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Digital Scholarship: Applying Digital Tools to Undergraduate Student Research Papers, A Proposal for a Freshman Seminar. Part I: Definition of Student Research Methodology

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Abstract
There are many digital tools that can be used for research and presentation in nearly every college discipline, including the social sciences and humanities. These tools hold the promise to radically change both the process and products of research. But in their application these tools have failed miserably to live up to their promise.

This paper is based on the hypothesis that one reason these tools do reach their potential is that there is no systemic way to include them in research process, resulting in the tools being seen as ways to improve the final research product. This results in the tools becoming just an added on kludge, and leading researchers to the conclude that they are hard to use, full of bugs and other problems, and that they do not bring a lot of value to the research.

This paper is an attempt to address this problem of including digital tools in a research process. It is part of a series of papers proposing a systematic methodology for including digital tools in a research process. This paper is the first, and outlines a methodology for the research process that allows the application of digital tools to a small area, undergraduate student research papers. It will outline a development process that will systematize the steps in the research process. These steps will then be used to classify the digital tools, and show how they can be applied to the research process.

The final product of this paper will be a process methodology for creating student research papers to be used in a class to be run as a freshman seminar. The students will be taught this research methodology, and be led through the development of a research paper using the steps defined in this methodology. The steps in the process being enhanced using appropriate digital tools applicable to each step in the methodology.

The ability of the students to do research using the research methodology and digital tools will be measured by the degree of success the students have in completing a humanities/social science research product as part of the class. The students will be followed in a longitudinal study by asking them to complete a short survey at the end of each year of their undergraduate education.

Digital Scholarship:
Applying Digital Tools to Undergraduate Student Research Papers, A Proposal for a Freshman Seminar
Part I: Definition of Student Research Methodology

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1.0 Abstract

There are many digital tools that can be used for research and presentation in nearly every college discipline, including the social sciences and humanities. These tools hold the promise to radically change both the process and products of research. But in their application these tools have failed miserably to live up to their promise.

This paper is based on the hypothesis that one reason these tools do reach their potential is that there is no systemic way to include them in research process, resulting in the tools being seen as ways to improve the final research product. This results in the tools becoming just an added on kludge, and leading researchers to the conclude that they are hard to use, full of bugs and other problems, and that they do not bring a lot of value to the research.

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2.0 Introduction

There are numerous digital tools that can be used to accent a research product. These tools include geospatial representation [1], time lines [2][3], and hyper linked documents [4], among

numerous others. Even simple Microsoft Word tables can be used to juxtapose thematic information. These tools can be used to collect, organize, and represent the facts and data which go into research, and can greatly enhance the professionalism and presentation of the final research product, be that product an online document with active content or a static content printed document.

With so many tools and so much promise, why does the use of these tools fall so short of their potential? One possible cause of this is that the digital tools are not built into the structure of the research process, but added in as ancillary or extra material to enhance the research. This enhancement is often only for presentation purposes. It is little wonder that these tools appear to be kludges glued into the research process, and are often viewed as a lot of work to integrate with limited added value.

But why are digital tools relegated to the final presentation of research, and not seen as an organic part of the research process. Part of the reason could be that current researchers have not been trained in these tools, and so do not see how they can be integrated into the research process. Further many researchers have a bias that holds that the use of these tools is hard, and not worth the effort. So while digital tools are amazing assets at collecting, organizing, and representing research, most researchers do not understand how these tools can be applied to their own research. Part of the problem is that most researchers are not trained to recognize collecting, organizing, and representing research as distinct activities. And while the tools for these activities have made quantum leaps in ease of use, researchers do not to see the research process as steps that digital tools can effectively and easily address. The only real value they see in the digital tools is in presenting final results, and then these tools tend to clash with the organization and representation that the research has already built, making them awkward and hard to understand and use, and of limited value.

A solution to this problem is to incorporate digital tools into the entire research process so that the tools integrate seamlessly into the final products. This requires a formalized research methodology into which the digital tools can be integrated. This paper will propose a research methodology for undergraduate student research into which these tools can be integrated. The paper will then give an example of how the process and tools can be used.

This paper purposefully limits the scope of the method to undergraduate student research papers. The reason the scope of this methodology is limited to undergraduate student research papers is that avoids a number of issues which would have to be dealt with in a real research project. Included are issues like:

- In true research, the identification of research problem is determined not just by the specific research questions or hypotheses, but follows from identifying the research problem, doing a literature review, and then specifying the purpose of research. It is often the case that the research problem may need to be modified while the research is ongoing.

   In most undergraduate research the identification of the research problem is usually much easier to define, and created with the help of a professor teaching the class. By choosing to address only undergraduate research the process of identifying the research

problem is greatly reduced, which makes the resulting methodology to be developed much simpler.

- There are no methodological issues involved in the data collection. Most undergraduate student research papers do not require discipline specific methodologies for how the data are collected. The sources for a student research paper is normally books, published research papers, or even the web. The process presented here is agnostic to any specific discipline, and avoids any data collection methodology issues which would be present in more robust, real world research.

- The process of organizing the representing the data is much simplified. In a student paper, the research problem will often identify the general outline of the final product of the research, and the entire process is guided by a faculty member, who is a trained researcher. The data is generally clean and there is less need to organize or represent the data in multiple fashions, as would be common when dealing with real research issues.

- The final product of the research can be generally sketched out when the research problem is identified. This makes the entire process easier to implement, and allows the student to better see how the parts of the process work together.

The fact that the initial definition of this research methodology is limited to undergraduate student research papers does not mean that it cannot be extended to deal with larger research issues. But the limitations of the methodology presented here are real, and should be kept in mind by anyone attempting to apply this methodology to larger research issues.

2.1 Research as a Way to Create Knowledge

To begin defining a process for research, a definition of term research as it will be used in this paper is needed. A broad definition of research is given by Martyn Shuttleworth, "In the broadest sense of the word, the definition of research includes any gathering of data, information and facts for the advancement of knowledge."[4]

This definition says that research takes raw data, information, and facts, and transforms these raw values into knowledge. This transformation is the value which research adds.

This process of adding value to raw information is very similar to the *Data-Information-Knowledge-Wisdom* (DIKW) model proposed by a number of authors such as [5] and [6]. What makes the DIKW model interesting to this paper is that it defines each of the products in the process of transforming data into wisdom, and the principals and steps to each transformation.

The terms data, information, knowledge and wisdom are defined in [5] as follows:

Data: discrete, objective facts about an event. This definition can also be applied to humanities and social sciences to represent original sources or case studies.

Information: a message meant to change the receiver's perception.

Knowledge: experience, values, context applied to a message

Wisdom: collective application of knowledge in action.

The DIKW model then specifies the process to transform the data into wisdom through each product phase. In the DIKW model, data is transformed to information by understanding the relationships between the data. This is done by contextualization, categorization, calculation, correcting, and condensing of the raw data. For the purposes of this paper, this will be called organization of the data.

Information is then transformed to knowledge by understanding the patterns in the data. This is achieved by comparison, and finding consequence and connections in the data. In this paper this will be called representation.

Finally knowledge is transformed to wisdom by finding the underlying principals in the data. For this paper, this represents the presentation of the research from the process, which is the understanding of the knowledge to be shared.

In order to relate the DIKW process to the research process, the following diagram outlines how the DIKW will be used in this paper.
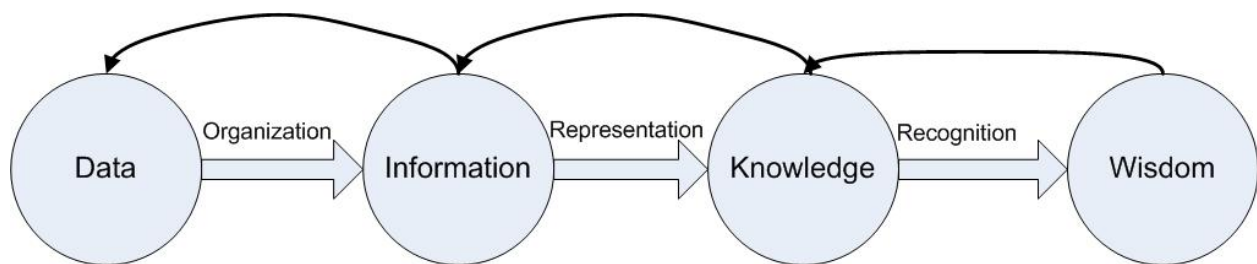
In this model, the raw data is first collected. This data is traditionally kept on index cards, and the use of index cards is supported by this methodology. However the methodology defined in this paper opens up the world of digital tools at this point, and the raw data could be kept in a spreadsheet, some sort of note taking tools, or downloaded in mass from some web site.

The raw data are then transformed to information by the process of organizing it. This organization can be by calculated values, dates, geographical locations, themes, or any way that it is traditionally organized in research. Once again the model does not force a digital perspective, but it allows tools, such as databases, photo galleries, hyperlink structures, and myriads of other tools to be considered. These tools can often take their input from the raw data which was digitally gathered, thus integrating these two steps.

Information is then represented. These representations can be, but are not limited to graphs, timelines, maps, and tables. The representations are normally representations of the data as it was organized in the previous step in the process.

Finally, representations are examined for patterns in the data, and those patterns allow the researcher to find the principals which exist in the data, and lead to Wisdom, or the conclusions of the research. The representations are normally use to scaffold and support the conclusions, and so the digital representations of the data are naturally integrated into the final research product. The digital tools do not produce pretty add-ons to the final research product. The digital tools are organic to the process, and so the features they bring thus are a natural part of the final product.

Note that nothing is said in this process about how to collect, organize or represent the information. These terms are left vague because there are many sources and methods to do each of these activities. These activities are also where digital tools can prove very useful in the research process, and thus will be the topics of future discussions. But realize that it is the formalization of these activities in the process of research that is central to integrating digital tools into research.

2.2 Research as a Process

Another definition of research is given by Creswell who states that - "Research is a process of steps used to collect and analyze information to increase our understanding of a topic or issue". It consists of three steps: Pose a question, collect data to answer the question, and present an answer to the question.[5]

In this definition research is a process. It begins with a question to be answered, and then gathers information which it transforms into that answer. According to Wikipedia, the steps in the research process are the following:

- Identification of research problem
- Literature review
- Specifying the purpose of research
- Determine specific research questions or hypotheses
- Data collection
- Analyzing and interpreting the data
- Reporting and evaluating research
- Communicating the research findings and, possibly, recommendations

We now have two processes for research, one from the previous section which outlined how to create wisdom from raw data, and the one above which outlines the steps involved in a typical research process. The next section will merge these two processes into a single process, and the single merged process proposed to be used to teach a freshman seminar in using digital tools to write a research paper.

2.3 Proposed research methodology

The research processes from the previous section will be married with the DIKW model to create a proposed research model. The purpose of this model is to allow the digital tools to be categorized as part of the research process so that the students can see how to break down a

research problem in a way that is amenable to the use of digital tools. The first two steps in this process are by far the most important, but also least likely to benefit from digital tools. This is because they are the hardest and most creative parts, and the parts where students need the most guidance. Digital tools are best applied to the more mechanical parts of any problem. The actual work of collecting, organizing, and representing the data, while it takes the most time, is the least creative and most mechanical.

The methodology will be broken down as follows:

1. Identify the research problem. This is simply a topic that the student is interested in. In a student research topic, it is often important that this topic be discussed with the teacher in order to obtain a proper scope for a paper. It will likely use limited support of digital tools.

2. Provide a functional description of the research. This step is a combination of the Literature Review, Specification of the purpose of research, and Determination specific research questions or hypotheses. It is heavily influenced the teacher, who should be a professional researcher. It will likely use limited digital tools.

   The functional description provides the central questions which will be asked by the research, the scope of the research, and the methods which will be used to defined the research. The functional description is a basic outline of what will in the paper, and thus defines what type of data will be collected, how the paper will be organized, and provide a direction on how to represent the research and how to present the final conclusions. This will become clearer in the example to be shown later in this paper.

3. The collection of the data. This is where digital tools will first become useful. Rather than using index cards, students can keep tract of notes in digital tools made to gather data and make it accessible to other digital tools. If a book or article is online, it might be possible to hyperlink directly to the source document. If data values need to be collected and manipulated, often large repositories of data are available online, and digital tools like spreadsheets were made to collect and manipulate data sets. Pictures can be collected and tagged into online photo albums. Much of the tedium of collecting raw data can be done more easily using digital tools.

4. Organization of the data. Once the initial data has been collected electronically, there are many of tools for organizing it around almost anything. Data can be grouped by time, geospatial coordinates, themes, hyperlinks, photo albums, or just about any relationship that can be imagined. Different organizations can be tried to see how that impacts the raw data. This is the first place where digital tools have a marked advantage over traditional non-digital research.

5. Representation of the data. Once the data have been organized, it can be represented. Timelines can be created, and pictures placed at appropriate points. Tables of themes can be created, and supported by including the data from a primary source. If a representation does not quite fit the purpose, it can be easily changed. At this point the power of having the created in a digital format can be realized.

6. Creation of the final product. This final product could be a paper, online web presentation, talk, etc. It is created by coming to conclusions based on the patterns found in the represented data, and should be organized around the representations which have been created to support those conclusions. This greatly simplifies the creation of the final product, as all the steps in the research process have been building towards the final product.

2.4 A simple example

The following is an example of applying this methodology to a topic. In this case it will be a paper on Nelson Mandela.

1. The first step is to identify the research topic. The research topic should be short, but it should give the guiding philosophy behind the paper, and so must be carefully considered and crafted. It will set the goals and bounds of the research. A good example would be:

> The life of Nelson Mandela had a huge impact on the country of South Africa as well as the world. This paper will juxtapose the events of Mandela's life against the political and social change in South Africa to show how his life influenced these events.

Note that while this statement seems simple, it defined the research to be done. It defines the following about the paper:

- what question will be answered by the research, which is how Nelson Mandela affected the social and political change in South Africa
- the scope of the research, which is the major events in Mandela's life and the major social and political events in South Africa.
- the methods which will be used in the research, which will be a time based juxtaposition of the Mandela's life verses the social and political events in South Africa.,
- the form of the representation of the data, which is a time line of political and social events that occurred in South Africa contrasted to the life of Nelson Mandela.
- the conclusion of the paper, which will be a discussion, based on the time line, of how the events in Nelson Mandela's life impacted South African.

This part of the document is so important because it provides the one thing which is often hardest for students and even professional researchers to do. It provides the goals

and limitations of the research. When including new facts, the question should always be asked if they are in keeping with the research topic. If something is not germane to the topic, it should either be discarded, or the research topic needs to be revisited.

2. The next step is to create a functional description of the research. The functional specification provides a form to the research topic, and formally states the assumptions implicit in the research topic. The type of raw data to be collected will be identified, along with the type of information which needs to present for each item. For example all information will need to be linked to its original source. Pictures might need to be tagged to a person, place, and/or date. Some descriptive data about might be useful to give a context. All of this data collection is influenced by the expected organization and representation of the data, which is in turn influenced by the final product.

   So the functional specification should start with an outline of the final research product, but it is more detailed than an outline. The outline itself should only detail the overall expected organization, and no details should filled in. The functional specification includes the outline, but should include what types of representations are anticipated being used in the final presentation. This will help specify how the data will be organized to allow for the desired representations, and feedback into the data collection. All of the information about types of representation, organization, and a methodology for obtaining and categorizing the information should be completed and formally documented. It should be obvious that if this step is completed correctly, the rest of the research should go smoothly. If this step is done badly, the entire project will likely fail.

   For the project on Nelson Mandela, the functional specification could start with an outline of the final document which specifies that conclusions will be based on a time line of Nelson Mandela's life and the major events in South Africa during that time. It could be specified that the time line include pictures. This implies that at least the pictures will have to be entered with specific dates, information about the events they represent, and probably a description.

3. The collection of the data. This step applies the data collection methods to the data sources which the researcher has identified. Note that the type of tool and information about each data item have been constrain by the way the data will be organized.

   For the Mandela research project, a digital photo album should probably be created which allows tags for the date, event, and a short description.

4. Organization of the data. The data should be collected in such a way as it is useful to the final research product.

   For the Mandela research project, perhaps separate categories or folders could be created to allow pictures about specific events to be grouped. This allows the researcher to quickly scan the photos about an event to choose ones they feel are relevant.

5. Representation of the data. This step takes the data which has been organized and creates artifacts which can be used in the final product. Timeline, graphs, maps, etc., are all created in this step.

   For the Mandela project, a time line could be created in appropriate time line software. Pictures and a short caption given for each event. A document could be created which gives a description of the event, and how it applies to the final research product.

6. The final product is created. This could be an active content, such as a web page, or static content, such as a paper. But in any case, the main parts of the product should have been generated in the previous steps, and what is left is to tie all the data together and present the conclusions.

3.0 Conclusions

This paper hypothesizes that the reason digital tools have made little progress in being applied to humanities and social science research is not the inappropriateness or difficulty in using the tools, but instead by the fact that researchers do not have a clear methodology for understanding how to integrate these tools into their research process. It develops a methodology, designed around undergraduate student research projects, which creates a simplified research process for integrating digital tools into research scholarship.

The paper furthers proposes that this methodology is testable, and outlines a simple experiment to determine if this methodology is applicable to its intended target. This experiment would be to teach a class in digital scholarship using this methodology. The final student projects from this class would be evaluated, as well as the degree the students feel that they have learned the digital tools. The results would then be applied in a longitudinal study by surveying the students each year after the class to see if they have used the tools and methodologies from the class.

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