Measuring Critical Thinking Through Concept Maps: A Semester-long Experiment in Lifespan Course

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Abstract

Critical thinking forms the core of our knowledge base. Students in higher education need practice and refinement of this skill crucial to help in their personal and social lives. The purposes of this study was to create an opportunity for the students in Lifespan Human Development course (n=20) to learn, practice and enhance critical thinking and conceptualization skills. This was studied using the assignment of Concept Maps, assessing the criteria Basic content, In-depth information, Connections/Comparisons, Theoretical/Holistic Views, Creativity/Novelty. Results showed that students improved in their critical thinking skills over the semester showing three performance patterns–Steady-progress, Inconsistent-progress, and Diffused. Researcher proposes that critical thinking ability to be introduced, practiced, supported, and promoted through deliberate instructional strategies and assessed regularly.

Key words: Concept maps, Critical thinking, Lifespan, Undergraduates, Students,

Introduction

Formal education today largely entails knowledge building through subject matter content coverage. Too often, this comes at the expense of skills building (Tsui, 2002). Instead of focusing too much on what to think, faculty can pay attention to teach the students on how to think. Higherorder cognitive skills, such as critical thinking capacity are invaluable; they prepare individuals to handle and resolve a multitude of challenges that one might face both, at personal and social levels. An individual needs to think critically before deciding on anything. An employer, no matter which discipline/field one might consider, requires some form of critical thinking skill among the candidates. An academician contemplates how to instil this skill among the college-going students. Can we ever teach someone to think critically? If so, how can we best do that? And, then, the next question would be, how do we know if someone actually learned to think critically? Are there any reliable methods of assessing such teaching and learning? If critical thinking is so important in all walks of life, where and when can we begin teaching it? Even before that, of what does critical thinking consist? The purposes of this study was to create an opportunity for the students in Lifespan Human Development course (n=20) to learn, practice and enhance critical thinking and conceptualization skills.

Operational Definition of Critical Thinking:

For the purpose of this study, an operational definition of critical thinking has been framed: critical thinking is a conscious, deliberate, reflective, creative approach for information-processing. This can include analysis, evaluation, and interpretation of existent knowledge combined with conceptual, methodological and focused inquiry. In other words, critical thinking includes the basic tasks of questioning, reasoning, reflection, objective commenting/critique, comparison, and conceptualization.

Statement of the Problem

The current research study plans to address these questions. The basic assumptions therefore are: a) that critical thinking is a skill and needs to be taught, and b) that it needs to be assessed to confirm its learning and practice. With this premise, the current research study was designed with the following objectives.

Research questions:

The current study aims at introducing, enhancing and finally assessing critical thinking skills among undergraduate students in Lifespan Human Development course. The specific research questions are:

1. How to implement the in-class assignment on constructing Concept Maps using resources and readings materials?
2. How to evaluate the assignments using the rubric on a three-point scale on five evaluation criteria?
3. How to assess, evaluate, and compare the students' critical thinking skills at the beginning, during, and the end of the semester?

Methodology

The current study aims at understanding, enhancing, and assessing critical thinking skills among undergraduate students in Lifespan Human Development course during Spring 2010 semester. The sample consisted of 20 undergraduate students at a mid-western university, who were enrolled in Lifespan Human Development course. This section was taught during Spring 2010 semester. The final sample included 3 male and 17 female (n=20) students from different majors and varied in their level of education (freshman, sophomores, juniors and seniors). The assignment was evaluated on five criteria: 1) Basic contents on the topic(s), 2) In-depth information about the topic(s), 3) Connections and/or comparisons, 4) Theoretical and/or holistic views/perspective(s), and 5) Creativity and/or novelty. To enhance the credibility of the grading rubric, two external experts in the discipline were consulted for reviewing it. Both were academicians in higher education and one of them taught the subject for over a decade, while the second expert taught in psychology. For clarity, this section consists of the following parts:

(i) Sample
(ii) Description/details of the assignment
(iii) Implementation of the assignment/project during the semester
(iv) Assessment/evaluation methods used
(v) Compilation and computation measures

(i) Sample

The sample consisted of 20 undergraduate students at a mid-western university, who were enrolled in Lifespan Human Development course. This section was taught during Spring 2010 semester. The final sample included 3 male and 17 female (n=20) students from different majors (because this was a General Education/elective course). They also varied in their level of education; some were freshman, sophomores, juniors and seniors. The class met twice a week for 85 minutes each class meeting. In all, the semester ran for 15 plus weeks, including holidays/Spring break, etc. The course was introduced as usual, along with the assignment in focus – the Concept Maps.

(ii) Description/details of the assignment

Educational research has indicated that sustained learning consists of a conceptual framework on which one could base the upcoming information and ideas (Osterhage, 2009). Concept mapping has been used in sciences, engineering, business and medical fields. These maps provide an estimate of prior knowledge, growth in current

knowledge and eventually, room for future knowledge. The author has designed Concept Maps as a learning activity and an assessment tool. The assignment was explained to the students in two places/ways. First was a brief description in the course syllabus and the second were detailed guidelines/instructions posted in Desire2Learn (D2L), the course management system.

Assignment requirements: The guidelines and rationale provided to the students in syllabus: **Concept Maps:** (15 @ 5 points = 75 points) Concept Mapping is a unique assignment that will make learning of the course content both in an in-depth and holistic exercise. The basic functions of this assignment are:

a. To provide a clear and distinct view of the concepts learned from the course.
b. To provide an opportunity to cause logical, reasoning, and analytical intelligences.
c. To help understand the connections among different developmental concepts and theories explaining human development.
d. To foster/encourage critical and creative thinking skills through class members' productions.

Every week, Concept Maps will be created during class, after which they will be displayed and discussed in-depth. You can come prepared with a rough draft of your work/ideas and depict it on the large-sized (11"X17") paper. You may use colors, graphics, images, drawings, words/phrases, or any other creative way to make your maps. I will provide the paper and you can bring your own writing/drawing tools. Additional details/guidelines and rubric are provided in D2L. Further details were provided through the online course management system, Desire2Learn. (See Appendix A)

(iii) Implementation of the assignment/project during the semester

Besides the description in the syllabus and in Desire2Learn, a grading rubric, examples of a few models/types, and samples from previous classes were posted for their review. And in-class, a practice (non-graded) Concept Map was conducted to help students understand the logistics. Instant, brief feedback on the technique and contents on these maps helped students understand the expectations of this assignment.

The assignment was spread across the semester. A total of 5 Concept Maps was created, each one about two weeks apart. This gave students enough time for thinking, planning, creating rough drafts and even consulting with peers and Instructor before finalizing their Maps. In-class time, about 20 minutes, was given to draw/create the map. Students were allowed to use their reading materials, rough drafts/sketches, colors, etc. The maps were then displayed in the classroom for peers' reviewing. Students walked around the room and carefully reviewed them. They were then given an evaluation rubric to assess one of the Concept Maps along with two comments listing highlights and suggestions for improvements. Since these peer reviews included students' names, the feedback was not given back to the students, but the Instructor used the reviews for monitoring their critical thinking and assessment skills. This part of the assessment process was not considered/computed for the purposes of the current study.

(iv) Assessment/evaluation methods:

Evaluating methods/rubric:

To help the students clearly understand the requirements and expectations of the assignment, a detailed rubric was created. The criteria were developed to capture the goals of the task and the Instructor's goals for this assignment. These criteria included: a) Basic content, b) In-depth information (hereafter, will be referred to as "In-depth info), c) Connections/comparisons, d) Theoretical/holistic view, and e) Creativity/ novelty. Each of these were graded as excellent, good and room for improvement categories with 3, 2, and 1 points respectively. (See Appendix B) Experts***:***

To enhance the credibility of the grading rubric, two external experts in the discipline were consulted for reviewing it. Both were academicians in higher education and one of them taught the subject for over a decade, while the second expert taught in psychology. An In-depth discussion and analysis of the rubric was conducted before finalizing it.

Samples of this discussion/feedback included:

a. Would the distances among concepts be assessed? Just thought being able to make a judgment about prototypicality of a concept, or providing a rationale for it might be an indicator of critical thinking.
b. In terms of creativity, connecting certain concepts in an unusual but creative ways might be another indicator of critical thinking. Would creativity criteria include that aspect too?
c. It is important to make each cell (on the rubric table) distinct from the next one-that drove my edits more than anything else.
d. It (the rubric) looks for elaboration of ideas and for insights.
e. Your rubric does assume that the student is on the right track. What would happen if the student were completely off track? Would that student receive zero (of the rubric) or have the project returned for revision?
f. Experience with the assignment across the semester (submitting 5 times) supports the use of this rubric.

Proposed plan of action/time plan:

For conducting the study, the following time plan was proposed.

a. Complete Concept Map 1, followed by their peer evaluation (using a similar rubric).
b. Complete 5 such Concept Maps over the semester (Feb-April, 2010)
c. Compare the assignment scores – initial, during and end-of-the semester submissions.

(v) Compilation and computation measures

All the scores from the assignment, which was conducted 5 times during the semester, were compiled into a spreadsheet. The experts were sent a random sample of the maps for review and the scores were verified across the two experts and the Instructor. (In addition, a graduate assistant for this course was also trained and asked to provide additional review/scoring.) These measures were taken to help in the triangulation of the evaluation process and to minimize any biases or inaccurate scoring. Detailed analyses of these maps are discussed under the Results section.

Results

The designing, planning and implementing of the assignment was the first half of the research study. The second and major part of the study was compiling and computing the results. This process required a thorough analysis of the scores considering different variables—in this case, the students, the number of maps, the evaluation criteria and finally, the scores achieved. The sample consisted of 20 students, the assignment was conducted 5 times, the grading was done on 5 evaluation criteria, and the scores were computed out of 15 points per map. In all, a total of 100 Concept Maps were graded and the scores were computed for patterns and further interpretations. The results are categorized into the following sub-sections:

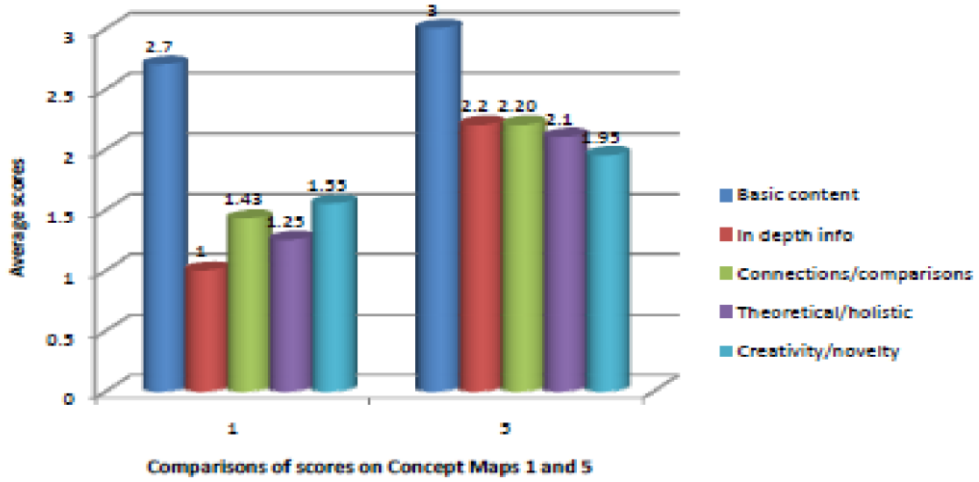
(i) Comparisons of scores of students on Map 1 with Map 5
(ii) Averages of total scores of all the students on all the maps
(iii) Scores on maps by students – patterns of change/peak points

(i) Comparisons of scores of students on Map 1 with Map 5

On Concept Map 1, the scores were highest on basic content (2.7) (See Figure 1). The two other variables that were similar in scoring were connections/comparisons and theoretical/holistic criteria, followed by creativity and In-depth info. It is clear that the creativity was evident only in 5 (25%) students, while the others scored only 0.5 – 1 points (out of 3 total). (See Appendix B).

This could be explained on the grounds of their varied backgrounds/majors. It could also reflect their level of education, freshman, sophomore, junior and seniors. It was, however, evident that students laid greater emphasis on the basic content and hence did well on that criterion.

Figure 1. Graph showing comparisons of averages from Map 1 and Map 5



On Map 5, there was a considerable increase on all the evaluation criteria, including the basic content. Figure 1 shows the changes in the abilities of the students, comparing Map 1 and Map 5. The maximum increase was seen on the In-depth info, followed by connections/comparisons, theoretical/holistic, and then, on creativity/novelty. On Map 5 on In-depth info, almost 50 % of the students scored over 2 points (out of 3), compared to 25 % on Map 1. The Basic Content, which was already at a high level (mean of 2.7 out of 3), changed to a full score (3 out of 3). The least developed criterion, creativity, was found to be hard to teach. Those students who already possessed some creativity, improved a little, but, others (over 50%) showed not much change. It might also be true that, since their focus was on the other criteria, like In-depth info, connections/comparisons, and theoretical/holistic criteria, the criterion creativity/novelty was not given much attention.

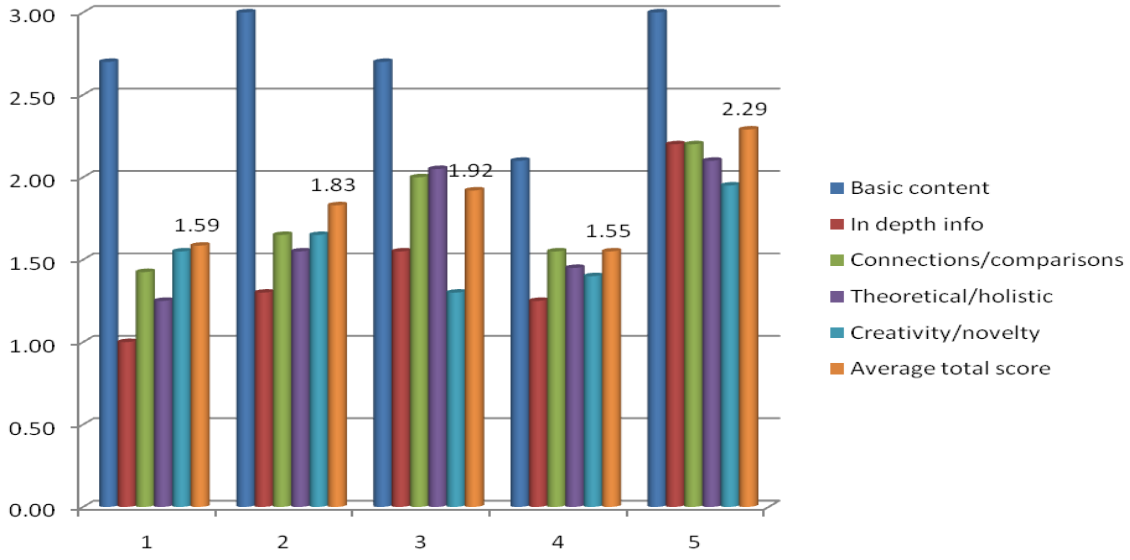
(ii) Averages of total scores of all the students on all the maps

The second part of the results section will now compare the total and their averages of the students on the Maps 1-5 (See Figure 2). These scores show the following:

a. There was a considerable growth in the overall scores all the students. The average total score changed from 1.59 (Map 1) to 2.29 (Map 5).
b. There was a major change in the criterion – In-depth info. It moved from less than 1 (Map 1) to a score of over 2 (Map 5). The growth was steady throughout, except on Map 4, where there was a slight drop on this criterion.
c. Theoretical/holistic criterion showed the next highest increase; its growth was small compared to Map 1 and Map 2, but, raised the most by Map 3. For reasons not known, this criterion, along with the other one, connections, dropped on Map 4. Timing of Spring holidays might have been one of the reasons.
d. Connections/comparisons also followed this growth pattern – increased from Map 1 to Map 2 and then, to Map 3, but dropped slightly on Map 4, but then, increased greatly by Map 5.
e. As mentioned before, the final criterion – creativity, was difficult to change, it only increased from a total average of 1.5 (Map 1) to 1.95 (Map 5).
f. And finally, an interesting trend can be noticed on the criterion – basic content, which was scored highest on Map 1, turned to a full score on Map 2, and dropped a little (by 0.25) in Map 3, and even further

(another 0.5) in Map 4. It was promising to see that the scores on this criterion – basic content, were back to a full score (3 out of 3) on Map 5.

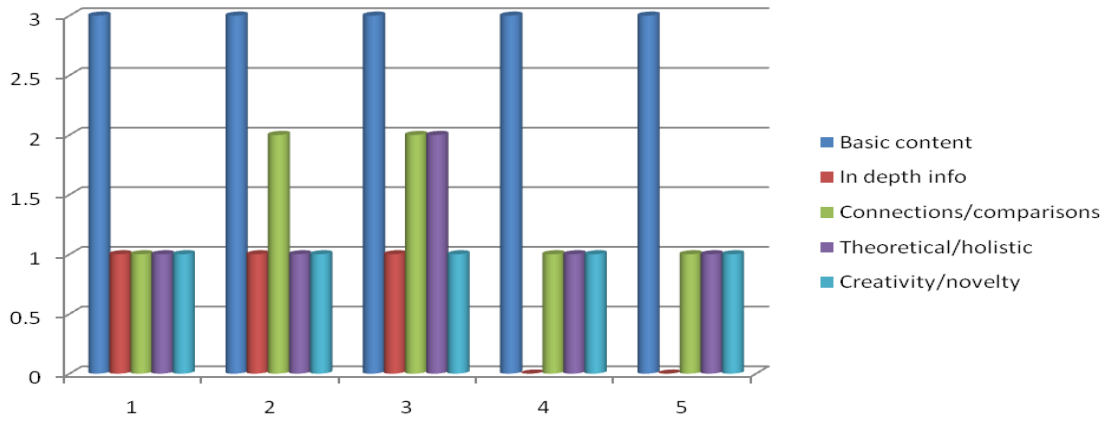
Figure 2. Graph showing average of total scores: Maps 1-5



(iii) Scores on maps by students – patterns of change/peak points

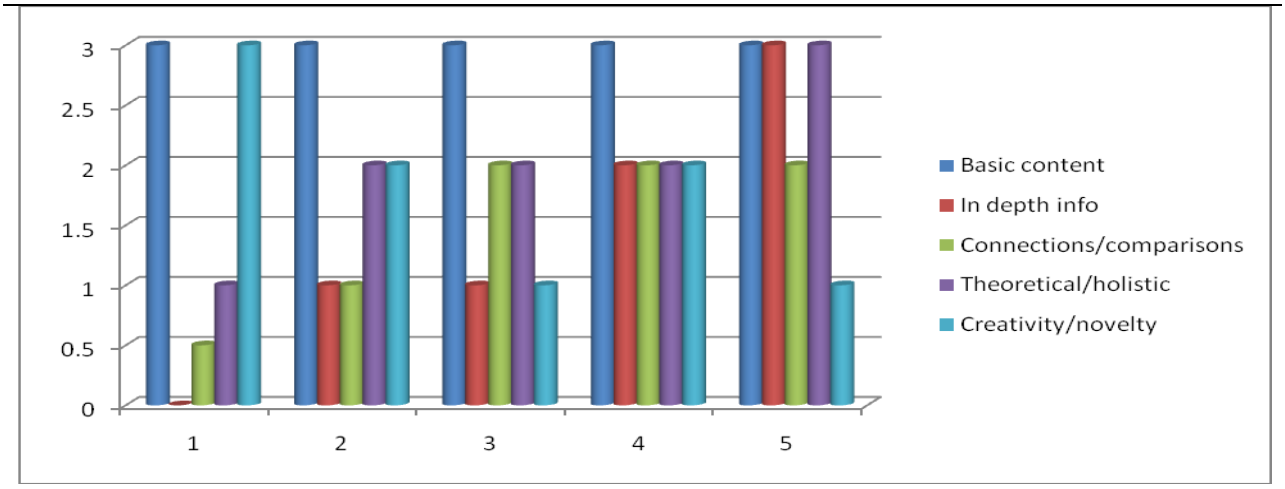
Although the overall growth was evident from the graphs above, it should be noted that all students did not change in the same fashion. To discuss patterns of change among students, a sample of them are studied In-depth below. These students' scores are selected to show a variety of patterns in their performance on each Map and on overall scores. One other outcome of this analysis was to discover the peak points in the performances of students. When the scores of each student were arranged and compared over the semester on the 5 Maps, some interesting patterns emerged, that will be elaborated under Discussion. However, these patterns were unique to each student, and hence, were not suitable to generalize to the class. Each of these samples below depicted a distinctive feature in their performance on the assignment.

Figure 3: Graph showing all the maps by criteria/variable of Student # 3



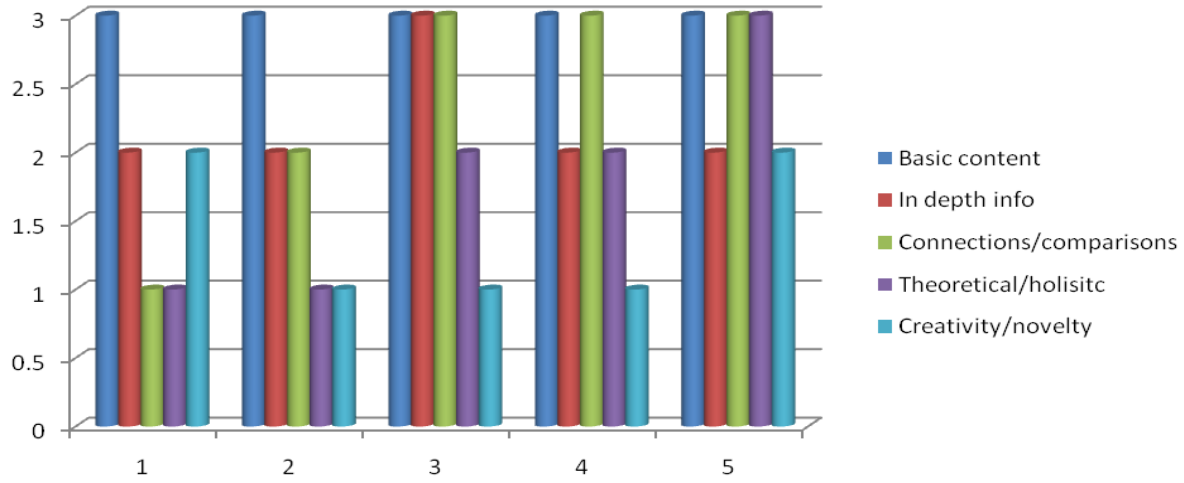
In the above sample, Student # 3 has scored full points on the first criterion – basic content, all through the semester (See Figure 3). The other four criteria, were at 1 out 3 points (on Map 1) and did not change much over the semester, except on Maps 2 and 3. The least scored criterion – In-depth info was always a 1 (on Maps 1-3) and a zero on Maps 4 and 5. The maximum overall score, hence, was on Map #3, when the criteria – connections/comparisons and theoretical/holistic were the highest. In a nutshell, it can be concluded that this student (#3) had the peak point at Map # 3 and demonstrated little change over the semester.

Figure 4: Graph showing all the maps by criteria/variable of Student #10



In the above example, Student # 10, showed a slightly different trajectory (See Figure 4). A brief account of this student's performance includes a full score on the criterion – basic content throughout the semester. The most growth was seen on criterion – In-depth information, which increased from a zero to a three. The next two criteria – connections/comparisons and theoretical/holistic increased from less than 1 to 3. On a downward change, the creativity moved from 3 points to less than 1. Overall, the student's peak point was at Map 5, followed by Map 4. In fact, this student's trajectory shows a steady growth in each of the criteria (except basic content and creativity/novelty) showing maximum change by the end of the semester.

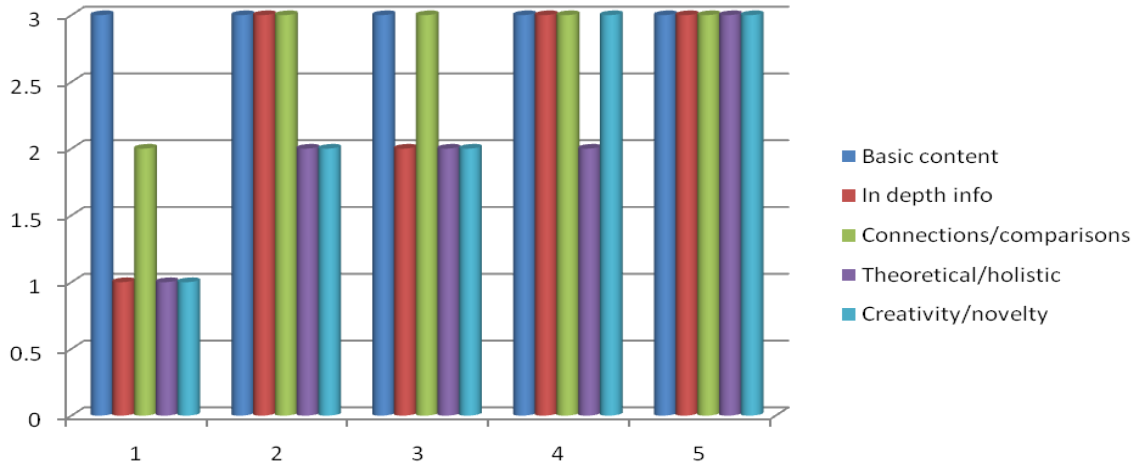
Figure 5: Graph showing all the maps by criteria/variable of Student #11



In the next example, Student # 11 portrayed a slightly different arrangement (See Figure 5). As in the previous cases, the criterion – basic content was scored well across the semester for this student too. The criterion – In-depth remained the same over the semester, except on Map 3, when the student scored full points. Connections/comparisons started at 1 point (Map 1), and moved 2 points (Map 2), and then went to a full score of 3 points thereafter. Similar trajectory was noticed on the criterion – theoretical/holistic, where the scores were the same on Maps 1 and 2, but increased on Maps 3 and 4, and finally, further increased to 3 (on Map 5). These two criteria showed a positive change and it was promising to see such progress. Although the maps 3, 4, and 5 certainly demonstrate high scores, the peak point for this student was at Map 5.

The last sample, Student # 20, differed in growth pattern (See Figure 6). This student, who had a total score of 8 (out of 15) on Map 1, went on to score 15 (out of 15) on Map 5. Most steady progress was noticed on two criteria – theoretical/holistic and creativity/novelty. These two were low on Map 1, increased in Map 2, and stayed the same on Map 3 and changed a little (creativity was higher) on Map 4, and finally, excelled in Map 5. The bumpiest changes were noticed on the criterion – In-depth info, where the scores went from 1 to 3, then to a 2, and then, a 3 and finally stayed at 3 (on Map 5). Connections/comparisons were fairly high initially, and fine-tuned further and remained the same from Map 2 onward, till the end. This student's peak point is clearly also at Map 5.

Figure 6: Graph showing all the maps by criteria/variable of Student #20



Discussion

From the analyses of the assignment and the explanations of different criteria lead the author to produce the following interpretations. The current section is divided into the following parts for further discussion: (i) Overall performance patterns of the class, (ii) Individual student performance patterns, (ii) Summary and conclusions, (iii) Limitations of the study, (iv) Recommendations for future research.

(i) Performance Patterns: Individual and Overall

Evidence from this study offers hope that mindful efforts by educators can utilize simple assignments like Concept Maps to facilitate and promote students' ability to think critically. Performance of the students during the semester varied significantly showing overall increase in their critical thinking skills. The results have clearly illustrated this fact. The main objective of this assignment was to master the information on Lifespan Human Development, which was accomplished partially through Concept Maps. This had a two-fold purpose.

First was to train the students to decipher the major concepts of the sections/units in the course. The second goal was to provide the students an opportunity to practice critical thinking and conceptualization of the learned content. Students were educated on this new method in the initial weeks of the semester. A non-graded, in-class practice Concept Map helped them to assess their own skill on this task. Instant feedback and elaboration, some samples/styles of maps, a few examples from previous semesters did seem to help. The part of the assignment, where the maps were reviewed in-class by peers did help the class overall.

Conversely, it was obvious that the assignment certainly did not benefit all the students in the same way. As described earlier, each student showed a unique path – some more steadier than others. Not all students progressed on all the five criteria under study. There were basically, three clusters of performance and were labeled based on their characteristic features. Some students had a rocky start but slowly picked up the skill after that. This group, showed a *Steady-progress pattern*. These students gradually improved their overall performance on all/most of the criteria. Approximately 50% followed this pattern. (Student #20 was one such example.) Second cluster of students showed unstable and irregular performance over the semester. This group demonstrated an *Inconsistent-progress pattern.* These students' scores increased and decreased in uneven fashion. This was true for all the measured criteria. Around 35% of the students fell in to this category (Student #10 was one such example.) Finally, the third group's scores were widely scattered and diffused over the semester on all the five criteria. It was difficult to describe their work as progress, since the scores on their Maps were disconnected, with unrelated elements randomly scattered, and coherence and in-depth information lacking. The label Diffused pattern seemed fitting for this group. Among the class, nearly 15% students performed in a Diffused pattern. (Students # 7 and # 8 are two examples.) (See Appendix D) This explains the difficult level, unpreparedness and unfamiliarity of students on this task. This could be due to their initial exposure to new assignment, which certainly was very different from what they were used to in earlier and/or similar classes and both inside/outside of the department.

One must remember that the visual complexity of these Maps may not necessarily represent the student's full capacity to learn and master the content. It however, represents the ability to make an attempt and work toward analyzing and synthesizing the contents. The Maps were distinct and varied in their style, complexity, content, and originality. Some Maps were based on the charts, graphs, tables, key words, headings, and any prominent parts of the book chapters and/or other readings. A few other Maps were a combination of different readings, not focusing just on the main points/headings but an overall or holistic meaning of the topic/unit. Some characteristics of these Maps were: organized, connected, coherent, conclusive, systematic, inventive, graphic, and categorize in nature (See Figure 6 for Map 5). Others were sometimes deceptive, segmented, disconnected, unrelated elements randomly scattered and lacked coherence and in-depth information (See Figure 4 for Map 1). Students demonstrated different approaches to compile the information and then depict it on a Map. Only few students actually 'processed' the information before creating a Map. This 'processing' of information required higher level reasoning and critical thinking skills mainly, analysis, explanation, inference, interpretation, evaluation, selfregulation and purposeful reflective judgment (Facione, 2010). Students who spent enough time on this phase (of processing the information) produced complex and in-depth Maps, compared to their counterparts who lacked these skills. Having said that, not all the students who possessed and used these critical thinking skills performed fully well on the Maps. That is because there was another ability/skill that was necessary, creativity. Creativity certainly made a difference in how the information was depicted on a Map. Students' own developmental level, hereditary and environmental factors played a role in what kind of novel ideas one could get during Map creation. Recognizing the variance among students' age, gender, educational level, background knowledge and practice, this assignment supports differentiated learning. And creativity, one of the criteria under study, underscores the differentiation of the assignment (M. Bold, personal communication, July 3, 2010).

Overall, there was a clear association between the appearance of a map and the scores it received. The rubric employed for evaluation supported a qualitative review of the students' work (Bold, 2010). It was noticed that

words were preferred in some instances, while graphics and color were added for beautification. In other cases, the focus was on a creative and decorative image embedded with information. These two styles were distinct in their own ways. The strengths of the Maps were Content and Theory/Holistic View. Since the requirement of the assignment was a thorough understanding of the readings, students mastered the topics under review for designing the Maps. Making Connections was an important criterion and students quickly learned it (since it affected their total score). A weakness that continued to remain till the end was In-depth information. Students seem to have the practice of learning the content at surface level and reproduce it during Exams or similar assignments. Creating a Map demanded a much deeper understanding of the information, which seemed to be lacking among many in the class. As described in Figure 1, the least developed criterion, creativity, was found to be hard to improve. Those students who already had roots of this skill, improved a little, but, others (over 50%)
showed little difference. It could be due to their focus and attention was on other criteria like Indepth info, connections/comparisons, and theoretical/holistic view.

This assignment made the students more alert toward their own learning and, hence, they seemed to work harder and effectively. Showing them a collection of generic models of concept maps seemed to help the students. After the first Map, the Instructor saw the benefit of showing the class a few samples from previous semester. There were mixed feelings about this in class. Some students expressed that it definitely helps to see previous class's work, while others said they rather not see them. But, overall, students did learn and enjoy review their classmates' work. Inclass review and assessment helped them to compare their own work with that of others, and learn some nuances of this conceptualization skill. Oral feedback from the students, during class included, "I have never thought about … (topic) in this way before," "It was cool to see that … (student name) came up with …. (this pattern)," and "looking at others' work helps me understand what I need to improve upon." Comments like these clearly demonstrate that the exercise was certainly beneficial, and that students were thinking critically of their own and others' work. Thinking of alternative solutions to a problem and seeing different perspectives were often considered as essential parts of critical thinking.

(ii) Summary and conclusions

"A concept map should both answer and ask a question" (Vacek, 2009, p. 49). In the current study the Concept Maps were used to answer the question – what is lifespan human development (at different stages)? The question that should be raised in students' minds is – How are these stages and developments compared and connected? The answers that student should be able to derive would be – the developmental process and its nuances. On the whole, it is believed that the assignment met the expectations of the course, seemed to help the students in training them on a new set of skills, and finally, provided some interesting insights into the student learning and teaching of this subject. The researcher believes that educators need to begin their teaching only *after* preparing the students with a proper mindset, most importantly, the skills related to questioning, thinking critically, and doing inductive and deductive reasoning. Dumping loads of content into students' minds that are unable to think critically (in other words, reason, analyze, reflect, and interpret) is an inefficient educational practice (Tsui, 2002). The author firmly believes this notion of teaching the skill rather than mere content in fact, has led to the current research study. "In principle, critical thinking in fact could serve as a predictor of course performance and as an outcome of learning experiences in the course" (Williams, Oliver & Stockdale, 2004, p. 1). Some major conclusions of the study are:

a. It was concluded that the course was conducive to this type of assignment, since it involved conceptualization of contents, and cumulative learning over the semester.
b. It was clear that students needed training and practice in mastering this skill of critical thinking and conceptualization.

c. It can be noted that critical thinking ability can consist of several parts, of which only four criteria were included in this study. The mastery of the information, the criterion – basic content, was the indispensable goal of the course.
d. It was found that there were different patterns of performance among students: Steady-progress, Inconsistent progress, and Diffused. Each of these patterns influenced different styles of accomplishment, learning, and functioning.
e. It can be also concluded that conducting this assignment and the study overall was not an easy task. A lot of time was involved in its planning, implementing and evaluating. The most difficult component was to articulate the rationale of the assignment and to prepare the students to begin the training/practice.
f. The current study for sure has made the researcher more alert to the students' needs, learning styles, and techniques of understanding subject. This will help the Instructor to cater to different students in the optimum manner.

The author wishes to continue this teaching strategy (of using Concept Maps) to enhance critical thinking skills among students. The goal is to infuse this method into all the courses and thereby making it a common practice instead of just a one-time trial. So, looking back at where we started (in the Introduction), we do seem to have a few questions answered. Our assumptions turned out to be accurate. Considering the results of this study it is obvious that, critical thinking can be facilitated through educational endeavors. Class assignments like Concept Maps can serve as a good start, not only to master the course content but also to induce and develop critical thinking skills. Then, the next question was about assessment of this new/learned ability. It was found, through this study that this step was not easy. It required rigorous procedure of using a definite rubric that was developed after serious thought, planning and deliberation. The rubric was refined incorporating noteworthy suggestions from the external experts. There are several commercial tests/scales to measure critical thinking, which may/may not apply to every classroom context. It would not be an exaggeration to say that an assignment like creating Concept Maps works well in most (almost all) of the disciplines. So, in essence, critical thinking is important, it has to be taught deliberately, and assessed (to confirm its learning) and finally, expanded regularly. Also, the researcher envisions further expansions of the assignment to address other instructional goals, like communication, demonstration, peer-teaching, and presentation to the class or a wider audience. The final goal (for now) is to train the students to learn to use their critical thinking skills, practice them well during the semester and then, showcase their abilities to a wider audience, be it the class, the department/college, university, state or even national levels.

(iv) Limitations of the study

As in any research, shortcomings are bound to exist. Some of the major limitations of the current study were:

- The size of the sample was small (n=20), and hence cannot be generalized for a larger population. The class distribution was also uneven (3 males and 17 females), hence comparisons among the genders could not be made.
- In this course, this was not the only assignment that was designed to promote critical thinking skills. It is hence difficult to separate the cumulative effect of all the exercises conducted during the semester.
- The level of the student's education (if they were freshman, sophomore, junior or senior), might have played a role in their critical thinking ability. If the study was conducted on a more homogenous group of these levels of students, a comparison might have been possible.
- The time limit on the exercise was one of the restrictive factors. Since this assignment was part of a course, which was content-intensive (and since Concept Maps were only one of the many other assignments that were planned for this course), only limited time was spent on this assignment.

- Also, this assignment was conducted only 5 times during the semester. Student performance may have been different if this was a daily or a weekly exercise and/or done in groups instead of individually.

(v) Recommendations for Future Research

The common characteristic of research is that while answering some questions, it raises some (other) newer ones. The author, hence, makes the following recommendations for future research. It was found that due to a lack of a pre- and a post measurement of the level of critical thinking skills among students, studies like these have debatable conclusions. It is difficult to determine if the changes, most likely the increases in the critical thinking skills, were due to the instruction and practice or due to natural developmental process of human learning. Unless there is a matched controlled group, how is it possible to know if the teaching strategies made any significant impact? A few suggestions to continue this line of research are:

- Administering the assignment more number of times, eg. as a weekly assignment.
- Include all levels of undergraduates (freshman, sophomores, juniors and seniors), and compare them as individual groups and across the groups.
- Including graduate students and compare them with undergraduates.
- Conducting this assignment alongside other assignments that promote critical thinking skills, such as reflective exercises, role-plays, debates, etc. to determine whether any such combination is more beneficial.
- Comparing males and females, making sure the sample size it large enough.
- And, finally, continuing to monitor these students in other classes to determine whether they have retained any of these critical thinking skills and if so, study how that retention is demonstrated.

The educational goal of developing critical thinking skills is significant as well as challenging. Direct instruction of critical thinking skills is certainly an arduous task, but if persistently continued along the program and at all levels, students in higher education can benefit the most and thereby leave the institution prepared for the real life. Use of simple and yet creative assignments like Concept Maps can help in such endeavors.

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Appendices

Appendix A: Assignment details provided to the students via syllabus and D2L
Appendix B: Concept Maps: Scoring guide/Rubric
Appendix C: Graph showing scores by student for Map 1 and Map 5
Appendix D: Graph showing scores by student and by maps
Appendix E: A sample of high-scoring Concept Map

Appendix A: Assignment Guidelines

Assignment Guidelines provided in Desire2Learn (D2L) **Concept Maps:**

Concept Maps are tools for visual thinking. Your learning will be obvious when it is depicted on paper, and even more, when put into a graphic representation. The concepts or individual pieces of information are stored and viewed by your brain in a certain fashion. Concept Maps give us an idea of such learning and understanding. Concept Maps help you reflect and deepen your understanding of the subject. These exercises are provided for you at regular intervals to improve your understanding of the subject. It is a tangible way of measuring your learning and understanding of the subject. In a nutshell, Concept Maps provide a snapshot of your learning, including the critical thinking and creative experiences.

A few benefits of Concept Maps:

By creating a Concept Map, you are:

1. Helping yourself to check your own learning.
2. Enhancing your understanding of the information that you have learned.
3. Visualizing the connections between the concepts/information in different styles/ways.
4. Facilitating in organizing the new information into the existing knowledge.
5. Improving the clarity of the information under study.
6. Exploring the missing links and finding the gaps in your learning.
7. Improving your creative thinking skills
8. Training yourself in taking visual notes during lectures/meetings, etc.

Prior thinking, planning, and reviewing the information and coming prepared to the class can improve your performance on this exercise. You may even create rough drafts before coming to the class. Reading and reviewing the information and then, analyzing and processing new information will help bring about assimilation and accommodation of knowledge.

The assignment will be evaluated on five criteria:

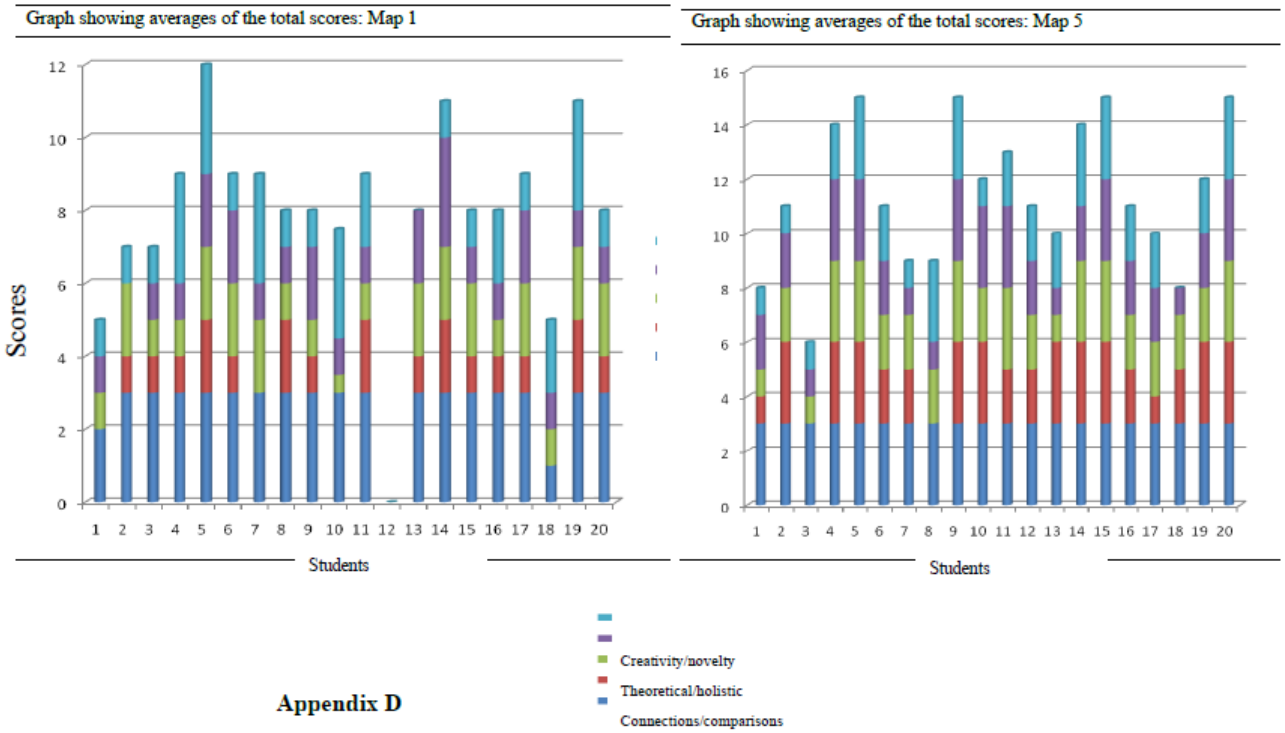
1. Basic contents on the topic(s)
2. In-depth information about the topic(s)
3. Connections and/or comparisons
4. Theoretical and/or holistic views/perspective(s)
5. Creativity and/or novelty

ps: In each Concept Map, you can include all the readings/materials discussed thus far in the course.

Appendix B
Concept Maps: Scoring Guide/Rubric

	Excellent	Good	Room for improvement
Criteria	**Outstanding 3 points**	**Average 2 points**	**Acceptable 1 point**
Contents	Listed all major and additional supplementary/ relevant/ related concepts	Listed most of the major relevant concepts	Listed a few major relevant concepts
In-depth information	Mentioned all and some unusual details to enhance the understanding of the topic(s)	Mentioned most of the details to explain the topic(s) in context	Mentioned a few details of the topic(s) in context
Connections/Comparisons	Made all and additional unusual connections with conceptual understandings among the concepts	Made most of the possible connections between/among the concepts	Made few connections between the concepts
Theoretical/holistic views	Made outstanding and far-reaching conceptualization(s) in presenting holistic views	Made notable holistic/ theoretical observations	Began to view the contents in a holistic approach
Creativity/novelty	Used extraordinary/ outstanding creative/novel methods in depicting the ideas	Used good creative/novel methods in depicting the ideas	Used limited creativity/novel methods in depicting the ideas

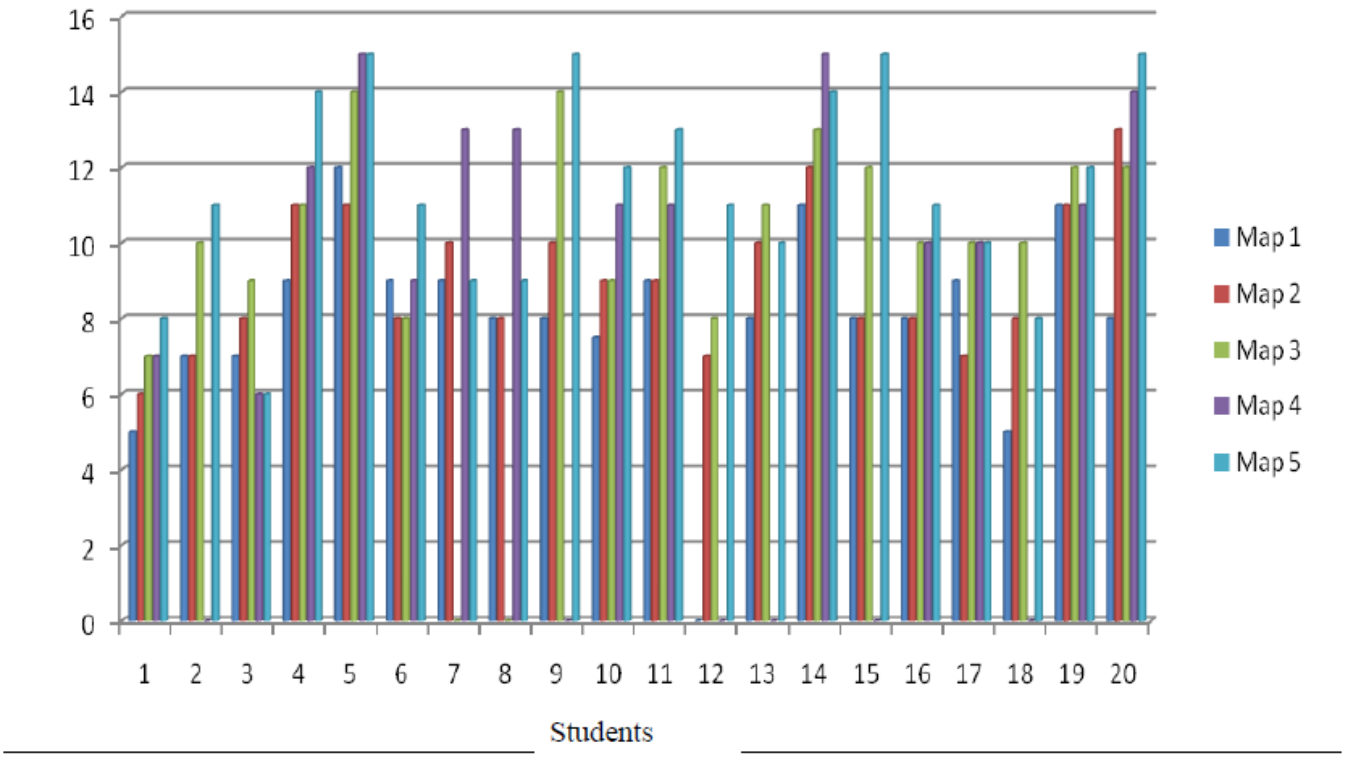
Appendix C



Appendix D

Graph showing total scores by of all students on all maps

Graph showing total scores by of all students on all maps



Appendix E

A sample of a high-scoring Concept Map (reprinted with permission of the student)