Visualization can be defined as the conversion of information to a symbolic representation of a particular idea, concept, or data object. In simplified terms, McCormick (1987) explained visualization as the process of transforming data, information, and knowledge into graphic symbolic presentations. There are advantages in use of tools designed to make the transformation of text possible. First, visualization tools can be used to make information more accessible. Early proponents reported successful use of visualization retrieval tools to present bibliographic displays generated from large amounts of digital information. According to Wise, (Wise, et al, 1995) data sources become manageable and information retrieval efficient through organized graphic displays.

Secondly, visualization permits perception at a higher level. Tools designed to create visualizations allow users to explore the symbolic structure of a text. Thinking processes are enhanced as users are interactively engaged in the reading process. Users may create images in order to identify relationships, main ideas, and patterns thus facilitating concept attainment and critical analyses of reading materials (Sadoski, & Paivio, 2001). Johnson-Glenberg examined the effects of question-writing and word association with visual imagery. The results of her study showed significant increase in reading comprehension scores for struggling readers (2005). These and other generative strategies suggest visualization tools can be used for ensuring recall and comprehension for readers of all ages (Hook & Borner, 2005; Mills, 2009; Wittrock, 1992). In more simple settings such as elementary school classrooms, concepts maps, pictographs, and word clouds can be used for making connections and predicting themes within expository text (Foote, 2009; Oliver, 2009). Most teachers have used pictographs and other representations for reading lessons however word clouds have only recently been used in K-12 classrooms.

The website Wordle.net provides an easy to use tool for creating word clouds by both teachers and K-12 students. In higher education, visualization tools accessible through Many Eyes provide interactive activities that include word clouds, tag clouds, and word trees, but with more complex textual information (Eisenberg, 2008; Hook & Borner, 2005; Viegas, Wattenberg, & Feinberg, 2009). Developed by designers in IBM labs, Wordle is the product of the creators for Many Eyes. Wordles produced by cut and paste of a selected reading passages result in a simplistic image from a complex narrative. Zhang refers to these visualizations as metaphors. Mental images can be formed and conceptual ideas more easily recognized, communicated, understood, and remembered (Zhang, 2008).

Both Wordle.net and Many-Eyes.alphaworks.ibm.com are interactive open source tools, but only Many Eyes permits registered users to post commentary on any of the thousands of visualizations published for public viewing. Although text can be entered directly through the user’s keyboard, value is added to the use of these tools through the cut & paste process possible with digital information. The wealth of accessible online resources makes use of these tools easy and efficient for educators.
Purpose of this Study

Strategies using tools such as Wordle, Many Eyes, and Tag Cloud provided promise for visualization tools to enhance reading within a variety of contexts and learning environments. Could use of visualization tools such as word cloud imagery enhance reading comprehension and help both graduate and undergraduate students understand complex ideas and abstract concepts? This paper is a report on findings in use of a variety of visualization tools to enhance reading for adult learners.

Methods

Two populations were examined for use of visualization tools to enhance reading comprehension and concept attainment for assigned reading in both graduate and undergraduate classes. The first data collection involved graduate students in a master’s level program for instructional technology. Visualization tools were used to analyze the contents of a job description for school technology specialists. A 500 word online reading from the state department of education was used as the source document for analysis. Using their assigned reading to copy and paste into Wordle.net, students generated visualizations representing the main functions of a technology facilitator. In small group discussion forums, students analyzed the keywords displayed in the visualization, predicting possible scenarios for the position of technology facilitator in a K-12 school. After the online discussions were concluded, students submitted proposals for internship experiences at their local schools. After writing the first draft of the internship proposal and posting these to the online discussion forum, students participated in a second discussion forum to compare interpretations of job functions for technology facilitators. Following the second discussion, a final proposal was written and submitted to the course instructor for evaluation. The design of internship proposals provided the first data set for this study. These are discussed in the results section below.

A second data collection involved pre-service teachers who received instruction in use of Phrase Net tools to visualize conceptual relationships in an assigned reading. Students in a traditional face-to-face Health Education methods class were given an online book chapter as assigned reading on the topic of learning and cognition. Following the reading of the book chapter, multiple choice tests were used to assess understanding of concepts discussed in the online book chapter as well as measures of confidence levels related to personal understanding. Test items included these areas: 1) concept attainment; 2) relationship between concepts with supporting ideas and examples; 3) relevancy to personal experiences. Mean scores for each of the measures were used to identify differences in pre and post use of the visualization tools. Mean scores for students’ self reported confidence levels for pre and post tests were used to identify differences in confidence levels when using the visualization tools.

A third group included both graduate and undergraduate students who examined visualization tools for potential use in their K12 classrooms. Review of students’ discussion threads revealed creative ideas for instructional use of tools. Lesson ideas were submitted to the course instructors who categorized each activity by skill, instructional method, outcomes, and assessment of learning. A summary of selected activities are presented in the results and discussion of this paper.

Results and Discussion

Word Clouds to Analyze Job Descriptions.

Interns in the MAEd in Instructional Technology used visualization tools to analyze content of internship proposals compared with similar visualizations produced using content from an online job description provided by the state of education. The tag cloud tool was used to calculate the presence and count of unique words in a document as well as statistical analysis of frequency and context of words and letter strings within the document. Interns compared output from their internship proposals with output generated from job descriptions accessed through the state department of education. The content of the job descriptions were dropped into Tag Cloud tools to produce visualizations that include word counts for all terms within the document. The interns used the output from their visualizations as a guide for discussions in an online forum. The visualizations resulted in a focused dialog with emphases in main functions for the job of technology integration specialist and technology facilitator. Qualitative evaluation of the students’ proposals showed a clear and consistent alignment with national standards for these positions in K-12 schools. Interns’ proposals from previous semesters did not reveal depth of understanding evident in this pilot group using visualization tools to analyze future job descriptions. Keywords predominate in the
visualizations prompted interns to plan around terms such as “teacher support”, “instruction”; and “collaboration”. These were then used as prompts for negotiating projects for the semester internship experiences.

Phrase Nets to Enhance Reading Comprehension.

Undergraduate students were given an assigned reading in an online book chapter followed by an assessment of their understanding for 1) main ideas, 2) relationship between terms in the readings, and 3) relevancy to readers’ personal learning experiences. The participants were also asked to provide a self-assessed level of confidence in their interpretations of content from the book chapter.

Following the reading assignment and assessment of understanding, students were instructed to access the website Many-Eyes.alphaworks.ibm.com and generate a visualization using the Phrase Net tool. Phrase Net analyzes a text by looking for pairs of words that fit particular patterns. In Figure 1 is an example from a science article on the solar system. The user will specify a particular pattern such as the terms earth or planets. Phrase Net will create a network diagram of the words it found as matches. The terms earth/planets will be connected if they occurred in the same phrase. When viewing the output from the visualization, the user can compare differences in font size, color, and size of connectors to determine frequency and relationship of the terms. The size of a word is proportional to the number of times it occurred in a match.

![Figure 1. Visualization using PhraseNet](image)

Note in the figure above the term “dioxide” is connected to terms “atmosphere” and “carbon”. Bold lines indicate a strong connection between terms “solar” \(\rightarrow\) “system”; and “magnetic” \(\rightarrow\) “field(s)”. Drawing attention to strong and weak connections between ideas enhances the reader’s conceptual understanding of complex reading material.

Undergraduate students who participated in this study completed visualization activities followed by a post assessment to measure reading comprehension and confidence levels when using the Phrase Net tool. Students’
responses were rated 0 to 4 with 4 being the highest score possible. T Test analyses were used to compare pre and post assessment for the following: 1) understanding main ideas; 2) comprehension of relationships between main ideas in the readings; 3) ability to make connections between main ideas and personal learning experiences, and 4) self-reported confidence levels in understanding and comprehension for the readings. Differences in Pre assessment and Post assessment of main ideas when using the Phrase Net visualization is marginally significant (p < .04, 2-tailed). No significant differences were identified between pre and post assessments relating readings to personal experiences. However, T Test comparison shows a significant difference in assessment of students’ ability to see Relationship Between Ideas when using the Phrase Net tool (p < .000, 2-tailed). Note in Table 1 differences in T scores (T = 11.3; p < .000, 2-tailed) for the pretest [before use of Phrase Net] compared to T scores (T = 14.3, p < .000, 2-tailed) for the post test score [after use of Phrase Net].

Table 1. T Test comparison of students’ ability to see relationships between ideas when using visualization tools.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>Std Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>RelationPre</td>
<td>14</td>
<td>2.5714</td>
<td>.85163</td>
<td>.22761</td>
</tr>
<tr>
<td>RelationPost</td>
<td>14</td>
<td>3.0000</td>
<td>.78446</td>
<td>.20966</td>
</tr>
<tr>
<td></td>
<td>t</td>
<td>df</td>
<td>Sig. (2-tailed)</td>
<td>Mean difference</td>
</tr>
<tr>
<td>RelationPre</td>
<td>11.298</td>
<td>13</td>
<td>.000*</td>
<td>2.57143</td>
</tr>
<tr>
<td>RelationPost</td>
<td>14.309</td>
<td>13</td>
<td>.000*</td>
<td>3.00000</td>
</tr>
</tbody>
</table>

Students’ confidence levels in identifying relationships among ideas also appear to be impacted through the use of Phrase Net visualization tool. In Table 2, differences in pre and post self-reported confidence levels is significant (p < .000, 2-tailed).

Table 2. T Test comparison of Pre use of Phrase Net with Post use of Phrase Net when measuring students’ confidence in ability to identify relationships of main ideas in assigned reading.

<table>
<thead>
<tr>
<th>Confidence in Identifying Relationships Between ideas</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
<th>Mean difference</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>ConfRelaPre</td>
<td>6.852</td>
<td>13</td>
<td>.000*</td>
<td>1.55643</td>
<td>1.0657 – 2.0471</td>
</tr>
<tr>
<td>ConfRelaPost</td>
<td>8.962</td>
<td>13</td>
<td>.000*</td>
<td>1.95786</td>
<td>1.4859 - 2.4298</td>
</tr>
</tbody>
</table>

Students’ comments following the use of Phrase Net seem to support the positive effect of the visualization tools used to help students understand relationships between major terms appearing in assigned reading. One student commented:

To visually see the connections of how strongly 2 concepts are linked to one another made me view this article in a different light. Previously, I selected main subjects points that were not as important or had fewer connections compared to the ones that I have selected after using PN. It reinforced the main issues that were being discussed in the article, rather than focusing on mini subjects that ever not he key points. For example, PN greatly reinforced the strong connection between synapse over production and loss, which is an imperative method in how information is translated into learned concepts.
Ideas for Using Word Clouds in K-12 Classrooms.

Both graduate and undergraduate students provided innovative ideas for use of visualization tools for K-12 classroom instruction. In response to a discussion forum asking for possible uses of Wordle (Wordle.net), students submitted ideas for a classroom activity and method for evaluating outcomes from the lesson. See Table 3 for a selected sample of classroom activities designed by students participating in the study.

Table 3. Instructional activities using word cloud and tag cloud visualization tools.

<table>
<thead>
<tr>
<th>Skills</th>
<th>Instructional Method</th>
<th>Outcomes</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify main idea</td>
<td>View word cloud for each paragraph one page narrative; compare key words; write one sentence with main idea for each paragraph.</td>
<td>Students made connection between font size and number of occurrences in the narrative; discussion on meaning of prominent words.</td>
<td>Teacher observation; enhance concept of &quot;Big Idea&quot;</td>
</tr>
<tr>
<td>Critical thinking</td>
<td>Individually generate a list of terms associated with educational theme; groups generate a 2nd list of terms; independently generate word cloud from assigned reading on the theme; reflect and discuss comparison of independent and group lists</td>
<td>Critical thinking required to compare and contrast word lists; accurate analysis of assigned reading; self-assessment associated with reflections on personal word clouds representative of themes in the reading</td>
<td>Comparison of word clouds representative of themes and main ideas within the reading; knowledge and understanding of vocabulary in the reading.</td>
</tr>
<tr>
<td>Expressive Writing</td>
<td>Assigned writing describing yourself; paste into word cloud software; compare characteristics with others in class; identify repeated words; reflect on self-image and your best attributes</td>
<td>Creative writing; good use of adjectives and adverbs; positive reinforcement for all students; identify the purpose of &quot;sparkle words&quot; for narrative writing.</td>
<td>Teacher assessment of writing style, use of vocabulary and positive dialog during whole class discussions.</td>
</tr>
</tbody>
</table>

The researchers summarized all students’ word cloud activities and placed these into categories. Although more than 30 student assignments were submitted, we synthesized these into three main themes: Reading to Identify Main idea; Critical Thinking Skills, and Expressive Writing. Table 3 provides sample activity for each of the three themes.

Summary/Conclusion

Use of visualization tools as a pre or post reading activity has potential to enhance reading comprehension in adult learners. Although the researchers consider this a preliminary study, pre and post tests reveal a positive effect through use of Phrase Net tool for identifying relationships in ideas in expository reading. Feedback from participants suggests a positive effect on reading for understanding using complex college level materials. The readers were able to make connections between key ideas within the narrative. Use of visualization tools reinforced what some readers identified as related terms within the assigned book chapter; for others use of the visualization tools resulted in “aah ha” moments with new understanding in the readings. The researchers also suggest that visualization tools might aid the generative thinking processes as students recognize conceptual relationships within the text. Students are motivated to use visualization tools resulting in cognitive maps. By viewing the visualizations, the participants in the study were able to participate in discussions based on a mental map of abstract concepts and ideas. We consider differences in students’ pre and post tests strong enough to warrant continued work in this area of research.

Use of word clouds and tag clouds provided imagery representing the many tasks and responsibilities of a technology specialist in a K-12 school. As students generated original word clouds and view output from others in
their class, ideas for internship proposals showed a strong correspondence with national standards for a professional position in K12 schools. Content within the proposals from this group, compared with earlier internship proposals from previous semesters, showed an increase in clarity of ideas, consistency with standards, and innovation in proposed projects.

Participants in this study were motivated to use visualization tools in the design of K12 classroom activities. Graduate students in instructional technology courses and undergraduates in pre-service teacher classes designed classroom activities using Wordle.net. The activities were designed for critical thinking, problem solving, and other higher order processes for K-12 students. Based on results of this study we propose visualization tools can be useful to enhance digital literacy and improve reading comprehension with young and adult learners.

References


