EXPLORING ACTIVE LEARNING TO CONNECT
SOCIAL ISSUES AND GAME THEORY

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ABSTRACT
Active learning is a frequent topic in higher education, typically resulting in questioning the type of empirical data on the effectiveness. Skeptics point to the lack of time for 'covering' material, a major challenge for the ever growing knowledge base ubiquitous in every discipline. Sound research begins with exploring the unknown to better understand the possibilities. The authors explore three teaching methods to determine their effectiveness in a freshmen seminar course. The methods are concept mapping, commercial storyboarding and educational wikis. The assessment tools used included pre- and post-concept maps, as well as a disposition survey. The outcomes revealed that in for a class size of 23 second semester freshman at a small private liberal arts institution, all methods were shown to increase engagement. Quantitatively, the concept mapping activity demonstrated the largest increase in mean scores across all areas, though the wiki group most often referenced material from the most recent out of class readings.

Keywords: Active Learning, Concept Mapping, Digital Storytelling, Wikis

INTRODUCTION
The Freshman Seminar II is the second semester course required of University students during their first year at college. Students complete the sequence with a third course the final semester of their senior year. The prerequisite course, Seminar I offers students a common syllabus looking at the question “What is a Good Society?” and related themes.
The second semester Seminar II course consists of topical discussion oriented seminars examining one or several of the first semester themes in depth. The university Mathematics department offers a course called Math and Social Issues. The course covers a variety of mathematics, statistics and mathematics education topics related to diversity, ecology, and other social issues. There is no post-secondary mathematics prerequisite for the course.

The course is structured around several mathematics topics, dedicating between three and six class periods to each topic and illustrating connections to social issues. The course is writing intensive and each section requires at least 20 pages of revised writing. As a continuation of Seminar I, instructors incorporate several articles from the original reader, chosen to fit within the special topics of Seminar II.

One of the modules in the course addresses the concept of Game Theory. This particular topic proved challenging to Seminar students in the past. This topic incorporates the essay from the Seminar I Reader, G. Hardin’s Tragedy of the Commons (1968). Hardin’s thesis regarding population growth provides a controversial topic for discussion, but, also for the purpose of Math and Society, illustrates the use of game theory in argument via the example, which forms the title of the essay. During the previous semesters teaching the course, this article proved difficult for the students to follow. One goal of this study is to determine if alternate methods of learning will help students make the connections between the Tragedy of the Commons and social issues of concern today, for example, environmental issues such as climate change.

The game theory module consists of a series of lectures, first introducing basic game theory concepts through games in class, followed by a series of classes introducing more complex topics and making connections through discussion of newspaper articles or examples from the course textbook. The final class follows the assigned reading of Hardin’s essay. In previous semesters this class consisted of a small group discussion of the essay, followed by a lecture about the tragedy of the commons game theory model, further class discussion and an examination of different models of a similar type, namely multi-player models.

**LITERATURE REVIEW**

**Collaboration**

Over two decades ago, Johnson and Johnson (1987) found that collaborative learning in higher education is the most effective way for students to learn. The idea of working together, in a ‘the whole is greater than the sum of its parts’ scenario is not a new concept, especially to primary and secondary education.

However, in tertiary education, the collaborative/cooperative perspective to teaching and learning, especially within a classroom learning environment has yet to gain wide acceptance.
The important issue of time and the lack thereof typically begins and ends most discussion of taking class time to ask students to interact in a group, reflect, share and possibly gain a consensus of ideology.

Vygotsky (1978) represented this approach in his dialectivism principle, whereby he believed for learning to be complete and sustained, a conversation or dialogue was required. The dialogue should be complete, in that it addressed each of three steps, thesis (an idea); antithesis (the opposite idea); and a synthesis (a combination of the ideas). This three tier approach is commonplace among productive, collegial conversations, and has been more evident in the advancing arena of communication via the web. People have embraced email, instant messaging, Skype, and blogs to connect in textual and audio/visual communication in an ever emerging advancement of tools (Hargis, 2006). Another perspective in collaboration, especially in a media-rich context is emergent- collaboration. Nachmias et al, (2000) define emergent-collaboration is “the process by which group configurations and transactional patterns evolve among participants during the course of learning.”

In this research, the authors create multiple opportunities for connections, cross-hybridization of ideas and conversations for students in presenting their work, as well as providing a common assessment tool of concept mapping.

**Concept Mapping**

The idea of mind mapping or graphic organizers has been a main part of education, albeit seen in distinctively different modes. One type of graphic organizer is a concept map. A concept map in its simplest form describes a concept in a non-linear way by connecting, or mapping two primary items: typically a noun, and various adjectives and verbs. Each noun can be connected to one or more adjectives, represented by arrows directed to and from the noun. Joseph Novak (2002) is noted as the creator of concept mapping with a team at Cornell University in the 1970’s based on a constructivist model and assimilation theory of connecting prior knowledge. The power of connecting prior knowledge was the main rationale for using this technique as both an instructional tool and an assessment vehicle (Marotta & Hargis, 2011).

The purpose of the experiment was to determine the best method to empower students to make the distinctive connections between social issues and game theory. Hence, by first identifying their prior knowledge (pre-assessment), we could identify the gains in both new knowledge and connections by the use of a subsequent concept map as a post-assessment.

One of the primary goals of the seminar course is to help students make global connections of “What is a Good Society?” As society advances, so does its use of technology. A technological approach to concept mapping can be visually created using a wiki.
**Wikis in Education**

Wiki is a Hawaiian word that means ‘quick’. It can also be an acronym for “What I Know Is”. Wiki’s in the context of the web have been growing over the past two decades. Probably the most famous wiki, Wikipedia began in January 2001. Richardson (2010) defines a wiki as a Web site where anyone can edit anything anytime they want. Educause, (2010) indicates that wikis can be a powerful addition to teaching and learning as they can “be the easiest and most effective Web-based collaboration tool in any instructional portfolio. Their inherent simplicity provides students with direct access to a site’s content, which is crucial in group editing or other collaborative project activities.” Wikis have been around for several years, and there are many educational resources and websites, which provide background information, instruction on how to create wiki’s and examples of wikis used in higher education classrooms.

The following is a representation of the types of wikis in higher education:

- **University of Delaware (UD)** ([http://udel.edu/~mathieu/wiki](http://udel.edu/~mathieu/wiki)) provides a full report of how their university is using wikis addressing the topics of What Is A Wiki Anyway; Typical Usage of Wikis (What Wikis Are Good For); What are the major differences between wikis and other tools?; Wikis in Education; Examples and Advices from the Literature and the Web; Lessons Learned in Defining Wiki Usage in a Course; Instructional Strategy; Control and Ownership Issues; Individual, Team, and Class Contribution; Templates; Wiki Charter and Etiquette; Using the Wiki Beyond the Wiki; and Grading Strategy. Key to this paper, the UD’s perspective on “What Wikis Are Good For” is particularly germane. The authors research capitalizes on UD’s identified aspects of: “Brainstorming: When starting a specific project or a creative process, participants are invited to add items and thoughts on a wiki. They are also asked to link all these random thoughts and concept together in order to stimulate creativity.”

- **North Carolina State University** ([http://wikis.lib.ncsu.edu/index.php/Wikis_in_Writing_Education_Research](http://wikis.lib.ncsu.edu/index.php/Wikis_in_Writing_Education_Research)) has “established a wiki in order to facilitate research on the use of wikis in education, specifically the teaching of writing.” The cite shares important items to consider, as well as advantages and disadvantages of wikis.

- **Michigan State University** ([http://www.wiki.educ.msu.edu/](http://www.wiki.educ.msu.edu/)) has developed a wiki in their School of Education to provide real time, accurate information of faculty and staff for student access.

- **University of Leeds** ([http://www.sddu.leeds.ac.uk/online_resources/wikis/external_case_studies.html](http://www.sddu.leeds.ac.uk/online_resources/wikis/external_case_studies.html)) posts a table of universities who use wikis, which include University of Arizona; University of British Columbia; Sheffield Hallam University; and the University of East Anglia.
MATERIALS AND METHODS

This study was conducted in a Center for Teaching and Learning (CTL) Learning Laboratory (lab), at a northern California Private Liberal Arts University. Learning Lab Faculty Fellows who teach in the lab were fully supported by the CTL staff with best-practices active strategies; a teaching resource library; a full time faculty developer; administrative assistance; instructional technology assistance, video/digital cameras; and many other teaching tools which the faculty member requires to pursue an active, innovative exploration of their instructional environment. The intent is to significantly assist faculty members in generating, using electronic instructional material, and collecting data to determine their effectiveness so they can implement the proven methods into their other courses.

The lab is equipped with a Smart Interactive WhiteBoard (SB680i2-Unifi 45 projector); Audio (SBA-NA USB audio system for 600 series); chairs with wheels (Torsion/Go Tablet armchair); whiteboards with wheels (Rolling four point base Marker board 48"x66" w/ casters); iPod nano's for digital recording and student response systems, or clickers (Hargis & Schroeder, 2010).

As part of the university General Education requirement, first year students are required to take a Freshman Seminar I class in the fall, a Seminar II in the spring, and a Seminar III on ethics during their final academic year. Students access a General Education website, which included brief descriptions of 42 different sections of Seminar II, which they can select.

The participants for this study were twenty three second semester freshman students, 15 male and eight female students of between the ages of 18-20 years with mixed cultural identity differences. The students signed up for the Seminar II class after reading the following description written by the instructor:

"Quantitative reasoning, a key component of scientific thinking, can provide insight into several of society’s problems. Indeed, we use numbers and data to quantify and thus to comprehend some of the themes and sub-themes addressed in Seminar I, such as Equity in Education, Free Market Economics, and the Environment. Is the death penalty linked to race? Are police interrogation methods just? What is the most equitable way to allocate seats in Congress? This topical seminar addresses these and other social issues from a quantitative viewpoint, thereby exploring the question, "What is a Good Society?" in a different way. We will use some basic techniques to analyze quantitative data arising in a variety of social arenas."

Three groups were developed, which included the following students:

I. Concept map: 4 male; 3 female
II. Commercial: 5 male; 3 female
III. Electronic Wiki: 6 male; 2 female
Data was collected during the spring semester, 2011. The design (table 1) is a pre/post-assessment using concept maps as the assessment tool.

The analyses are conducted on data collected from the 23 participants; however one male student in the Commercial group did not participate in the pre-assessment so this data is not included in the study.

### Table: 1
Study Design

<table>
<thead>
<tr>
<th>Attitude Survey</th>
<th>Group Assignment</th>
<th>Pre-CM Assess</th>
<th>TRT #1 CM</th>
<th>TRT #2 Commercial</th>
<th>TRT #3 Wiki</th>
<th>Post-Assessment (CM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>R (n=7)</td>
<td>O</td>
<td>X1</td>
<td></td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>O</td>
<td>R (n=7)</td>
<td>O</td>
<td>X2</td>
<td></td>
<td></td>
<td>O</td>
</tr>
<tr>
<td>O</td>
<td>R (n=8)</td>
<td>O</td>
<td></td>
<td>X3</td>
<td></td>
<td>O</td>
</tr>
</tbody>
</table>

[O =Observation; R =Random; CM =Concept Map; TRT =Treatment]

The assessment included a central provided concept labeled “game theory”. Measures were taken for:

- number of concepts
- number of connections
- depth of the concept map (number of steps from the central concept)
- number of social issues
- number of game theory concepts, and
- a binary measure, whether students included social issues or game theory concepts that could reasonably be connected to the Hardin reading.

All information was numerically coded by the participant’s last four digits of their student ID number, and confidentiality was maintained to the extent stated and required. The three different active learning Treatments deployed, were derived from Angelo and Cross (1993), concept mapping, and creating a storyboard for a television commercial that represents the concept and recording the commercial on Flip video cameras. The third active method utilized a free interactive, self-authoring web 2.0 tool, called a Wiki. The descriptions of each treatment are as follows:

- Concept Mapping -Students were provided instructions and a model of a concept map. They were asked to write keywords that pertained to the topic of Game Theory onto adhesive Post-It notes and then organize them on a wall into a structure that makes sense.
Students then wrote arrows connecting the terms written on the notes which describe the relationship between each term. These connections or transition terms are essential, as this provides information as to the students’ holistic understanding of the concept(s).

TV Commercial - In groups, students were trained on how to create a storyboard and script by a CTL staff member, whose expertise is in theatre and visual performance. After the staff member approved the student group storyboard, each group was provided a Flip video camera, and shown how to capture, store and transfer video. Students were asked to create a one minute TV commercial on the topic of Game Theory. They were encouraged to be creative, although accuracy and connecting the concept to social issues was the primary goal.

Wiki - Students were shown a wiki within the university online Learning Management System and asked to discuss the topic. Wikis are defined by Educause as “a Web page that can be viewed and modified by anybody with a Web browser and access to the Internet. This means that any visitor to the wiki can change its content if they desire.” (Educause, 2010). Students were then asked to generate a wiki, and build it collaboratively on the topic of Game Theory. The wiki remained available for all students to view, and add to, after the study ended.

All participants were assigned an in-class introduction to concept maps early in the semester, in order to minimize instructor involvement during the assessment periods. Students were asked to create a concept map about how they would be evaluated in the course, a topic chosen to minimize mathematics concepts and social issues. The Game Theory module consists of four days of material, including textbook readings and one essay (Hardin). Because of the experiment, the first day of class was designed to focus on the mathematics language and fundamental ideas of Game Theory and to minimize context of social issues. This is similar to how the class was taught in the prior semesters. The pre-assessment concept map was given during the final 15 minutes of the first day of class.

The students were asked to prepare a concept map of the relationship between Game Theory and social issues. They were reminded that this was a pre-assessment, whose intent was to gauge the prior knowledge before the content was taught, so that if they did not have much experience with these topics that was acceptable. For the experiment, students were divided into groups based on random assignment using an Excel spreadsheet to assign random numbers to each student before sorting into groups.
The students were assigned to six groups, five with four students and one group with three students. At the end of the third day of Game Theory instruction, students were assigned to their groups, and provided with a list of group members and limited instructions about material to bring to class. Students were not informed of the exact activities at that time.

Set-up Details
At the start of fourth game theory class period, each group was provided written instructions about their activity, and sent to different locations. Each TV commercial group went to an enclosed study room located in a room adjacent to the classroom in the library. The wiki groups were sent together to get instructions on using the wiki software. Each concept mapping group was given separate physical space, one in the classroom and one nearby in the CTL. All groups were provided one hour to complete their tasks. Instructions were provided on Day 3, prior to the experiment on Day 4. Briefly, for the Concept Map groups, they were asked to bring a laptop computer and reserve a library study room. The TV Commercial group was asked that every student bring a laptop. And for the Wiki group, no special instructions were needed. Instructions for creating a TV commercial were to put together a Superbowl commercial about Game Theory and social issues. They were instructed to Brainstorm: Throw out ideas for your commercial. Nothing censored at this step; Discuss: Narrow down your ideas to one you like; Script (Scene Planning): Assign roles and write out what each person is to say and do; and Storyboard: Plan out the commercial shot by shot. Even simple scenes might have multiple shots. Then take multiple shots for editing later. Download the film to a computer and edit it, as much as time permits. Instructions for Wikis were to create a Wiki about Game Theory and social issues after meeting with the CTL Technology Coordinator. Log into our Sakai CLE and Read the Welcome to the Wiki then connect to the Group 2 Wiki.

Find the all-important edit button on the top of the Wiki panel. Practice editing and saving your wiki. Read the tips on the side bar to the left. Click the History button. This allows you to undo mistakes. Each student will find a different place within the library to log into your group 2 Wiki and simultaneously build it. Instructions for the Concept Mapping included Brainstorming as many concepts about Game Theory or Social Issues and write the ideas on the Post It notes to rearrange as they make sense. After you are happy with the placement of concepts, connect the concepts with arrows and write explanations for the connections. Switch after 30 minutes and review/edit each other’s map.

Data Analysis
A quantitative analysis was used to determine the number of items on the pre/post concept map. Four measures were used: Number of concepts (other than the original central concept), number of connections between concepts, number of social issues referenced and number of game theory topics referenced.
In addition, a descriptive rubric was created to determine the quality of terms on the concept map (see table 1):

- No connections between Game Theory and Social Issues (or one or the other topic not present on the concept map)
- Few connections between Game Theory and Social Issues. Connections lack depth.
- Several connections between Game Theory and Social Issues, showing some depth of connection.
- Many connections between Game Theory and Social Issues, showing considerable depth of connection.

The evaluation of the concept maps was blind to the treatment group of each student, but not to the pre or post assessment of the map.

RESULTS

The mean and standard deviations for the concept map measures are represented in table 2, divided by treatment groups. Pre-and post-assessment scores are included as well as the means and standard deviations for changes in scores. The Concept Map treatment group resulted in the largest mean change in all categories.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre/Post/Change</th>
<th>Treatment 1 Concept Maps (n=7)</th>
<th>Treatment 2 TV Commercial (n=8)</th>
<th>Treatment 3 Wiki (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts</td>
<td>Pre-assessment</td>
<td>5.14 (3.72)</td>
<td>7.88 (4.76)</td>
<td>7.29 (3.50)</td>
</tr>
<tr>
<td></td>
<td>Post-assessment</td>
<td>10.00 (3.74)</td>
<td>8.88 (3.48)</td>
<td>9.00 (3.21)</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>4.86 (2.67)</td>
<td>1.00 (5.18)</td>
<td>1.71 (4.23)</td>
</tr>
<tr>
<td>Connections</td>
<td>Pre-assessment</td>
<td>5.71 (3.90)</td>
<td>9.63 (7.65)</td>
<td>8.57 (5.41)</td>
</tr>
<tr>
<td></td>
<td>Post-assessment</td>
<td>11.86 (3.18)</td>
<td>9.25 (3.54)</td>
<td>9.71 (3.25)</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>6.14 (3.63)</td>
<td>-0.38 (8.80)</td>
<td>1.14 (5.93)</td>
</tr>
<tr>
<td>Social Issues</td>
<td>Pre-assessment</td>
<td>1.86 (0.90)</td>
<td>3.25 (1.83)</td>
<td>3.00 (1.91)</td>
</tr>
<tr>
<td></td>
<td>Post-assessment</td>
<td>3.00 (2.00)</td>
<td>3.13 (1.73)</td>
<td>3.71 (1.50)</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>1.14 (1.77)</td>
<td>-0.13 (3.27)</td>
<td>0.71 (2.21)</td>
</tr>
<tr>
<td>Game Theory</td>
<td>Pre-assessment</td>
<td>0.43 (1.13)</td>
<td>0.50 (0.53)</td>
<td>1.00 (1.29)</td>
</tr>
<tr>
<td>Terms</td>
<td>Post-assessment</td>
<td>5.13 (2.79)</td>
<td>0.63 (0.92)</td>
<td>2.43 (2.37)</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>4.71 (3.04)</td>
<td>0.13 (0.83)</td>
<td>1.43 (1.81)</td>
</tr>
</tbody>
</table>

The authors were primarily concerned with the change in scores from the pre- to post-assessment.
The difference in standard deviations and an examination of the distribution of data precluded a use of ANOVA or similar tests.

The differences were instead examined with the Kruskal-Wallis Signed Rank test. The null hypothesis being that all of the mean changes are the same and the alternative being some difference between the mean changes.

Table: 3
Statistical Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Kruskal-Wallis Test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concepts</td>
<td>H = 3.828</td>
<td>0.148</td>
</tr>
<tr>
<td>Connections</td>
<td>H = 4.626</td>
<td>0.099</td>
</tr>
<tr>
<td>Social Issues</td>
<td>H = 0.218</td>
<td>0.897</td>
</tr>
<tr>
<td>Game Theory Terms</td>
<td>H = 11.326* (p &lt; .005)</td>
<td></td>
</tr>
</tbody>
</table>

The measure of Game Theory Terms does show statistical significance, and we conclude that the mean change in the number of game theory terms is different for the three treatment groups.

Table 3 indicates that the mean change for the concept map group is higher than for the other two groups. Regarding the question of whether students would process ideas from the reading, out of the class, zero students included references to the tragedy of the commons or ecological issues during the pre-assessment, and eight students included such concepts in the post-assessment.

These students were distributed across the treatment groups as illustrated in table 4.

Table: 4
Proportion of students providing concepts related to the reading, by treatment group

<table>
<thead>
<tr>
<th>Measure</th>
<th>Treatment 1</th>
<th>Treatment 2</th>
<th>Treatment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concept Maps</td>
<td>0.29</td>
<td>0.25</td>
<td>0.57</td>
</tr>
<tr>
<td>TV Commercials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wikis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unlike the changes in concepts, the wiki group was most likely to reference key ideas from the readings, although the Chi-Square analysis (chi^2=1.94, p =0.381) does not provide evidence for a statistically significant difference in group proportions.
Comparison of means between female and male students by the use of the two sample t-test showed no statistical significance difference in means between the groups in all areas. Other measures based on demographic or disposition data proved problematic due to the amount of diversity in the student group resulting in small sample sizes, frequently as small as one or two students in a group.

**DISCUSSION**

Since the pre- and post-assessment measures were concept maps, it is expected that the concept map treatment would produce the greatest improvement in comparison to the other two treatments. Group 1, which received the concept map treatment, did see the greatest improvement in mean scores in all areas and greatest final scores in all areas except the number of social issues.

Group 3, which received the wiki treatment, did reference the reading with higher frequency. With a small sample size, even large differences might not be statistically significant.

In the measure of number of game theory terms, the mean difference was strong enough to measure as statistically significant, with a higher difference seen in Group 1 and a minor difference seen in Group 2. This result is not surprising, since the group required to make a concept map had time to discuss and organize the game theory concepts.

The wiki group, Group 3, too were required to provide a broad base of information, but the commercial group, Group 2, generally focused on one key concept. The measure of the number of social issues, on the other hand, showed the least difference between the groups.

Group 1 showed the greatest increase, but did not catch up to the mean final measure of either Group 2 or Group 3. We speculate that social issues resonate with students more, and thus are more easily recalled compared to more abstract or technical terminology.

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**Table: 5**

Qualitative measure of connections between issues, pre/post-assessment and difference, mean and standard deviations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre/Post/Change</th>
<th>Treatment 1 Concept Maps</th>
<th>Treatment 2 TV Commercial</th>
<th>Treatment 3 Wiki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connections</td>
<td>Pre-assessment</td>
<td>1.29 (0.49)</td>
<td>1.63 (1.06)</td>
<td>1.86 (0.90)</td>
</tr>
<tr>
<td></td>
<td>Post-assessment</td>
<td>2.86 (0.90)</td>
<td>1.63 (0.74)</td>
<td>2.14 (1.21)</td>
</tr>
<tr>
<td></td>
<td>Change</td>
<td>1.57 (0.98)</td>
<td>0.00 (1.31)</td>
<td>0.29 (1.50)</td>
</tr>
</tbody>
</table>

Kruskal-Wallis Test is not conclusive at the 0.05 level of significance ($H = 5.418, p = .0669$)
Although the students in the Commercial group did not show much improvement on the concept map measures, they did show considerable enthusiasm for the activity and returned to class excited and energized. The groups asked to work on the concept map showed the least enthusiasm. We speculate that the amount of time, much more than normally assigned to concept mapping, and isolation of the groups during the activities may have led to the lack of energy. In the class period following the activity day, students in the class were polled in a non-scientific fashion about the topics. The class showed a large majority positive response toward the wiki project and commercial project, but expressed the opinion that they would not want to participate in the concept map project. There was one exception, one of the students in the activity observed that he appreciated the amount he learned during the activity.

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