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USING CONCEPT MAPS AS A TOOL FOR CURRICULUM PLANNING AND STUDENT ASSESSMENT IN CULTURALLY DIVERSE SCHOOLS[1]

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Abstract Recent science and teacher education reports continue to stress the need for radical changes in the way teachers are prepared to teach science to diverse learners. In response, we developed a three-year intervention project to help teachers in culturally diverse schools transform their science teaching practices using learning technologies. A key component of this project was the use of concept maps as tools for collaboratively planning inquiry-based and culturally relevant science units with the participating grades 4 through 6 teachers. Versions of the same unit concept maps were also used as assessment tools to measure students' cognitive growth. All participating teachers stated that they gained new science knowledge and skills, as well as increased proficiency in the use of instructional technologies. In addition, all of them found the use concept maps as curriculum-planning tools very useful for helping them better organize the units and for making the science content more relevant and engaging for their students. Most students also showed significant knowledge growth on the pre- and post instruction concept map tests and expressed that they prefer these forms of tests instead of the traditional multiple-choice assessments.

1 Concept Mapping and Sociotransformative Constructivism

Various education reform reports and commissions continue to stress the need for radical changes in the way teachers are prepared to teach science to diverse learners. In response to these calls for reform, we implemented a three-year, professional development research project, *Integrating Instructional Technology with Science Education (I²TechSciE)*, with grades 4 through 6 teachers. A key component of this study was the use of concept maps (Novak & Gowin, 1984) as tools to assist teachers plan and implement inquiry-based and culturally relevant instructional units. After conducting a review of studies that used concept maps for student assessment, Shavelson, Lang, and Lewin (1993) found about 128 variations in concept-mapping techniques. Keeping this in mind, we also took into account that that this was the first time that participating teachers and their students had ever been exposed to concept maps. Thus, we decided to provide them with fill-in-the-blank semi-structured maps. These maps were collaboratively developed with the teachers in order to make them relevant to the required science standards. For example, one of the units for the grade 5-science curriculum in California is on the cell structure and function, and teachers may take between 6 or more weeks to cover it. Figure 1 illustrates an example of a unit concept map test. As it can be observed, our approach involved providing students with the key topics to be covered and requiring them to generate as many hierarchical (linking) connections and to write their responses as fully as possible.

We believe that by developing the unit concept maps with the teachers we could help them take a more holistic and student-centered approach to their pedagogy, and at the same time identify the areas in which they needed the most assistance for integrating learning technologies and for making the content more culturally and socially relevant. In fact, it has been well documented in the literature that elementary teachers often feel unprepared to teach science and much less prepared to engage students in inquiry-based, student-centered activities using learning technologies (Weiss, Banilower, McMahon, & Smith, 2001).

It has also been well documented that teachers often feel ill prepared to address the linguistic and cultural diversity of their students (Rodriguez & Kitchen, 2005). To better assist the participating teachers meet these challenges; our study was guided by sociotransformative constructivism (sTc). Sociotransformative constructivism is an approach to teaching and learning that merges the core tenets from multicultural education (as a theory social justice) with those of sociocultural constructivism (as a theory learning) [Rodriguez, 2005, 2002, 1998]. In order words, sTc focuses not only on preparing teachers to conduct student-centered, hands-on, minds-on, inquiry-based activities, but it also encourages teachers to engage in the critical discussion of how these pedagogical approaches can be linked to social justice and multicultural issues. In addition, sTc encourages the critical analysis of how science knowledge is produced and reproduced, and how those in power determine what's worth learning (more

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information in sTc, examples of lessons plans and other activities are provided in the project's web site: www.edweb.sdsu/i2techscie).

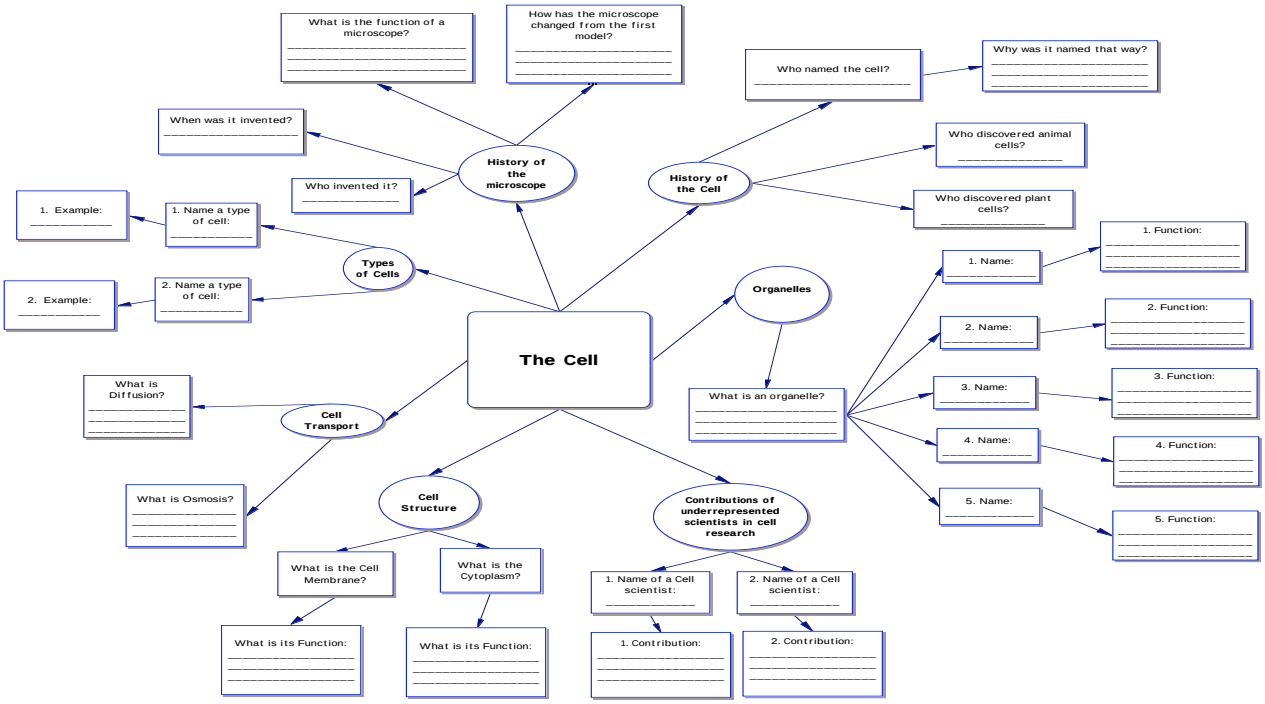

Figure 1 An example of one of the unit concept map tests used in grade 5.

2 Concept Maps as Student Assessment Tools

Another key goal of the I2TechSciE Project was to assess what the students already knew about the topics to be covered in the science unit and then to measure their knowledge growth after instruction using sTc pedagogical approaches and learning technologies. Given the context of our study, our focus on an sTc orientation to teaching and learning, and the teachers and students' inexperience with concept mapping, we decided that pre- and post-instruction semi structured, fill-in-the-blank concept maps were the most appropriate choice. Zeilik, Schau, Mattern, Hall, Teague, & Bisard (1997), for instance, have made extensive use of a select-and-fill-in concept map approach at the college level with astronomy students. The select-and-fill-in approach to concept mapping is similar to a multiple-choice test, with the difference that each map, arguably, measures connected and hierarchical understanding. The instructors also scored these maps. They used a rubric in the way that teachers use an answer sheet to grade multiple-choice tests.

Because the students also had the freedom to write their responses in the designated boxes and/or to generate and make as many connections as they deemed appropriate, it was essential that a scoring rubric be developed by including the teachers' voices in the process. This is particularly important when one takes into account that teaching is dependent on many factors and that some topics may not be covered as thoroughly as planned. Thus our scoring rubric was related to the content covered and to the fact that the class included more than just content knowledge.

In short, the following research questions are the focus for this component of the larger three-year study: I. How does the use of concept maps as curriculum planning tools impact teachers' feelings of preparedness to teach science in inquiry-based and culturally relevant ways using learning technologies? II. How do students respond to the use of concept maps as alternate assessment tools? III. What do pre- and post instruction concept maps and the students' focus group interviews reveal about the effectiveness of concept maps for measuring students' academic achievement?

3 Participants and Methodology

I^2TechSciE includes all the grade 4, 5, and 6 teachers at one elementary, urban school located in the Pacific Southwest. Of the 10 teachers involved, there are 2 Latinas, 3 Latinos, 1 Anglo male, and 4 Anglo females. One of the teachers has fifteen years of experience, but most of the participating teachers have been teaching for four to eight years. Only one has two years of teaching experience.

The student population consists of 56.5% Latino/a, 18.8% Anglo, 5.6% African, 0.6% First Nations, 2.6% Asian, and 16% Other. On average, 37% of the students participate in the free lunch program, and 37% of all students are classified as English Language Learners. During the first year of the project, a representative cohort of twelve students was selected from each grade 4, 5 and 6 classrooms. Each year, the I^2TechSciE students in the cohort groups are placed in classrooms with project teachers to maintain continuity and to explore the impact of the project on students' learning.

Two unique aspects of this intervention project are its longitudinal design and the *responsive, on-going, and on-site support* the research team offers (Rodriguez & Zozakiewicz, 2005). Each summer a two-week summer institute is provided, which is collaboratively designed with the participants and focused upon meeting their professional needs. We also conduct activities that model how to make the science curriculum units multicultural, inquiry-based and hands-on/minds-on (or sTc) using learning technologies. In addition, teachers participate in monthly meetings to discuss progress with colleagues and continue professional development opportunities.

Quantitative analysis of the concept maps consist of carrying out dependent *t* tests for each set following an approach similar to that used by Zeilik et al. (1997) and many others. Using answer key rubrics collaboratively developed with the teachers, each concept map was independently scored by two or three raters with an interrater reliability of at least 90%.

Qualitative analyses of two ethnographic interviews are conducted with each teacher each year, as well as two same-gender, focus group interviews with students (up to 12 total) per grade per year. Other multiple data sets are being collected throughout the project including: videos of lessons and monthly meetings, student artifacts, lesson plans, field notes, district documents, and various school assessments. Using an ethnographic approach to data analysis (Lincoln & Guba, 1985; Spradley, 1979), all interviews, videotapes, transcripts and field notes were read several times by members of the research team. As themes surfaced, their strength and validity were determined by triangulating emerging claims across various data sets (Erickson, 1986).

4 Key Findings

Analysis of all data sets gathered during the first two years of the project strongly demonstrate that all participating teachers gained new science knowledge and skills, as well as increased proficiency in the use of instructional technologies. In addition, all of them found the use concept maps as curriculum planning tools very useful for helping them organize and structure the science units in order to make them more relevant and interesting to the students. As Ricardo, one of the Latino, Grade 6 teachers shared,

> I think we are ending the year on a good note leading into next year, where it's, we're kind of having a real good foundation, or idea for how to start laying out these units, you know. Like you said, starting with the large concept map, and then just breaking those up, presenting to the kids, thinking of activities that we can do for each one [each topic]. And like I said, the possibilities with the equipment are unbelievable (Ricardo, Interview 2, Year I, 11).

It is important to note that Ricardo revealed during the first interview that he did not feel prepared to teach science and that he did not feel comfortable with using learning technologies. After participating in this project for the last two years, Ricardo has become one of the teachers that most often use the project's wireless laptop computer cart and other equipment to teach science every week.

Another participant, Becky, an experienced Anglo teacher who often taught grade 5 science, expressed how the collaborative planning with unit concept maps helped her:

> It's been great having the extra help and having just the ideas when we brainstormed the other day and talked about how to do these different projects. It makes such a difference (Becky, Interview 2,Year I, 1).

Finally, Aaron, an Anglo male teacher, explained his perspective on the use of concept maps as a planning tool during our planning sessions:

> I like the concept maps. They are great for me in terms of just even organizing myself and I think it is great to have a pre and post because I like to have something to compare at the end (Aaron, Interview 2, Year I, 4).

Even though we found that there was some uneven implementation by the teachers in terms of making the science units more culturally and socially relevant using learning technologies as planned, it was obvious that by the end of year II for the most part the participating teachers were more confident with the subject matter, with the use of learning technologies, and with collaborative planning to "help students see the big picture."

Quantitative analysis (*t* tests) of the students' pre- and post unit concept maps showed significant knowledge growth across grade levels for all the units we tested (i.e. Plate Tectonics, Grade 6; Cell Structure and Function, Grade 5; and Living Things, Grade 4). We were not surprised to find consistently strong indication of students' knowledge growth across grade levels ($p < 0.005$). After all, the concept maps we designed with the teachers mainly measure straight knowledge recall, and they do not do justice to the deeper knowledge students acquired through the variety of inquiry-based activities they carried out using learning technologies. This was evident to us as the students created digital photo slide shows, power points, i-Movies, concept maps, and various of products to show what they learned (this can be better ascertained by visiting the project's website at www.edweb.sdsu.edu/i2techscie). In any case, in regard to the semi-structured concept maps, we were more curious to know how upper elementary school students responded to this tool as an alternate form of assessment (as oppose to the traditional multiple-choice tests). Our focus group interviews consistently revealed that most of the students (80%) preferred the concept maps as a unit test. A grade 6-student explains,

> I think this is a better way to learn 'cause it cuts it right down to the point, like, first theory of the plates then you write your answer then type of the tectonic plates and then you have the definition all the way down to the picture and it's pretty simple to do because, like, before when we did the pre-test, we didn't know hardly anything and then once we learned it and we got it back we, like, snapped back into it, we knew everything or at least we were supposed to.

This and many other students indicated that being able "to see" the various key concepts they covered in class and how these concepts connected to other terms helped them write their responses. Out of the 20% of students who did not like the concept maps as an assessment, most of them stated that they preferred multiple-choice tests because they had a chance of "guessing the answer." Others students seemed to prefer multiple-choice tests because they "dislike writing."

Detailed analyses of Year III interviews and students' concept maps are currently being conducted in order to better assess the overall impact of the project on the participating teachers' practice and on the students' learning. We hope the insights gathered from this study will add to the knowledge base on the use of concept maps for enhancing learning and professional development in culturally diverse schools.

5 Some Key References

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