was submitted to the IRB at Northwestern College of Iowa and received approval before the intervention was implemented. Informed consent forms were given to students in class before the intervention was implemented. The grades given using the rubric were only used for research purposes; they were not entered into the district gradebook and did not have any influence on student grades in the class. Students had the option to opt-out of the study at any time with no repercussions.

Findings

Data Analysis

To analyze the annotated bibliography results, several chi-square tests of association were used at a significance level of 0.05. Since a rubric is being used to score student annotations, the data are categorical, meaning a t-test or a four-way factorial means test could not be used. Since students will write a set of five annotations for each entry assignment, the median total score and the median relevance score for each students' set of five will be used for data analysis purposes. For the chi-square tests, students are considered proficient for the total score if they earn a 20 out of 25 or above, as this equates to a B grade. Similarly, students are considered proficient in the relevance score if they earn a 4 or above.

The first chi-square test compared the initial annotation scores (before the intervention was implemented) between both test groups (those that used the spreadsheet matrix vs. those who used the Coggle concept map). One test compared the median for total annotation score and the other compared the median for relevance annotation score. This test was conducted to ensure there was no statistical difference between test groups before implementing the intervention.

The second chi-square test compared initial annotation scores (before the intervention was implemented) to final annotation scores (after the intervention was implemented). One test was conducted with the spreadsheet matrix group and a second test was conducted for the Coggle concept map group. This test was conducted to determine if each individual organizational tool improved student scores. This test was repeated for the individual relevancy sub-score to determine if each organizational tool led to students being better able to find connections between sources and connect sources to their topic of inquiry.

The third chi-square test compared the final annotation scores between the two groups to determine which organizational tool resulted in higher annotation scores overall. This test was repeated for the individual relevancy sub-score for the same reason as the second chi-square test.

Chi Square Results

Before the intervention was implemented with each test group, seven of 20 students in the matrix test group were proficient in writing their annotated bibliography entries compared to nine of 19 in the Coggle test group. These results were analyzed using a chi-square test for association to ensure there was no statistically significant difference between test groups before implementing the intervention. This test revealed that there was no significant difference between test groups' median annotation scores, $\chi^2 (1, N = 39) = 0.62, p = .433$. Students in the matrix group were no more likely to receive a rating of proficient on the overall annotated bibliography rubric before the intervention than those students in the concept map group. The median relevance scores were also compared between test groups, showing that six of 20 students using the matrix were proficient and eight of 19 students using Coggle were proficient. A chi-square test for association showed that there was no significant difference between the two groups' median relevance scores, $\chi^2 (1, N = 39) = 0.62, p = .431$. Students in the matrix group were no more likely to receive a rating of proficient on the relevance portion of the annotated bibliography rubric before the intervention than those students in the concept map group. The frequency of proficient and not proficient scores can be found in Tables 1 and 2.

Table 1

Frequency of Students with Proficient Pre-intervention Overall Annotation Scores for the Matrix and Coggle Test Groups

	Proficient	Not Proficient	Marginal Row Totals
Matrix Pre Total	7 (8.21) [0.18]	13 (11.79) [0.12]	20
Coggle Pre Total	9 (7.79) [0.19]	10 (11.21) [0.13]	19
Marginal Column Totals	16	23	39 (Grand Total)

Table 2

Frequency of Students with Proficient Pre-intervention Relevance Annotation Scores for the Matrix and Coggle Test Groups

	Proficient	Not Proficient	Marginal Row Totals
Matrix Pre Relevance	6 (7.18) [0.19]	14 (12.82) [0.11]	20
Coggle Pre Relevance	8 (6.82) [0.2]	11 (12.18) [0.11]	19
Marginal Column Totals	14	25	39 (Grand Total)

After the matrix intervention was implemented, 17 of 20 students were found to be proficient regarding total annotation scores compared to the seven of 20 who were proficient before the intervention. The proportion of students who were proficient after using the spreadsheet matrix was found to be significantly higher than before the intervention was implemented $\chi^2 (1, N = 40) = 10.42, p = .0012$. Students were more likely to receive a rating of proficient on the overall annotated bibliography rubric following the use of a spreadsheet matrix to organize their annotated sources. Regarding the median relevance score on the annotations, 15 of 20 students in the matrix group were found to be proficient compared to six of 20 before the intervention. A chi-square test for association revealed a significant difference between test groups' relevance scores, $\chi^2 (1, N = 40) = 8.12, p = 0.0044$. Students were more likely to receive

a rating of proficient on the relevance portion of the annotated bibliography rubric following the use of a spreadsheet matrix to organize their annotated sources. The frequency of proficient and not proficient scores can be found in Tables 3 and 4.

Table 3

Frequency of Students with Proficient Overall Annotation Scores Before and After Matrix Intervention

	Proficient	Not Proficient	Marginal Row Totals
Matrix Pre Total	7 (12) [2.08]	13 (8) [3.12]	20
Matrix Post Total	17 (12) [2.08]	3 (8) [3.12]	20
Marginal Column Totals	24	16	40 (Grand Total)

Table 4

Frequency of Students with Proficient Relevance Annotation Scores Before and After Matrix Intervention

	Proficient	Not Proficient	Marginal Row Totals
Matrix Pre Relevance	6 (10.5) [1.93]	14 (9.5) [2.13]	20
Matrix Post Relevance	15 (10.5) [1.93]	5 (9.5) [2.13]	20
Marginal Column Totals	21	19	40 (Grand Total)

The above chi-square tests were repeated for the Coggle test group. After the intervention was implemented, 18 of 19 students were found to be proficient regarding total annotation scores compared to the six of 19 who were proficient before the intervention. The proportion of students who were proficient after using the Coggle concept map was found to be significantly higher than before the intervention was implemented, $\chi^2 (1, N = 38) = 10.36, p = .0013$. Students were more likely to receive a rating of proficient on the overall annotated bibliography rubric following the use of a Coggle concept map to organize their annotated sources. Regarding the

median relevance score on the annotations, 15 of 19 students were found to be proficient compared to eight of 19 before the intervention. A chi-square test for association revealed a significant difference between test groups' relevance scores, $\chi^2 (1, N = 38) = 5.40, p = 0.020$. Students were more likely to receive a rating of proficient on the relevance portion of the annotated bibliography rubric following the use of a Coggle concept map. The frequency of proficient and not proficient scores can be found in Tables 5 and 6.

Table 5

Frequency of Students with Proficient Overall Annotation Scores Before and After Coggle Intervention

	Proficient	Not Proficient	Marginal Row Totals
Coggle Pre Total	9 (13.5) [1.5]	10 (5.5) [3.68]	19
Coggle Post Total	18 (13.5) [1.5]	1 (5.5) [3.68]	19
Marginal Column Totals	27	11	38 (Grand Total)

Table 6

Frequency of Students with Proficient Overall Annotation Scores Before and After Coggle Intervention

	Proficient	Not Proficient	Marginal Row Totals
Coggle Pre Relevance	8 (11.5) [1.07]	11 (7.5) [1.63]	19
Coggle Post Relevance	15 (11.5) [1.07]	4 (7.5) [1.63]	19
Marginal Column Totals	23	15	38 (Grand Total)

A final chi-square test for association was used to compare the post-intervention scores between the two test groups. For the overall annotation score, 17 of 20 students in the matrix group were found to be proficient compared to 18 of 19 students in the concept map group. This test revealed that there was no significant difference between test groups' median annotation

scores following the intervention, $\chi^2 (1, N = 39) = 1.00, p = .316$. Students in the matrix group were no more likely to receive a rating of proficient on the overall annotated bibliography rubric after the intervention than those students in the concept map group. For the relevance annotation score, 15 of 20 students in the matrix group were found to be proficient compared to 15 of 19 students in the concept map group. The chi-square test for association showed that there was no significant difference between test groups' median relevance annotation scores following the intervention, $\chi^2 (1, N = 39) = 0.09, p = .770$. Students in the matrix group were no more likely to receive a rating of proficient on the relevance portion of the annotated bibliography rubric after the intervention than those students in the concept map group. The frequency of proficient and not proficient scores can be found in Tables 7 and 8.

Table 7

Frequency of Students with Proficient Post-intervention Overall Annotation Scores for the Matrix and Coggle Test Groups

	Proficient	Not Proficient	Marginal Row Totals
Matrix Post Total	17 (17.95) [0.05]	3 (2.05) [0.44]	20
Coggle Post Total	18 (17.05) [0.05]	1 (1.95) [0.46]	19
Marginal Column Totals	35	4	39 (Grand Total)

Table 8

Frequency of Students with Proficient Post-intervention Relevance Annotation Scores for the Matrix and Coggle Test Groups

	Proficient	Not Proficient	Marginal Row Totals
Matrix Post Relevance	15 (15.38) [0.01]	5 (4.62) [0.03]	20
Coggle Post Relevance	15 (14.62) [0.01]	4 (4.38) [0.03]	19
Marginal Column Totals	30	9	39 (Grand Total)

Discussion

Summary of Major Findings

This action research study with two sections of twelfth-grade AP Research students demonstrated that the use of an organizational tool helped to improve students' annotated bibliography entries both in terms of overall summary and connections between sources. Students in the matrix test group improved from 35% proficient to 85% proficient on total annotation score and from 30% proficient to 75% proficient on relevance annotation score. Students in the concept map test group improved from 47% proficient to 95% proficient on total annotation score and from 42% proficient to 79% proficient on relevance annotation score.

The results of the chi-square test showed that students who used a spreadsheet matrix and students who used a Coggle concept map to organize their annotated bibliography entries were more likely to earn a rating of proficient compared to when they wrote annotations without that tool. This implies that by providing students with a tool to organize their sources, it helped improve their ability to summarize their sources and see the connections and relationships between sources better. This study also revealed that there was no difference in student annotation scores between those that used a spreadsheet matrix compared to those who used a Coggle concept map. This implies that the use of either organizational tool will improve student annotated bibliography entries, both in overall summary and connections between sources.

The findings of this research support the current literature and the studies reviewed about the use of a spreadsheet matrix and a concept map to organize information and the benefits of doing so. In Broman and Woo's (2018) systematic review of research regarding the use of spreadsheets as an organizational tool, students showed improved comprehension of large amounts of information and found it easier to explain how various sources of information or data

points were related to each other, which was confirmed by this action research study. However, these results contradict the findings of Poon et al. (2014) who found that inexperienced users of Excel, which describes most high school AP Research students, found it be cumbersome and difficult to use, leading to spreadsheet errors. This action research study found that even though AP Research students have minimal experience with Excel, when trained properly by the teacher, they could use it efficiently and use it to improve their annotated bibliographies.

In regards to the use of a concept map as an organizational tool, this action research found similar results to studies researching the impact of concept map usage on student growth, which found that they led to more effective organization of information and better connections between concepts (Reiska & Soika, 2015), higher critical thinking skills (Kaddoura et al., 2016), and an increase in learning gains, conceptual growth, and stronger conclusions (Ries et al., 2021). However, it is still unclear whether spreadsheet matrices or concept maps lead to more significant gains in these areas. While this action research found no significant difference, no other current research was found doing a similar comparison, so more research is needed to see if these conclusions hold true for other populations.

Limitations of the Study

The current study had several limitations. First, because this study was conducted with a twelfth-grade AP Research class at one high school in Northeastern Tennessee, the extent to which its findings can be generalized to the national population of high school seniors is limited. The results here may only be limited to schools or classrooms with similar demographics and abilities. The second limitation is related to sample size and diversity. This study focused on two sections of AP Research comprised of 39 students total, which was large enough to conduct a proper chi-square test, but not sufficiently large to generalize conclusions to a broader

population. Further, the sample was 79.4% White, so the findings may not be generalizable to other ethnicities and races. Finally, this study was limited to annotated bibliography entries only and did not examine the quality of the final literature review. It is possible that the organizational tools only improved students' abilities to write entries and not the overall literature review, but due to time constraints and the timeline of the AP Research course, it was not feasible to assess students on their final literature reviews.

Further Study

Despite the limitations of this action research study, the findings offer an important contribution to the literature on the effect of an organizational tool on student writing, growth, learning, and achievement. Specifically, it is the first comparison of the effectiveness of spreadsheet matrices and digital concept maps in improving students' annotated bibliography entries and ability to see connections between sources used in an AP Research literature review. Since this is the first research of its kind, it is still unclear whether spreadsheet matrices or concept maps lead to more significant gains in these areas. While this action research found no significant difference, no other current research was found doing a similar comparison, so more research is needed to see if these conclusions hold true for other populations. In addition, a larger sample size with a more diverse group of students would aid in generalizing the conclusions to a broader population of students.

Future studies should also investigate the impact of these organizational tools on student ability to write a complete literature review. This action research only evaluated student entries for their annotated bibliographies, which should be connected to the quality of the literature review, but a study that evaluated student literature reviews after the use of each organizational tool would give more definitive evidence that they can help improve student writing ability

overall and student ability to put sources in scholarly conversation with each other. Other studies could carry the investigation even further to determine if a relationship exists between the quality of a student's annotated bibliography or literature review and their official AP Research score from College Board at the end of the school year. Such a study would imply that organizational tools not only help students write their literature reviews, but also aid in the overall design of their study and improve writing ability in general.

Conclusion

AP Research students often find writing the literature review for their thesis papers challenging because they either lose focus of their original topic in the process of conducting the literature search or struggle to see connections between sources, leading to difficulty in establishing a gap in the literature (Broman & Woo, 2018). However, incorporating the use of an organizational tool can help students with the above challenges and lead to more thorough and interconnected annotated bibliography entries. With limited research into how well spreadsheet matrices and concept maps help AP Research students improve their writing of these entries, this action research project aimed to add more insight and further the conversation of how best to help AP Research students approach writing a literature review. This research paper looked to answer the question: Is utilizing a synthesis matrix spreadsheet or utilizing a Coggle concept map more helpful to students in improving students' annotated bibliography entries in terms of discussing connections and relevance between sources?

The findings suggest that the use of either a spreadsheet matrix or a digital concept map can lead to better proficiency in writing their annotated bibliography entries, both overall and specifically for connecting sources with each other. A chi-square test for association ($\alpha = 0.05$) confirmed a significant increase in proficient scores after the intervention was implemented. However, no significant difference in proficient scores was found between students who utilized the matrix compared to those who utilized a Coggle concept map. The implication of these findings is that AP Research teachers should train students to use either a spreadsheet matrix or a digital concept map to help improve their ability to write an annotated bibliography, see connections between sources, and ultimately begin writing their literature review.

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Appendix A: Annotated Bibliography Rubric

Instructions: Now that you have identified a topic of inquiry it is time to learn about the “conversation” that other Researchers are having surrounding your topic. You will need to complete an annotated bibliography entry for FIVE sources for this first annotated bibliography.

Why do you need an annotated bibliography?

An annotated bibliography asks you to think critically about WHY or WHY NOT a source will help support the argument you’re crafting. The more information you can provide at this point the better off you’ll be when writing your lit review in the next couple months.

	Citation	Summary of Source	Credibility of Source	Method Used	Relevancy to Inquiry
5	Student accurately cites the source through the use of the citation style appropriate for the discipline associated with the topic of inquiry.	Student summarizes the source. The summary is clear, detailed, and identifies all components listed in the instructions below. The summary is concise, and does not comprise the majority of the entry.	Student discusses the credibility of the source. If credibility is not traditionally present (peer reviewed journal), student justifies the credibility in the context of the research topic.	Student describes the method. The description includes who/what was in the sample, what procedures were followed, what kind of data (quantitative or qualitative or both) were collected, and how long it took to implement. Student discusses how this method fits into their own research.	Student describes how this source directly connects to the different perspectives relevant to their inquiry. Student establishes a clear connection between the source and developing a better understanding of the conversation happening between academics relative to the subject by explaining the relationship(s) to at least three other sources in the annotated bibliography.

4	N/A	Student summarizes the source. The summary is clear, detailed, and identifies most components listed in the instructions below. The summary is concise, and does not comprise the majority of the entry.	N/A	Student describes the method. The description includes all but one of the following: who/what was in the sample, what procedures were followed, what kind of data (quantitative or qualitative or both) were collected, and how long it took to implement. Student also discusses how this method fits into their own research.	Student describes how this source directly connects to the different perspectives relevant to their inquiry. Student establishes a connection between the source and developing a better understanding of the conversation happening between academics relative to the subject by explaining the relationship(s) to two other sources in the annotated bibliography.
3	Student cites the source through the use of the citation style appropriate for the discipline associated with the topic of inquiry, but there are minor errors in the citation.	Student summarizes the source. The summary is clear, but is somewhat lacking in detail, and identifies some of the components listed in the instructions below. The summary may or may not be concise, and may or may not comprise the majority of the entry.	Student discusses the credibility of the source. If credibility is not traditionally present (peer reviewed journal), student attempts to justify the credibility in the context of the research topic.	Student describes the method. The description includes all but two of the following: who/what was in the sample, what procedures were followed, what kind of data (quantitative or qualitative or both) were collected, and how long it took to implement. Student also discusses how this method fits into their own research,	Student describes how this source connects to the different perspectives relevant to their inquiry, but the explanation is not clear. Student establishes a connection between the source and developing a better understanding of the conversation happening between academics relative to the subject by explaining the relationship(s) to one other source in the annotated bibliography.

				but the description may lack clarity/specificity.	
2	N/A	Student summarizes the source. The summary is clear, but is lacking in detail, and does not identify many of the components listed in the instructions below. The summary is not concise and comprises the majority of the entry.	N/A	Student describes the method. The description includes all but two of the following: who/what was in the sample, what procedures were followed, what kind of data (quantitative or qualitative or both) were collected, and how long it took to implement. Student does not discuss how this method fits into their own research.	Student describes how this source connects to the different perspectives relevant to their inquiry, but the explanation is not clear. Student attempts to establish a connection between the source and developing a better understanding of the conversation happening between academics relative to the subject, but does not connect to a specific source in the annotated bibliography.

1	Student cites the source, but either the citation style is incorrect OR there are major errors in the citation	Student summarizes the source, but it is unclear, lacking in detail, and does not identify the components listed in the instructions below. The summary is not concise and comprises the majority of the entry.	Student does not discuss the credibility of the source. If credibility is not traditionally present (peer reviewed journal), student does not attempt to justify the credibility in the context of the research topic.	Student describes the method, but only includes one of the following: who/what was in the sample, what procedures were followed, what kind of data (quantitative, qualitative or both) were collected, and how long it took to implement. Student does not discuss how this method fits into their own research.	Student does not describe how this source connects to the different perspectives relevant to their inquiry. Student does not establish a connection between the source and developing a better understanding of the conversation happening between academics relative to the subject.
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Format

Your work must be written in paragraph form and follow proper APA format for headings (unless a different style is approved by teacher)

Citation: Proper APA citation style is followed with hanging indent. Only students who get explicit approval from the teacher may use a different citation style. If you need help with following APA style, please visit the [Purdue OWL website](#).

Paragraph One (Summary): Student summarizes the source. The summary is clear, detailed, and identifies the main objective of the source. The summary should be concise, and should compose a clear picture of the main ideas of the resource (main argument/thesis, brief description of method used, findings, implications/limitations of conclusion). Student should also discuss the credibility of the source. If credibility is not traditionally present (peer-reviewed journal), student should justify the credibility in the context of the research topic.

Paragraph Two (Method): Student describes the method. The description should include who/what was in the sample, what procedures were followed, what kind of data (quantitative or qualitative or both) were collected, and how long it took for the researcher to implement the method. Student should also discuss how this method fits into their own research (can this method be used in the student's research? If not, can this method be adapted in some way to be used by the student? Do other sources use similar methods?)

Paragraph Three (Relevance): Student describes how this source is relevant to their topic of inquiry and how it directly connects to the different perspectives relevant to their inquiry. Student establishes a clear connection between the source and developing a better understanding of the conversation happening between academics relative to the subject by explaining the relationship to at least three other sources in the annotated bibliography.

Appendix B: Raw Data

Pre-Intervention Scores for Matrix Test Group

Pre Annot. 1	Pre Annot. 1 Relevance	Pre Annot. 2	Pre Annot. 2 Relevance	Pre Annot. 3	Pre Annot. 3 Relevance	Pre Annot. 4	Pre Annot. 4 Relevance	Pre Annot. 5	Pre Annot. 5 Relevance	Median Pre Annot.	Median Pre Annot. Relevance
18	3	17	3	19	4	18	4	18	3	18	3
16	2	14	2	14	2	16	3	18	3	16	2
19	3	20	4	17	2	18	4	16	2	18	3
14	2	22	4	19	4	18	3	18	3	18	3
19	4	20	4	17	3	21	4	22	4	20	4
18	3	20	4	20	4	19	3	21	4	20	4
13	2	14	2	17	3	17	3	18	4	17	3
17	3	17	3	18	4	18	4	18	3	18	3
12	2	14	3	16	3	16	3	17	4	16	3
18	4	20	4	18	3	20	4	22	4	20	4
18	4	16	3	20	4	21	4	21	4	20	4
17	3	18	4	17	3	18	4	19	3	18	3
14	2	15	3	18	3	19	4	18	3	18	3
18	3	17	3	18	4	20	4	22	3	18	3
20	3	21	4	21	4	23	4	21	4	21	4
17	2	19	2	19	3	19	3	17	2	19	2
12	1	14	2	10	1	9	1	10	1	10	1
19	3	21	4	22	4	21	3	17	3	21	3
10	1	12	1	10	1	12	2	15	3	12	1
23	3	24	4	24	4	23	4	24	4	24	4

Pre-Intervention Scores for Coggle Test Group

Pre Annot. 1	Pre Annot. 1 Relevance	Pre Annot. 2	Pre Annot. 2 Relevance	Pre Annot. 3	Pre Annot. 3 Relevance	Pre Annot. 4	Pre Annot. 4 Relevance	Pre Annot. 5	Pre Annot. 5 Relevance	Median Pre Annot.	Median Pre Annot. Relevance
19	4	18	3	21	4	22	4	21	4	21	4
18	3	20	4	17	3	21	4	20	4	20	4
17	3	17	2	20	3	20	3	20	3	20	3
17	3	18	4	17	3	18	3	19	4	18	3
15	2	16	3	19	3	19	4	21	4	19	3
12	1	14	2	13	2	14	3	15	3	14	2
14	2	14	2	15	3	16	4	15	2	15	2
16	2	16	3	17	3	17	3	19	4	17	3
18	3	20	4	18	3	20	4	21	4	20	4
17	3	20	4	20	4	18	3	20	4	20	4
13	2	15	3	14	3	15	4	17	3	15	3
18	4	18	3	22	4	20	4	20	4	20	4
19	3	21	4	16	3	21	4	22	4	21	4
17	2	18	3	17	2	18	3	19	4	18	3
13	1	14	2	16	3	14	2	19	4	14	2
11	1	10	1	13	2	15	3	11	1	11	1
19	3	19	3	20	4	21	4	20	4	20	4
20	4	21	4	22	4	21	4	18	3	21	4
16	2	16	2	19	3	18	3	20	4	18	3

Post-Intervention Scores for Matrix Test Group

Post Annot. 1	Post Annot. 1 Relevance	Post Annot. 2	Post Annot. 2 Relevance	Post Annot. 3	Post Annot. 3 Relevance	Post Annot. 4	Post Annot. 4 Relevance	Post Annot. 5	Post Annot. 5 Relevance	Median Post Annot.	Median Post Annot. Relevance
24	4	22	3	24	4	23	4	21	3	23	4
21	2	20	3	22	3	22	3	24	4	22	3
23	4	22	3	21	3	21	3	19	2	21	3
20	3	25	5	25	5	25	5	23	4	25	5
23	4	23	3	25	5	24	4	24	4	24	4
25	5	24	4	25	5	25	5	24	4	25	5
18	2	18	3	21	4	20	4	19	3	19	3
22	4	19	3	20	4	21	4	23	5	21	4
20	2	20	4	19	3	16	2	19	3	19	3
24	4	25	5	25	5	25	5	24	5	25	5
21	4	19	3	20	3	21	4	23	4	21	4
25	5	22	3	25	5	23	4	25	5	25	5
20	3	21	4	21	4	25	5	21	4	21	4
24	4	25	5	24	5	25	5	25	5	25	5
20	3	21	4	24	5	23	4	24	4	23	4
24	4	25	5	25	5	25	5	24	4	25	5
19	3	18	3	22	5	20	4	21	4	20	4
24	4	24	3	25	5	25	5	25	5	25	5
17	3	19	3	20	4	17	3	15	3	17	3
23	4	25	5	24	4	25	5	25	5	25	5

Post-Intervention Scores for Coggle Test Group

Post Annot. 1	Post Annot. 1 Relevance	Post Annot. 2	Post Annot. 2 Relevance	Post Annot. 3	Post Annot. 3 Relevance	Post Annot. 4	Post Annot. 4 Relevance	Post Annot. 5	Post Annot. 5 Relevance	Median Post Annot.	Median Post Annot. Relevance
24	4	25	5	25	5	25	5	25	5	25	5
22	4	24	4	23	4	20	3	23	4	23	4
24	4	23	4	23	4	21	3	25	5	23	4
19	2	20	3	25	5	21	4	21	3	21	3
20	4	23	3	24	5	24	4	25	5	24	4
22	4	19	2	21	4	21	3	21	3	21	3
22	3	23	4	23	4	22	4	20	3	22	4
20	3	20	3	19	2	19	2	20	4	20	3
24	4	25	5	25	5	25	5	24	4	25	5
20	3	20	4	22	4	24	4	22	3	22	4
17	2	18	3	21	4	20	4	21	4	20	4
20	3	20	4	22	4	22	4	25	5	22	4
25	5	24	4	25	5	25	5	25	5	25	5
20	4	24	4	25	5	25	5	25	5	25	5
21	4	24	4	21	4	20	3	21	4	21	4
14	1	19	3	15	2	19	3	23	4	19	3
21	3	18	3	23	5	21	4	18	4	21	4
23	4	25	5	25	5	23	4	25	5	25	5
21	4	17	3	21	4	24	5	19	4	21	4

Frequency of Proficient and Not Proficient Scores for Median Relevance Annotation Score

	Matrix				Coggle	
	Pre	Post			Pre	Post
	NP	P			P	P
	NP	NP			P	P
	NP	NP			NP	P
	NP	P			NP	NP
	P	P			NP	P
	P	P			NP	NP
	NP	NP			NP	P
	NP	P			NP	NP
	NP	NP			P	P
	P	P			P	P
	P	P			NP	P
	NP	P			P	P
	NP	P			P	P
	NP	P			NP	P
	P	P			NP	P
	NP	P			NP	NP
	NP	P			P	P
	NP	P			P	P
	NP	NP			NP	P
	P	P		TOTAL NP	11	4
TOTAL NP	14	5		TOTAL P	8	15
TOTAL P	6	15				
				NP = Not proficient = 3 or below		
				P = Proficient = 4 or above		