Examining High School Students' Learning from Collaborative Projects Related to Alternative Energy

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Abstract: Constructivist learning theory is used to examine students' individual understandings from a collaborative science-writing project on alternative energies supported by Web 2.0 technologies. We examine how high school chemistry students (n=30) make sense of alternative energy constructs through analyzing changes in pre- and post-intervention concept maps. Through statistical and structural analysis of their concept maps, we investigate changes in the students' understandings about alternative energy. Our findings suggest that students increased their knowledge about alternative energies at different levels, reflecting both surface and deep learning of related environmental education concepts, as well as creating strong connections between concepts related to safety, costs, and health for different types of alternative energy. In addition, student elaboration increased for all energy types, suggesting that the jigsaw pedagogy was successful in improving individual understandings.

Introduction

Learning sciences research has taken a fruitful line of work to provide students engaging in collaborative projects with technologies to support their thinking and learning (Stahl, Koschmann, Suthers, 2006). Our work is situated in the effort to support learners with educational technologies as they participate in science practices with a goal of understanding how students use Web 2.0 tools as they collaborate to make sense of complex scientific topics. However, within school settings, the collective learning that occurs in classrooms is still often measured on an individual basis (Sawyer, 2006). Therefore, although knowledge is constructed through negotiation of meaning within the group, the individual's understandings are of great importance. For this paper, we analyze how a collaborative unit on in two high school classrooms that uses wikis, social book marking, and podcasts can support individuals' meaning making about alternative energies.

Conceptual Framework

Our work adopts a constructivist approach to learning: learning is the individual's process of building knowledge and skills based on their social interactions (Pena-Shaf & Nicholls, 2004; Sharples, Taylor, & Vavoula, 2005). In accordance with Vygotsky (1978), we view the process of construction of knowledge as containing both individual and social practices (Scardamalia & Bereiter, 2006). This constructivist approach connects individual learning to the negotiation and understandings of the meanings within the group environment (Jonassen, Davidson, Collins, Campbell, & Bannan Haag, 1995).

Our focus is on understanding learners' outcomes: the ways in which individuals made meaning from the group learning experience (Sawyer, 2006). To understand student sense making about alternative energies, we employed qualitative and quantitative analyses of pre- and post-concept maps (Hay, Wells, & Kinchin, 2008). Students used concept maps to place their ideas about topics into nodes, and then the students were asked to connect nodes using lines (annotated with linking terms) showing relationships between the concepts (Novak, 1990). Researchers (Hay, Wells, & Kinchin; Novak & Canas, 2008) have shown that repeated use of concept mapping about the same topic provides the researcher data about prior knowledge; learners are integrating new concepts into prior understandings, and making evident changes in connections that students see about concepts through changes in the map structures (Hay, 2007; Hay, Kinchin, & Lygo-Baker, 2008). Through analyzing how students arrange the nodes into structures such as spoke, chain, and network representations (Kinchin, Hay, & Adams, 2000), students make visible their understanding of the concepts and provide insight into how they made sense of the newly learned materials (Jonassen, Reeves, Hong, Harvey, & Peters, 1997). Categories commonly used to describe the meaning making observed on concept maps (Hay, Kinchin, & Lygo-Baker) include non-learning, surface learning, and deep learning (See Table 1).

In this analysis, we answer the question: How does the breadth and depth of high school students' individual understandings about alternative energy resources change following their participation in an online collaborative learning project in a high school chemistry class? While we conducted both qualitative and quantitative analyses, only the quantitative results related to meaning making are shared due to space limitations.

Table 1: Levels of learning demonstrated on concept maps (based on Hay, Kinchin, & Lygo-Baker, 2008)

Learning	Changes on concept map	Interpretation

Non-learning	No changes to the structure occur.	No new learning - prior knowledge is repeated.
Surface learning	Some concept nodes can be eliminated. New concept nodes are added but not connected or linked to the prior knowledge concepts, or chains of concepts are formed.	Students have adopted new concepts but have not connected these to prior knowledge. Elaboration of concepts via simple chains shows sequentially structured information has been added. Considered rote learning.
Deep learning	Concept nodes are added to the map and linked to the prior concept nodes and/or each other. This can occur as elaborated spokes or networks.	Integration of new concepts as well as significant elaboration of original concepts with added nodes or levels of hierarchy. Connections across concepts or additional links are created. Considered meaningful learning.

Alternative energy unit

This study occurred in two rural high school chemistry classrooms using 1 to 1 laptop computing. Students (n=30) completed a Web 2.0 technology project that focused on argumentation as a means of acquiring content knowledge (Zohar & Nemet, 2002), related to the strengths and weakness of forms of alternative energies. The students, aged 15 to 17, developed an online wiki resource for each other about alternative energy. Learners used the wiki pages to create persuasive podcasts for a fictitious scenario: to sway the town council to vote for an alternative energy plant to be built in their local community. Alternative energies covered in the unit were biomass, solar, wind, geothermal, hydroelectric, and nuclear power. Jigsaw pedagogy (Aronson, 1978; Brown, 1994) was used: the students were placed into small groups to each create a wiki page about one alternative energy resource; podcasts were created for a second resource. All students were responsible for understanding information about every type of energy resource. Computer-supported collaborative learning occurred within this unit both asynchronously across two classrooms and synchronously within the classrooms.

Before and after the unit, concept maps were created by each individual student using the same focusing question (Novak & Canas, 2007): "What do you know about different types of alternative energy resources that would allow you to make an informed decision about their use in your community?" These maps were used as an assessment of individual understanding and meaning making about alternative energies.

Methodology

We conducted a three-week video-based case study focused on the role of Web 2.0 technologies in supporting high school students' engagement in argumentation. In this paper, we present the statistical and structure analyses from students' pre- and post-concept maps from two high school chemistry classes (n=30). These analyses allow for comparison of prior knowledge and new knowledge as well as the meaning making that occurred (or did not occur) demonstrated by changes in concept maps (Hay, Kinchin, Lygo-Baker, 2008; Novak & Canas, 2008). Data collected for the project included: 1) video-podcasts, 2) social bookmarking records, 3) student constructed wiki pages, 4) questionnaires, 5) interviews, 6) pre- and post-concept maps, and 7) 3-weeks of daily video-recordings. Our strategy provides reliability for the overall study through triangulation of data.

For this analysis, we focus on individual meaning making through changes on the pre- and post-intervention concept maps. To address reliability of the coding, a key was constructed with examples and definitions (see Table 2). The first author coded all concept maps. An independent researcher coded approximately 20% of the maps and discussed differences until consensus was reached. We conducted two analyses: a statistical analysis of the pre- and post-concept map counts and a qualitative analysis of structure. The concept maps were coded for organization: number of nodes, hierarchy, connections, annotations, and branches. During the construction of the wiki pages, students chose topics that they felt were central to understanding how alternative energy plants would impact their community; these were used as coding categories as well: types of energy; safety of energy; cost to community and/or individuals; impacts to the geographic region and community space; and impacts to community and human health (see Figure 1 for a sample coded map). In addition, we also analyzed changes in connection structures (spoke, chain, network) within each pair of maps (Hay, Kinchin, Lygo-Baker, 2008); each map was evaluated for the level of learning (non, surface, or deep) and was assigned a value (1, 2, 3). The counts for each coding category were entered into Minitab statistical software and analyzed using a paired T-Test.

Table 2: Coding/counting scheme for several categories used in analysis of the concept maps.

Code	Definitions
Nodes	Number of nodes created; this is a proxy for the number of ideas the student understands.
Levels	Hierarchy of the map – the number of levels of nodes (where the first level is linked to the center node); this is a proxy for the student's connections and conceptual integration.

Types	Types of alternative energy resources that are listed. Types studied in this unit are hydroelectric, wind, solar, nuclear, biomass, and geothermal.

Findings and Results

Of the coding categories, “safety”, “geography/space”, “costs”, and “health” were found to have significant changes at a $p < 0.05$ level in the post-intervention map (See Table 3). Students used these organizing topics from the wiki, as well as specific related details about them, in their maps showing that these ideas were incorporated into their knowledge structure. This indicates an increase in student understanding of the social and scientific issues involved in communities adopting alternative energies. The structural differences in the maps indicate changes in the individual student’s meaning making (Hay, Kinchin, Lygo-Baker, 2008). Only 4 map sets were identified as non-learning based on lack of changes in the structure; all other maps showed evidence of representation changes that indicate either surface or deep learning through elaboration of concepts and complexity of the new map structure. Although few linking words or connections across maps were observed, the number of ideas (nodes) added in complex chain and spoke structures provided evidence of change in level of learning. A paired T-test was used to examine the assigned scores for changes in level of learning, which was significant at a $p < 0.05$ level (Table 3).

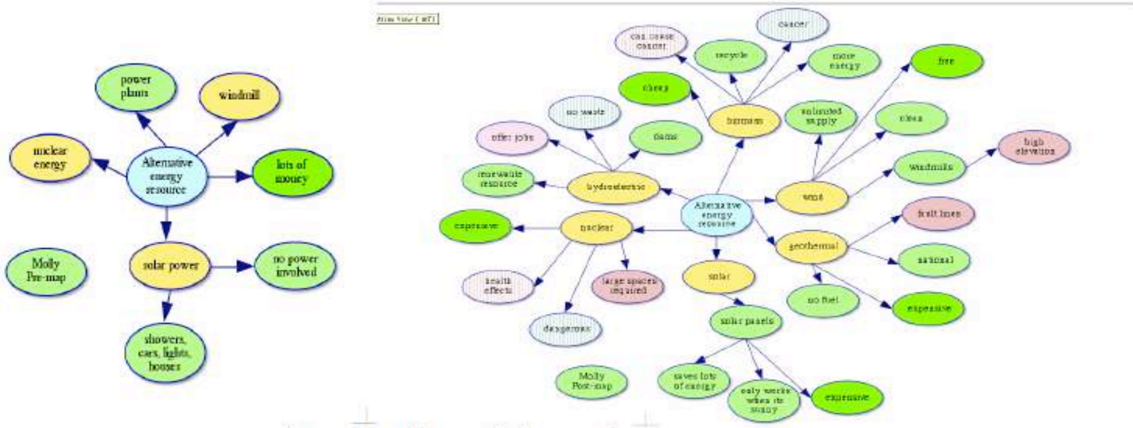

Figure 1: Molly’s coded pre- and post-concept maps

Statistical analysis indicates that student knowledge of alternative energy concepts has changed in breadth and depth over the course of this unit. The number of nodes, or ideas, and hierarchy of levels increased significantly; increases in these factors show significant elaboration within the post-intervention map, indicating that learning has occurred (Hay, 2007; Novak & Canas, 2008). The number of types of energy that were identified by students on their post-maps increased significantly from a mean of 3.367 to 5.033 types. In addition to the structural changes in the maps, ideas (nodes) added show that the number and type of terms students’ used to describe alternative energies increased on their post-concept map. These changes in breadth of learning through the greater number of energies that students chose to include on the map indicate increased learning at a deeper level. Through student display of content related to all types of energy on the maps, not only the topics assigned to their groups, our analysis indicates the jigsaw pedagogy was successful in providing supporting meaningful learning about all topics.

Table 3: Coding categories with differences in pre- and post-concept maps at a statistically significant level

Code	Pre-intervention		Post-intervention		Significance p-value
	Mean	St. Dev.	Mean	St. Dev.	
Node quantity	9.27	4.93	18.47	7.93	p = 0.000
Levels of node connections	1.967	0.615	2.500	0.820	p = 0.003
Energy types	3.367	1.159	5.033	1.542	p = 0.000
Safety of energies	0.567	0.971	1.333	1.446	p = 0.011
Costs of energies	0.800	1.186	2.867	1.871	p = 0.000
Geography/space impacts	0.733	1.596	1.667	2.187	p = 0.019
Health impacts from of energies	0.133	0.434	2.100	2.155	p = 0.000
Changes in learning via structure	1.400	0.563	2.533	0.730	p = 0.000

Conclusion

With a focus on collaborative work in classrooms (Sawyer, 2006), understanding how individuals make sense of group knowledge building experiences is an important line of research. We showed that concept maps are a tool that can assist researchers and educators in this area. Students used the pre- and post-intervention concept maps as tools to make their individual understandings of alternative energy visible. Analysis of the map structures and alignment with levels of learning (Hay, Kinchin, Lygo-Baker, 2008) allowed us to understand how students were creating connections to prior knowledge and individually making sense of the group learning experience. Future research can examine how these structural changes can assist in differentiating instruction within the collaborative projects to better support individual learning.

We investigated student meaning making from participation in a collaborative wiki and podcast project through analyses of pre- and post-intervention concept maps. The statistical analysis indicates that students learned about all types of energy in this project. They increased the breadth (number of ideas about alternative energies) and the depth of understanding (expanding the ideas they had by connecting and reorganizing their concepts) at a statistically significant level, indicating that individual students adopted content from both the energy topics for which their groups specifically built resources as well as for those alternative energies that the others in the class created within the jigsaw pedagogy (Aronson, 1978). Research can focus on design principles to support making connections between segments of projects in which students are not directly involved.

Also, we found that using the student-created artifacts (i.e., the wikis) to develop the qualitative coding scheme for the maps allowed us to understand the development of ideas from the social to the individual level. Future research can go more in-depth into the qualitative analysis of concept maps to assess the nuanced details of individual meaning constructed through collaborative projects, connecting ideas from the in-classroom discourse and computer supported discourse.

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