Energy as a Unifying Concept in Science Teaching: Results from a Hybrid (Online/Onsite) Course for Middle School Science Teachers

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Abstract

Energy is an overarching concept in science teaching that should be a common strand throughout the life, physical, and earth sciences. During their undergraduate training, however, science teachers are usually taught in disconnected science courses focusing on specific content areas and energy may be taught solely within the context of each course. This may cause teachers to form misconceptions about energy, conceptualizing it as an incoherent and fragmented entity within and across different areas of science. This presentation will share the development and results of a hybrid-based (online/onsite) professional development course that promoted the effective implementation of energy as a unifying concept for middle school science classrooms. Course participants attended onsite, face-to-face meetings for hands-on, inquiry-based interactions regarding energy content and effective pedagogy. The onsite meetings were supplemented by online modules which allowed the participants to continue their learning offsite at their own convenience. Each weekly module involved professional development videos from Annenberg Media, short textbook readings, supplemental readings, interactive web simulations, a content quiz, and a discussion board forum. Prior to the first class, all participants were given the Energy Concept Inventory as a pretest. The course sequence followed several important concepts relating to energy such as transfer, conservation, force, work, cycles, efficiency, and flow (including life/ecological) within and between systems. Posttest scores using the ECI showed an increase in test scores for all thirteen participants ranging from 27-80% with an average increase of 45%. The posttest also showed an average increase in scores for each individual test item ranging from 23.1-84.6% with an average increase of 43% per item. Researchers found the hybrid course model to be both effective and popular with participants.

Keywords: Hybrid course, online, energy education, professional development
Introduction

In the past decade, energy awareness, conservation, and independence have re-emerged as a national concern. It is vitally important that students have a conceptual understanding of energy and how their choices affect these issues on local, national, and global scales. Toward that goal, many states are beginning to infuse energy education into their K-12 curricula. In spring 2011, U.S. Department of Energy Secretary, Steven Chu; U.S. Department of Education Secretary, Arne Duncan; and Francis Eberle, Executive Director of the National Science Teachers Association (NSTA) presented America’s Home Energy Education Challenge, a new energy education program. This initiative is designed to educate students about the essential concepts of energy, energy efficiency, and how to play an active role in their families’ energy use of energy (USDOE, 2011). However, effective energy awareness may be a difficult endeavor unless the general public has a fundamental knowledge regarding the indirectly observed quantity we identify as energy.

The phenomenon of energy is a concept that is often difficult to understand because it can be interpreted different ways in various contexts both in and out of the classroom via ambiguous terms and definitions (Bauman, 1992). As a result, many studies show that students from a range of grade levels have many fundamental misconceptions about energy and related concepts (Beynon, 1990; Meltzer, 2004; Se-Yuen & Young, 1987; Seoung-Hey, Boo-Kyung, & Go, 2007; Slone, Tredoux, & Bokhorst, 1990; Sozbilir, 2003). Without a firm conceptual understanding of important concepts and their interconnectedness, it will be quite difficult to create students, and ultimately citizens, who are scientifically literate regarding such important natural phenomena and socioscientific issues (Kolsto, 2001). Therefore, it is of great importance the concept of energy be correctly taught throughout the sciences as a unifying concept without causing the
misconception that it exists “in different forms” in various contexts. As a result, we created and tested the influence of a hybrid course on preservice and inservice teachers’ knowledge of major energy concepts. With the benefits of combining the onsite and online aspects of the course, the teachers had the opportunity to gain understanding about the topics in a combination of ways. As a result, our research questions became (1) How can we develop a hybrid online/onsite summer course to improve teachers’ conceptual understanding of energy and (2) What are the influences of this course on teachers’ conceptions of energy across content areas?

Theoretical Framework

In order for students, and society in general, to have an effective conceptual understanding of energy, public teacher education and professional development programs must provide teachers with effective training that can help promote conceptual understanding for such key topics. Energy is an overarching concept in science teaching that should be a common strand throughout the life, physical, and earth sciences. During their undergraduate training, however, science teachers are often taught in disconnected science courses focusing on specific content areas and energy may be taught solely within the context of each course. Ultimately, this may cause teachers to continue the misconceptions of energy as an incoherent and fragmented entity within and across different areas of science.

Several studies focus on energy content in teacher development, classroom practice, and student understanding on energy content knowledge. Many studies focus on misconceptions students and teachers have regarding major aspects of energy content (Bauman, 1992; Beynon, 1990; Mak & Young, 1987) while others focus on teachers’ content knowledge, their level of pedagogical content knowledge, and their students’ conceptual understanding (Magnusson, 1992; Trumper, 1997). More recently, the study of student and teacher understanding of energy
content by means of scientific modeling is beginning to expand (Swackhamer & Hestenes, 2005). More research into effective teacher professional development and conceptual understanding of energy content as a unifying concept in physics, chemistry, biology, earth sciences, and societal issues needs to be implemented.

Appropriate preservice and inservice teacher professional development needs to be in place before effective energy education can be implemented in schools to help develop students’ conceptual understanding of energy and related topics (Liarakou, Gavrilakis, & Flouri, 2009; Trumper, 1997). However, one such study has shown that teachers who participate in a summer-long energy education institute were more likely to incorporate energy topics into their existing curricula (Bitner-Corvin, 1983). Another study found that teachers who participated in one-day workshop could result in positive changes in teachers’ knowledge and attitudes toward energy activities (Dunlop & Fazio, 1981). There seems to be an urgent need for new programs and updated research in science education regarding both energy content awareness and how it can affect societal actions. This paper will focus on an intensive, six-week, master’s level course taught in a hybrid format that focused on energy as a unifying and necessary integrated topic in the middle school science classroom.

The Participants

This master’s level course consisted of thirteen preservice and inservice teachers as shown in Table 1. Eight of the teachers in the class were in a middle school MAT, transition-to-teaching program. Three of the MAT students had spent a year as provisionally certified teachers in their own science classrooms. The remaining five were completing their degrees/certification before taking teaching positions. Five of the class participants were had already completed teacher certification requirements with undergraduate teaching degrees, and
were currently in a program for MA. Ed. Three of those five students were considered inservice teachers, having been in their own classrooms (average of five years). The remaining two MA Ed participants were still considered preservice because they had yet to become classroom teachers. Two of the thirteen participants were elementary certified (grades K-5) and were completing MA Ed degrees to become certified to teach science in the middle school (grades 5-9).

Table 1  
Description of Master’s Level Participants

<table>
<thead>
<tr>
<th>Participant</th>
<th>Program</th>
<th>Description</th>
<th>Participant Description</th>
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<tbody>
<tr>
<td>Steve</td>
<td>Pre-MAT</td>
<td>Preservice</td>
<td></td>
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<td>Pre-MAT</td>
<td>Preservice</td>
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<tr>
<td>Sherry</td>
<td>Post-MAT</td>
<td>Post-ST ELE certification</td>
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<td>Katy</td>
<td>MA Ed</td>
<td>MA Ed, MS science extension</td>
<td>Preservice Post-MAT</td>
</tr>
<tr>
<td>Charlie</td>
<td>MAT</td>
<td>Post provisional certification Pre-MAT</td>
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</tr>
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<td>MAT</td>
<td>Preservice Post MAT</td>
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<td>Anita</td>
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<td>Post-provisional certification BS ELE</td>
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<tr>
<td>Sheila</td>
<td>Rank I</td>
<td>5-yr ELE experience  MA Ed science extension</td>
<td></td>
</tr>
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<td>MAT</td>
<td>Post-MAT Post-provisional certification</td>
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<td>Jerry</td>
<td>MA Ed</td>
<td>MA Ed, MS science 4-yr MS experience ELE certification</td>
<td></td>
</tr>
<tr>
<td>Jesse</td>
<td>MA Ed</td>
<td>MA Ed MS science extension</td>
<td></td>
</tr>
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<td>Fannie</td>
<td>Rank I</td>
<td>MS science Rank I</td>
<td></td>
</tr>
<tr>
<td>Freddie</td>
<td>MAT</td>
<td>Post provisional certification</td>
<td></td>
</tr>
</tbody>
</table>

*MAT (currently in MAT program); Pre-MAT (beginning MAT program); Post-MAT (completed MAT program); MA Ed (master of arts in education); Rank I (30+ post master’s degree); Preservice (no formal classroom experience);*
The Intervention

The Energy as a Unifying Concept in Science Teaching course was designed as a hybrid course (insert a couple references about hybrid courses). Each aspect, both the onsite and online, served not as complements of one another, but the overall purpose was for the whole to create an experience more beneficial than the two parts alone.

Onsite Aspect of Course. This course was designed to introduce the preservice and inservice teachers to several aspects of the overarching concept of energy and how it is an essential common thread throughout the physical, earth/space, and life sciences. In addition, the course related the concepts to socioscientific issues relating to several aspects of energy.

The special topics hybrid course was designed to meet onsite a total of six times during a summer session at a regional university. It met each of the six Fridays for 4.5 hours. Each class meeting involved a hands-on component that immersed participants in inquiry-based activities as related the topics for the week. Ultimately, the main purpose of the onsite aspect of the course was to allow the teachers to experience activities as their own students would in the classroom, in the hopes of helping the teachers build upon their own concepts of various aspects of energy. The course involved mixing types of lessons that included content-level activities for the content knowledge of the teachers. Some activities were completed that were more geared towards conceptual understanding for middle school students. Several of the activities, however, could be considered a challenge to both the teachers and their students if implemented in the classroom. In addition to the immersion of the teachers into the science concepts, time was given to debrief after each lesson, thus allowing the class to reflect on the nature of the lesson itself, the content, and the pedagogical strategies that were used.
Each class meeting was designed around a theme or set of themes taken from the Annenberg Media teacher professional development program (2002), and various other course materials (Robertson, 2002).

Online Aspect of the Course. The online aspects of the course were purposefully designed to happen after the onsite meeting relating to those topics. The teachers in the classroom first experienced the concepts both implicitly (participation) and explicitly (debriefing) during their 4.5 hours in the classroom sessions. They then had the week to complete the online individual components (readings from textbook or provided articles, posted videos, supplemental video questions, interactive websites, Blackboard quizzes, and projects as well as the group component (interactive discussion board). It was the intention of the instructors to have the onsite experiences each week before the teachers had from Saturday-Thursday to complete, and participate in, the online aspects.

Each aspect of the online experience served to further the teachers’ knowledge of the topics by extending the experiences in a more informal way by allowing the teachers to complete at home. The professional development videos that were posted (two per week) served as parallel compliments to the course by matching the topics nearly 100%. The videos used interviews with scientists from the hard sciences, interviews from cognitive scientists and science educators, instances of teachers teaching elementary and middle school classrooms, and interviews with adults and children about various aspects of energy—all of which served as extensions to the topics and activities from the previous class meeting. The weekly quizzes were administered via Blackboard and opened on Sunday after the class and closed on Thursday evening. The quizzes were created to measure the participants’ knowledge of the weekly content by addressing concepts from the onsite meeting, the textbook readings, article readings, the
videos. There were two weeks in which online discussion boards were open to provide prompts that encouraged interactions between teachers in various contexts such as looking for relevant examples in daily life, potential applications to the classroom, etc. Overall, the online components were used after the onsite meeting to serve as a way to allow the teachers to extend or apply the concept from class (as opposed to using the online aspects as an introduction before class meetings).

*Professional Development Training.* Part of the next-to-last class meeting (fifth class) involved a PD, Population Connection, hosted by the instructor. The 3-hour workshop consisted of activities from the PC resource curriculum that could connect ideas between local to global population and any relations to various concepts of energy. This workshop allowed the instructor to apply the course content to population concepts and problems. These concepts were then used to implement issues of energy and population in the context of socioscientific issues as a means of promoting scientific literacy (Kolsto, 2001).

The last (sixth) class period was a six-hour PD sponsored and delivered by the NEED Project (http://www.need.org). The guest facilitators delivered a basic NEED workshop that focused on basics of energy education, energy content, energy sources, energy issues in society, classroom projects that could relate to energy concepts, teaching techniques modeled by the presenters, and several free curricular and classroom materials participants could use in their classrooms. Although attendance was mandatory, participants received six-hour PD certificates they could use towards PD requirements required by their school districts. With the exception of the course posttest, the NEED workshop was the last aspect of the course.

Methods
Data Collection

Results from this course will primarily focus on the conceptual understanding of energy content of the participants. First, the participants had to make appointments to visit campus the week before class started to take the Energy Concept Inventory (cite…) as a pretest. The Energy Concept Inventory is a 35 question test that measures several aspects of energy in the physical and life sciences. The test is conceptually based and there is no need for calculations to complete the test items. The course instructors only decided to use 30 of the test questions for measurement. Questions 30, 31, 32, 34, and 35 were omitted from both the pre and posttests because they didn’t relate to the overall content and sequence of the course.

For the purposes of this course, the original ECI was adapted by creating 1.5 inch spaces after each question that required the teachers to provide explanations for the answers they chose for each individual item. If the teachers were unsure of the item, or simply guessed, they were to state that in the response space. There were no time constraints for those taking the test. The same test, with space for teachers’ explanation of answer for items, was given during the week after the final class meeting and all prior assignments were submitted. Just as with the pretest, the posttest required an appointment and the teachers came to campus to take the test on their own time, by appointment. One exception was granted for the posttest for a teacher who drove more than two hours for class. She took the posttest directly following the six-hour NEED Project PD on the last day.

Data Analysis

Data analysis primarily focused on comparing the pre and post scores on the ECI from the summer course. Due to the small number of participants (n=14), only descriptive statistics were used. Two types of quantitative data were measured and will be discussed. Pre and posttest
scores (items correct on the 30-question test) for each participant were analyzed. In addition, each of the 30 items was analyzed by comparing the total correct on both tests. To serve as a means of triangulation, participants’ written responses for test items were used to more richly judge understanding and/or conceptual change for each participant or item when comparing both tests, especially for participants or items that showed larger gains or scores.

Results

Pre/Post Participant Scores

All thirteen teachers completed both the pre and post-tests. As expected, participants fared poorly on several test items due to our findings in the literature regarding the lack of understanding and misconceptions for both children and adults, including teachers. As represented in Table 1, the average number of correct items on the 30 question pretest was 10.92 (SD=4.94) with a range of 4-20. The average score on the posttest increased by nearly 14 items (SD= 3.12) with a range of 17-29. Every participant in the class increased his or her test score during the six-class periods supplemented by online coursework and modules.

Table 2

<table>
<thead>
<tr>
<th>Pretest Score (M)</th>
<th>Posttest Score (M)</th>
<th>Difference (M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(SD)</td>
<td>(SD)</td>
<td>(SD)</td>
</tr>
<tr>
<td>10.92</td>
<td>24.38</td>
<td>13.46</td>
</tr>
<tr>
<td>(4.94)</td>
<td>(3.12)</td>
<td>(4.63)</td>
</tr>
</tbody>
</table>

14 participants, 30 item test

Eleven of the thirteen participants increased their scores by more than ten questions. The largest improvement was by Gwen, a middle school MAT teacher who just completed her first year of teaching middle school math as a provisionally certified teacher. She was scheduled to start teaching science the upcoming year. Gwen not only made a large gain in the number of
correct items on the test, she was also able to elaborate much better on most of the items on the posttest. For example, on Gwen chose the correct answer for question 14 on both tests. The question tells the test taker to imagine a piece of smooth wood and a piece of smooth steel that are both at 0°C Celsius. It then asks what one would feel if she grabbed one in each hand. She chose answer c) “the steel would feel colder than the wood, even though they have the same temperature.” This is the correct answer. However, she wrote that she was unsure about the answer, stating, “Not sure why, but if you stick your tongue to a cold steel beam, it will stick and it won’t to wood.”

Six weeks later, on the posttest, she again chooses item c), the correct answer. However, she is better able to explain it in terms of heat transfer:

- Metal (steel) is a conductor of heat so it would allow the heat from your hand to more quickly travel to your hand, thus making it feel colder.

Question 14 happened to be the only question that everyone got correct on the pretest. However, despite all participants choosing the correct score, most were able to elaborate on the question much more explicitly in terms of heat transfer, conduction, etc.

Another student who made a large gain was Sheila, a first grade teacher seeking a middle school science extension as part of her MA Ed program. She shared on her information sheet that she didn’t necessarily want to teach middle school science. Instead, she wanted to replace the fourth-grade science teacher in her school who would soon be retiring. She would then be teaching science all day as a result of the school’s departmentalized schedule. She received a score of 4/30 on her pretest. She increased her score by 13 points on the posttest.
One example of a question Sheila missed on the pretest but got correct and elaborated much better on was question 5 (coincidentally a question that nearly everyone got wrong on the pretest). The question asks the test taker to imagine having a cold can of soda, a warm sandwich, some aluminum foil, and some wool. It asks which would be the best combination to keep the sandwich warm and the soda cool. The correct answer would be to use the wool for both because it serves as an insulator, thus creating a system to keep heat in or out, based on the situation. Sheila answers the following on the pretest:

Both wool and foil keep most of the current temperature contained. Either one will maintain the desired temperature within a few degrees.

While taking the posttest, Sheila not only chooses the correct answer, she elaborates on the answer fairly well:

The wool blanket serves as an insulator for both items…keeping heat from escaping the sandwich and heat from entering the cold drink. The foil wouldn’t keep the desired temperature. The wool allows the sandwich to stay warm and the drink to stay cool. They will both change temperature somewhat, but for the most part, will remain the desired temperature.

Another example of Sheila showing an improved understanding of energy involves question 20. The question asks the participant to think what happens to the energy used to operate a toaster after the toast is finished toasting. Sheila chooses answer d, “it gradually disappears until none of it remains anywhere”. She elaborates shortly, “Don’t know the answer to this. Maybe the energy is lost.” When answering the same question on the posttest, she correctly picks the correct response, “It still exists in the toast and toaster, around the toaster, and in the air.” She elaborates:
There is still energy in the toast, toaster, and the air. The kinetic energy is now heat energy and some of it transfers to the surroundings.

The smallest increase in score was by Jonathon, a middle school teacher in an MAT program who had just completed his first year as a provisionally certified sixth and seventh grade science teacher. This course was an elective and it was the last in his MAT program. He officially completed his induction year and received teacher certification in the summer just before taking the course. This was mostly due to his earning such a high score on the pretest. One example that shows how Jonathon’s understanding of energy, in this case, heat and transfer, improved. Question 8 gives the scenario of a soccer player’s friend injuring her ankle during practice. The coach removes an “instant cold pack” from the medical kit and asks the participant to punch the pack and she immediately feels it start to get cold. The question ultimately asks what conclusion can be made about why the cold pack quickly gets colder after it is punched. Jonathon responds:

The chemical reaction causes the pack to give off energy as part of the conservation of energy because it is not created but transferred away from the chemicals.

Jonathon does use some appropriate terminology in his response to the question. However, he shows a misconception about the reaction itself and the transfer within the system. When Jonathon takes the posttest, he chooses the correct answer and gives an appropriate elaboration:

The cold pack removes heat energy from the body to continue the endothermic reactions inside the cold pack. The “cold” that the person feels is the actually removal of heat from the body…not due to the “addition of cold.”
As can be observed from Table 3, there was a noticeable gain in overall test scores as measured by the number of correct answers given. In addition to the gain in each individual’s score, the provided examples show a satisfactory increase in participants’ elaborations for a significant number of item responses.

Table 3  
Pre and Post ECI Scores by Participant

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Difference</th>
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</thead>
<tbody>
<tr>
<td>Steve</td>
<td>10</td>
<td>27</td>
<td>17</td>
</tr>
<tr>
<td>Natalie</td>
<td>16</td>
<td>24</td>
<td>8</td>
</tr>
<tr>
<td>Sherry</td>
<td>11</td>
<td>24</td>
<td>13</td>
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<tr>
<td>Katy</td>
<td>9</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Charlie</td>
<td>10</td>
<td>21</td>
<td>11</td>
</tr>
<tr>
<td>Gwen</td>
<td>4</td>
<td>28</td>
<td>24</td>
</tr>
<tr>
<td>Anita</td>
<td>7</td>
<td>25</td>
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<tr>
<td>Sheila</td>
<td>4</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Jonathon</td>
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<td>25</td>
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<tr>
<td>Steve</td>
<td>10</td>
<td>27</td>
<td>17</td>
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</table>

Note: Energy Concept Inventory consists of 30 items

Pre/Post Item Scores

Not only did each class participant increase his or her score on the ECI, there was an overall increase in the number of correct responses for each item individual item as seen in Table 4. In addition to each class participant having increased their total scores by 7-24 points, all items but one saw some type of increase in correct responses between the pre and posttests. The only item that everyone answered correctly on the pretest was question 14. Five of the thirteen responses answered correctly although they only put question marks or wrote “I don’t know” for the explanation. Natalie, a MAT student just entering the program stated, “Not really sure, I just know it feels colder.” This was quite possibly due to everyone having the experience of picking
up wood versus metal in cold temperatures, sitting on wood versus metal bleachers at a sporting event in cold weather, or a host of other things from their everyday experiences. This is further shown as stated in an earlier shared scenario. Gwen related this question to the fact that one’s tongue would stick to metal when it is cold and it wouldn’t do so with wood.

Table 4
Energy Concept Inventory Pre and Post Scores by Item

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Pretest Correct</th>
<th>Posttest Correct</th>
<th>Increase</th>
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30 item test; 14 participants

Also, we feel the number of correct responses for number 14 was increased by the wording of the next question. Question 15 asks for the user to choose an item that is “the best
explanation to the previous question." One of the responses was “Heat goes more quickly from your hand to the steel than it does to the wood.” It seems that having this as one option, in addition to four more for the item gave participants scenarios for which they could apply to the previous question. It is worth pointing out that, although all 13 people got number 14 correct, only six people got number 15, which serves as an explanation for number 14, correct. For example, Anita got question chose the correct answer for number 14, she wrote “not sure” for the reasoning. Then, on number 15, she chose the wrong response for 15, “steel absorbs cold better than wood does.” On the pretest, Steve justifies his correct answer by saying, “The difference would be in the amount of moisture in the material. Wood would have some, steel would not.” Both specifically explain in terms of heat transfer, conductor, and insulator when they took the posttest.

There were several items for which the number of correct responses between the pre and posttests went up substantially. As discussed earlier, item 5, the scenario with insulating the hot sandwich and cold soda using aluminum foil or wool, saw the largest increase. Only two of the fourteen people got that correct on the pretest. Perhaps this was due to experiences many people have in which they wrap a sandwich for lunch in aluminum foil. However, when people wrap sandwiches in foil to take for school or work, they are usually placed in refrigerators a short time after. We assume this could play a small part in the overall misconception the participants had. There were many activities and resulting concepts we covered in the class such as heat transfer, systems, heat versus temperature, insulators, and conductors, among others. Even though this particular question was not address explicitly in the course, all thirteen participants answered correctly on the posttest.
The test item with the second largest increase on the ECI was question 33. It gave a scenario of a small, dorm-sized refrigerator (as shown in a small, cartoon-like illustration) that was open in a dorm room to keep it cool after the air conditioning went out. The question asks what will happen to the temperature of the room if the small refrigerator is left on for the rest of the afternoon. Only one person, Freddie, answered this question correctly. He chose the response that stated that the temperature of the room will increase. He supported his correct item choice by saying, “Releasing heat/energy from the compressor will have a greater effect than cooling.” He was correct in saying so. As a transfer-to-teaching MAT student, Freddie had a professional background in HVAC and restaurant equipment. He had first-hand knowledge and experience regarding how compressors work and how they release large amounts of heat. He didn’t relate this explicitly to energy, however. After the six-week course sequence, Freddie gave a much more content-appropriate response regarding the refrigerator scenario:

There is only energy being input into this closed system…With no output, the increase in total energy would be converted to heat.

A common theme throughout the course was the idea of systems, designing/identifying systems, efficiency, and many related topics. As a result of the many activities and topics from the course, Freddie was able to make the connection that there was only energy coming into the supposed closed system (the room) via an electrical receptacle bringing energy into the refrigerator without any, or negligible, energy leaving the system. The responses of the other eleven participants were basically parallel with Fannie, a veteran science teacher working on graduate hours beyond her master’s degree. She stated:

The refrigerator may decrease the temperature of the room, but it is too small to produce enough cold to cool such a large room.
Several people made the assumption that the room would get cooler to some degree, yet the device was too small to actually have an effect. In fact, several of the responses used terminology relating to “producing cool air.” Fannie’s answer changed somewhat on the posttest by speaking in terms of a defined system. She stated:

The compressor in the refrigerator produces heat as a result of cooling air in the room.

With no way for this heat to escape the room (closed system), the room will become warmer.

Although she didn’t mention there was some form of energy actually coming into the room that was increasing the total input, as Freddie did, she still connected her response to the idea of a closed system and did not refer to the misconception of “producing cold.”

Discussion

In investigating our primary research question regarding the influence of this hybrid onsite/online summer course on the participants’ overall conceptual understanding of various aspects of energy content, we found that teachers gained in their understanding of energy content by overcoming some of their prior misconceptions based on the administration and evaluation of their 30-question version of the Energy Concept Inventory scores. Not only did each teacher increase his or her score by a minimum of seven questions on the test, the class collectively increased the number of correct items by 13.46, or 44.8%. This is evident by comparison of the pre and post-scores on the test, along with the explanations each participant provided on both versions. In theory, the participants did not use the pretest to increase their scores on the posttest. Each individual made appointments to come take the test on campus. No one took the test as the same time as another participant. Upon arrival to campus, each participant was told the pretest simply was a way to measure their prior understanding of the content to inform the
teacher about the group’s collective understanding before the summer class started. They were not told, in any manner, that the posttest was going to be the actual pretest they would take more than six weeks later. We feel that it is safe to say the primary reason for increase in participants’ own individual scores, along with the positive increases in the item scores, could be very highly correlated to the design, content, and delivery of the hybrid course.

Course Evaluations

The instructor found this hybrid model of teacher professional development, delivered as a master’s level course, to be beneficial because it allowed the participants from many different areas, backgrounds, and experiences to interact both online and onsite to improve their knowledge of science content and teaching. Many of the course participants made end-of-course evaluation statements stating the overall usefulness of the class. Upon receiving the results from the IDEA Center Diagnostic Form Report the University uses for course and instructor evaluation, the participants rated the course as an overall 5.0/5.0 and the instructor as a 4.8/5.0.

Several of those who responded stated the class was a good mix between “on campus class and internet.” Several of those who responded stated how they liked being able to get to know the other students and the other students in the class by having interactions and doing hands-on activities that improved their knowledge and serve as things they could take back to their own classrooms. In addition, the majority stated they enjoyed being able to follow up these activities by working on their own using the various assignments and resources on Blackboard. Several of those in the class had to drive up to an hour to get to campus. Many of those who responded stated they appreciated that they didn’t have to make several trips as they would have in a regular, onsite-only course.

Implications and Recommendations for Professional Development
We found that the use of a hybrid online/onsite course is a beneficial and convenient method for providing teacher professional development and master’s-level coursework opportunities for middle school science teachers. It allowed several to participate in the course who otherwise may not have been able to attend due to the distances they had to drive. Also, a partial purpose of the course was to provide a conceptual-based delivery of energy content without focusing too heavily on the mathematical components of energy concepts secondary science teachers may need.

This course will be taught again two summers after it was initially offered. The data from the two courses will be pieced together and collectively analyzed by creating a rubric to more-specifically measure both misconceptions and the degree of conceptual understanding for each question a participants answers. In addition, as a means to increase the online community via Blackboard, the same course may be delivered by a colleague at another university with his local science teachings using the same onsite format and meeting at the exact days and times. With nearly exactly similar activities, all participants will be placed in a single Blackboard unit as a means to increase the amount of interactions for discussion board interactions.
References


Appendix

General Syllabus

1. **University Department**
   - **EMG 807:**
   - Credit Hours: 3
   - Instructor:

2. **Catalogue Course Description:**
   - *Independent work, workshops, special topics, or seminars. May be retaken under different subtitles.*

   **Special Topic:**
   - **Energy as a Unifying Concept in Science Teaching**
   - This special topics course will focus on the major and integral concepts of energy and their importance across science content and science teaching.

3. **Text:**
   - *Stop Faking It: Finally Understanding Science So You Can Teach It: Energy* (NSTA Press)
   - *NEED Project Workshop and Teacher Resource Packet* (purchased from workshop administrator – approximately $35)

4. **Student Learning Outcomes:**

   The inservice/preservice teacher will be able to:
   - Connect age-appropriate content knowledge in middle school science with appropriate pedagogical techniques
   - Connect ideas of energy concepts across all areas of science teaching
   - Synthesize his/her own ideas about energy, the types of energy, transfer of energy, and how such concepts relate to the learner
   - Further develop his/her own teacher content knowledge of basic energy concepts to improve his/her own conceptual understanding and that of his/her students
   - Develop a list of important concepts in his/her teaching content and apply how the grand unifying theory of energy as a concept to improve students broader conceptual understanding of science
   - Understand basics of inquiry, the 5E Learning Cycle, discrepant events and other pedagogical techniques essential to conceptual understanding in the science classroom
   - Synthesize science content and pedagogical content knowledge using the following topics to create an more scientifically-informed conceptual understanding of energy:
     - Types of Energy
     - Energy in Everyday Language
     - Energy and Work
     - Transfer and Conservation of Energy
- Cycles of Energy
- Energy as a Unifying Factor in the Life Sciences
- Heat, Work, and Energy Efficiency in Systems
- Global and Socioscientific Issues Related to Modern Situations and the Environment
5. Evaluation Methods:

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<th>ITEM</th>
<th>REQUIREMENTS</th>
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| 1.   | Classroom Attendance and Active Participation (6*25 points) = **150 points**  
      | *June 24, July 1, July 8, July 15, July 22, July 29* |
| 2.   | Weekly PD Energy Video Modules (Questions/Reflections) (9*30 points) = **270 points**  
      | Upload to Bb |
| 3.   | Weekly Content Quiz - Text, Articles, Videos, Homework: (4*30 pts) = **120 points**  
      | *Post-Courses 1, 2, 3, and 5* |
| 4.   | Content Quiz for Class 4 (the week following class): **60 Points** |
| 5.   | Energy Puffs Energy Source Cereal Box Design: **90 points**  
      | *Share-a-Thon during Class #5* |
| 6.   | Energy Across the Curriculum Planning Project = **120 points**  
      | *(alternative final projects can be negotiated for this based on the needs of the teacher)* |
| 7.   | Course Post-Test: (35 questions*5 pts. each) = **140 points**  
      | *3 points for MC Response and 2 Points for Short Answer Elaboration* |

**950 Points Total for the Course**

Video notes should be uploaded to Bb by 10:00 AM on Thursday.  
Bb quizzes should be completed by 9:00 PM on Thursday.
6. Course Outline:

**Class #1 6/24/11**
Concept of Energy and Everyday Language
Types of Energy
Historical (Epistemological) Concepts of Energy
Energy and Work

Homework:
PD Videos 1 (*What is Energy?*) & 2 (*Force and Work*)
Complete Video Questions from videos 1 & 2
*Read Chapter 1 and Ch. from midpoint of pg 25 - midpoint of pg 32*
EXTRA READING: *Energy Transformations*
Take online Bb quiz

Due by Class 2:
Upload video notes to Bb by Thursday
Take Bb quiz by Thursday

**Class # 2  7/1/11**
Transformation and Conservation of Energy
Potential and Kinetic Energy
Energy Transfer
Energy Cycles (begin, sustain, decay)

Homework:
PD Videos 3 (*Transfer and Conservation of Energy*) & 4 (*Energy in Cycles*)
Complete video questions for videos 3 & 4
*Read Ch. 2 pages 17-midpoint pg. 25 and midpoint pg 32 – pg 40*
Additional: *Read Energy Content Review Document* (pg 23 – 36)
Take online Bb quiz

Due by Class 3:
Upload video notes (3 & 4) by Thursday
Take Bb quiz by Thursday

**Class # 3  7/8/11**
Potential Chemical Energy
Energy Conversion in the Life Sciences
Energy Flow/Chains/Efficiency Throughout the Community
Energy in the Body and in Ecosystems

Homework:
PD posted video #5 (Energy in Food) & #5a (Energy Flow in Communities)
Complete video questions for video #5 and related video (upload via Bb)
*Read provided pages from Essentials of Ecology book (provided hard copy and/or via Bb scan)
Take Bb Quiz

Due by Class 4:
Upload video notes by Thursday (#5 and additional video)
Take Bb quiz by Thursday

→ Don’t forget to be working on your Energy Puffs cereal box! It is due Class 5.

Class # 4  7/15/10
Energy and Systems
Energy Transfer in Systems (from high concentration of energy to lower concentration of energy)
Equilibrium of Systems Regarding Energy

Homework:
PD Videos #6 (Energy in Systems) & #7 (Heat, Work, and Efficiency)
Two sets of video questions (upload to Bb)
Readings Chapter 3
   Read all of Chapters 3, 4, and 5
Read posted reading Temperature, Heat, and Sorting Things Out (via Bb and/or distributed in class)

Due by Class 5:
Upload video notes by Thursday (#6 & #7)
Take Bb quiz by Thursday (longer quiz than usual—worth double points)

→ Energy Puffs Share-a-Thon
   o Be sure to have your cereal box ready for presentation for Class #5

Class # 5  7/22/11
Energy and Implications for individuals and Society
Implications Regarding Population and Energy (Population Connection PD Mini-Workshop)
Socio-Scientific Issues and (Respectful) Argumentation
Energy Puffs Share-a-Thon

Homework:
Video #8 (Understanding Energy)
One set of video questions (upload to Bb)
Readings: Chapter 6
Additional Reading: Cognitive Resources for Understanding Energy (posted and/or hardcopy)

Due in Class 6:
Upload video notes for #8 by Thursday (to Bb)
Take Bb quiz by Thursday

Class # 6  7/29/11
6-Hour Required Professional Development Workshop -- 9:00-4:00
   NEED Project

Due After Class #6:

→ Posttest (7/29/11 at 4:30 or by appointment the following week)

→ Energy Across the Curriculum Planning Project
   o Individual or group
   o Hardcopy or CD due at end of Class #6
   o Internet project due by 11:59 PM Sunday night.
   o Please discuss other useful project options with Dr. Townsend