Using different conceptual change methods embedded within 5E model: A sample teaching of Endothermic – Exothermic reactions

Fatma TÜRK[1] and Muammer ÇALIK[2,3]

[1]Graduate School of Natural and Applied Sciences, Karadeniz Technical University, Trabzon, TURKEY

[2]KTÜ, Fatih Faculty of Education, Department of Primary Teacher Education, Trabzon, TURKEY
[3]Correpondence author
E-mail: muammer38@hotmail.com

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Abstract

Since Widodo, Duit and Müller (2002) addressed that there is a gap between teacher's theoretical knowledge and their practical classroom constructivist behavior, we presented a sample teaching activity about Endothermic – Exothermic Reactions for teacher usage. Therein, the aim of this study is to design a 5E model to include students' alternative conceptions using conceptual change text, analogy and worksheet together. The aim of this study is to design a 5E model to include students' alternative conceptions using conceptual change text, analogy and worksheet. Also, we have made some suggestions for further research.

Keywords: Endothermic–Exothermic Reactions, Alternative conceptions, Conceptual Change, Constructivism

Introduction

In the early 1990s, Fensham claimed that 'The most conspicuous psychological influence on curriculum thinking in science since 1980 has been the constructivist view of learning' (Fensham, 1992, p. 801). During the last two decades, two issues have highly been investigated: (a) students' pre-existing knowledge and (b) conceptual change. Of course, it is not surprising since constructivism stresses that a student can actively acquire new knowledge based on his/her pre-existing knowledge. However, several studies show that teachers have difficulty incorporating students' pre-existing knowledge in their courses (e.g. Çalık & Ayas, 2005; Driver & Oldman, 1985; Fensham, Gunstone & White, 1994; Matthews, 2002; Palmer, 2005).

Because of the importance of students' pre-existing knowledge, much research has been carried out in different perspectives including: chemical reactions, chemical equilibrium, solution chemistry, chemical bonding, electrochemistry, stoichiometri, enthalpy change, etc. As in the case of thermodynamic studies, the related literature points out that students are unable to comprehend and differentiate the relationship between exothermic and endothermic reactions (Anthoney, 2006; Carson and Watson, 1999; De Vos and Verdonk, 1986; Greenbowe & Meltzer, 2003; Johnstone, MacDonald & Webb, 1977; Rollnick & Mahooana, 1999; Sunal, Sunal, Smith, Dwyer & Holloway, 2000; Thomas and Schwenz, 1998). They also believe that endothermic reactions take place spontaneously (Boo, 1998; Cachapuz & Martins, 1987; Johnstone et al., 1977). Moreover, as cited in Carson and Watson (1999), students have difficulty discriminating between the activation energy and the total enthalpy change of the reaction.

Even though we have looked for conceptual change studies for foregoing alternative conceptions in related databases, such as EBSCOHOST, ERIC etc., we have not encountered a direct relevant study. Generally, some conceptual change studies using conceptual change texts, analogies, worksheets, etc. are used to overcome students' alternative conceptions. However, using these methods frequently may fail to produce effective results, and students may be bored with them (Çalık, 2006; Dole, 2000; Huddle, White & Rogers, 2000). Even though conceptual change text is effective in refuting students' alternative conceptions, a hands-on activity that students explicitly experience may sometimes have more advantages (Chambers & Andre, 1997). In brief, we predict that using different conceptual change methods embedded within a 5E model may completely eliminate students' alternative conceptions. Since Widodo, Duit and Müller (2002) addressed the gap between a teacher's theoretical knowledge and his/her practical constructivist classroom behavior, we presented a sample teaching activity for teacher usage. The aim of this study is to design a 5E model to include students' alternative conceptions using conceptual change text, analogy and worksheet. By doing this, we wish to eliminate one of resources of alternative conceptions as implied by Gabel (1996): '*We know that chemistry is a very complex subject from both the research on problem solving and misconceptions …and from our own experience…Students possess these misconceptions not only because chemistry is complex, but also because of the way the concepts are taught'* (p. 43). Such an assumption has some advantage points: (1) multiple conceptual change perspectives allow us to enhance student learning and to increase teachers' awareness of alternative conceptions (e.g. Harrison & Treagust, 2001) and (2) using different methods within the same context enables students to utilize multiple learning styles (e.g. Brinda, 2004; Harvey & Hodges, 1999).

Theoretical Framework

Although constructivist models such as 3E, 4E, 5E and 7E possess similar steps, 5E is the most popular version (e.g. Hanuscin & Lee, 2007; Kurnaz & Çalık, 2008). Every "E" represents a part of the process of helping students' sequential learning to bridge prior knowledge and new concepts. 5E consists of: (1) *engagement/enter* where the teacher engages students in a new concept using short activities or questions that promote curiosity and draw out prior knowledge in order to unveil students' pre-existing knowledge*;* (2) *exploration* where students not only conduct activities, i.e. lab activities, group discussion, hands-on activities, role playing, analogies, by means of their own pre-existing knowledge, but also explore questions and implement a preliminary investigation; (3) *explanation* where the teacher has an opportunity to directly introduce a concept, process, or skill so that students imply their understanding of the concept or track their correct and incorrect knowledge*;* (4) *elaboration* where students try to advance their newly structured knowledge into a deeper and broader understanding in order to elaborate on their conceptual understanding and skills; (5) *evaluation* where students' comprehension and abilities are assessed, and thereby, the teacher is able to monitor how his/her students have progressed in accomplishing the educational objectives. (e.g. Abell & Volkman, 2006; Boddy, Watson & Aubusson, 2003; Bybee, Taylor, Gardner, Scotter, Powell, Westbrook & Landes, 2006).

Teaching Design

Now we will present how to adjust the related conceptual change methods within the 5E model (**E**ngagement/**E**nter, **E**xploration, **E**xplanation, **E**laboration and **E**valuation).

Engagement/Enter

Before handing out the worksheet, the teacher asks the first question on the worksheet to solicit students' pre-existing knowledge and to activate them: 'What is the direction of energy in an endothermic reaction or exothermic reaction? How can we show these changes using diagrams?"

Exploration

Since students are divided into small groups of 3-4 students**,** the teacher hands out the worksheet. Then, (s)he asks them to engage in the related activities by conducting a group discussion. Through discussion, students acquire some ideas about the related concepts. Next, the teacher observes all groups and participates in their discussions but refrains from any clue (called Socratic Dialogue). Also, the teacher may ask follow-up questions in order to get students to re-consider their ideas.

Table 1. Analogy map for an exothermic reaction analogy

Analog	Compare to	Target Feature
Beginning money	**Compared to**	Potential reactant energy
Ending money	**Compared to**	Potential product energy
Unhappy ending	**Compared to**	Negative ΔH (-)
Losing money	**Compared to**	Releasing energy
Borrowed money	**Compared to**	Activation energy where reactants are activated with an increase in potential energy as a result of the energy transfer
Money	**Does not compare to**	Energy is not concrete like money
Borrowing money (10 YTL)	**Does not compare to**	Activation energy cannot be paid back. However, money does need to be paid back
Unhappy ending	**Does not compare to**	The negative ΔH (-) chemical reaction occurs spontaneously
Cumulative money changes over time	**Does not compare to**	A sudden event occurs where exothermic reaction takes place

Explanation

First, in this phase, a class discussion is conducted to get students to notice what their peers thought. Then**,** the teacher confirms/disconfirms students' experiences. To discriminate analogs from the targeted feature, analogy maps (see Table 1 and Table 2) are utilized. The teacher should pay special attention to discern the difference between an **Unhappy end and Negative ΔH (-)** and a **Happy ending and Positive ΔH (+)**. Even though there is an unhappy ending in our story for exothermic reactions, an opposite situation where chemical reaction occurs spontaneously can happen in reality. Likewise, despite the happy ending for endothermic reactions, a contrasting situation where the chemical reaction does not take place spontaneously exists in reality. Such an explanation may frustrate any different meaning.

Table 2. Analogy map for an endothermic reaction analogy

Analog	Compare to	Target Feature
Beginning money	Compared to	Potential reactant energy
Ending money	Compared to	Potential product energy
Happy ending	Compared to	Positive ΔH (+)
Making a profit	Compared to	Absorbing energy
Borrowed money	Compared to	Activation energy where

		reactants are activated with an increase in potential energy as a result of energy transfer
Money	**Does not compare to**	Energy is not concrete like money
Borrowing money (25 YTL)	**Does not compare to**	Activation energy cannot be paid back. However, the money does need to be paid back.
Happy ending	**Does not compare to**	Positive ΔH (+) because this means that the chemical reaction does not occur spontaneously
Cumulative money changes over time	**Does not compare to**	A sudden event may occur where endothermic reaction takes place

Elaboration

In this stage the priority is to generate a new concept related to earlier conceptual gains, and so a conceptual change text **(Appendix B)** is handed out. Students' alternative conceptions, which are not modified in earlier steps, may be refuted. In this step, as well as the presented conceptual change text, are meant to introduce new concepts related to previous ones. Additionally, a new conceptual change text on energy conservation and energy transformation concepts may be used.

Evaluation

To advocate students' newly constructed conceptions in this phase, the following question is used: (1) Please choose the subsequent phenomena's type(s) (endothermic or exothermic) (a) condensation of rain from water vapor, (b) burning sugar, (c) conversion of frost to water vapor and (d) cooking an egg. Further, to make students conscious of their learning, they are asked to outline what they have learned.

Implications for Practice

To teach endothermic and exothermic reactions, specifically the differentiation from each other, using varied conceptual change methods embedded within the 5E Model is illustrated here. In such a situation, students' motivation may increase since the presented materials are attractive to them since the method/materials/activities presented may differ from their usual learning habits or experiences. But, the study has a shortcoming in investigating the degree to which conceptual change is achieved in terms of the numbers of students' alternative conceptions. For this reason, further research should focus on the mentioned limitation by designing a comparative study.

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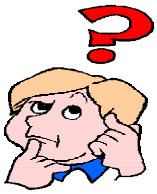
Appendix A



Hey Friends !!!

What is the direction of energy in endothermic reaction or exothermic reaction?

After you follow the subsequent directions, answer the following questions in depth

STAGE 1

Story 1: Ali is a guy who has 20 YTL and wants to deal. However he needs 30 YTL to get things that he must buy. He borrows some money to start his new job, but his work does not go as he planed and he loses money. The unhappy ending is that he realizes that he has lost 5 YTL.

FIRST YEAR

1. How much money does Ali borrow for starting his new job?

……

2. How much money does Ali have at the end of first year?

……

3. What is the maximum accumulation in this case?

……

4. What is the total change in this case (positive or negative)?

……

Story 2: The next year, Ali decides to deal in again with his 15 YTL. But his money is not enough for his new job. So he borrows 25 YTL and buys the required things. All goes as he planed and he makes a profit. The story has a happy ending; he has 30 YTL after paying back his borrowed money (25 YTL)

SECOND YEAR

1. How much money does Ali need for his new job?

……

2. How much money does Ali make a profit from his job?

……

3. What is the maximum accumulation in this case?

……

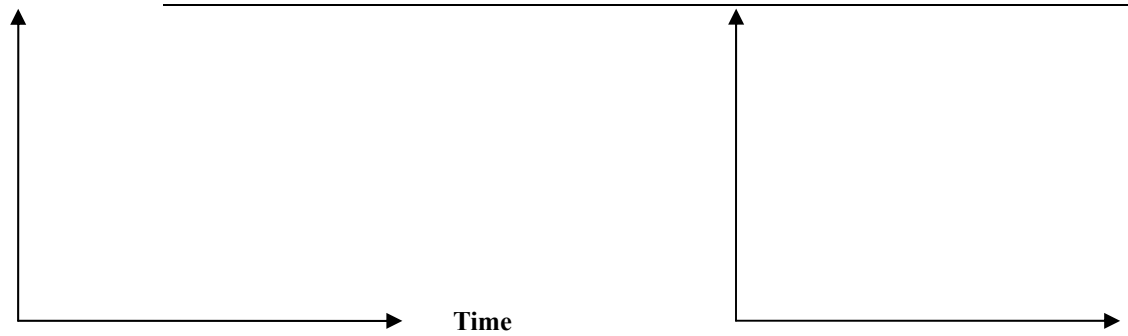
4. What is the total change in this case (positive or negative)?

……

STAGE 2

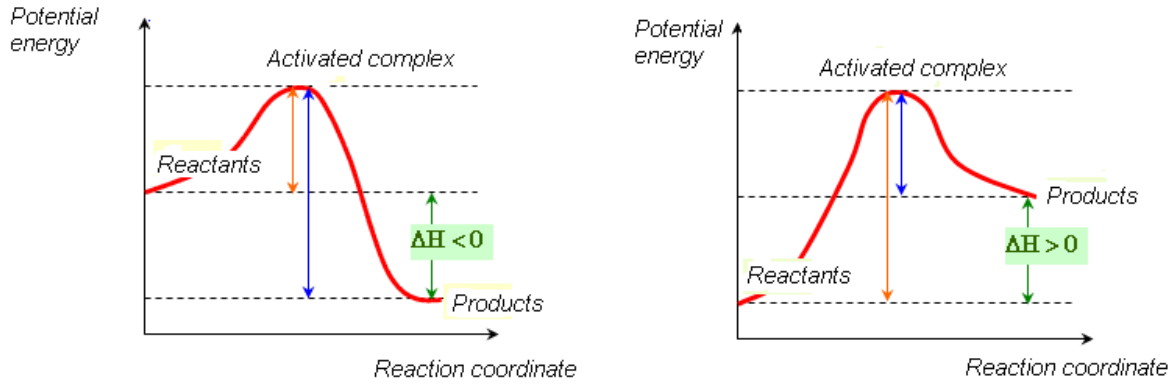
Please show how money changes over the course of time on these diagrams

Cumulative Money **Cumulative Money**



Time
First year
Second year

STAGE 3



- Match your diagrams with the ones above

……

- How does energy change in an endothermic reaction affect its environment (surroundings)?

……

- How does energy change in an exothermic reaction impact its environment (surroundings)?

……

- What does *endothermic reaction* mean?

……

- What does *exothermic reaction* mean?

……

Based on your experiences, please answer the following questions.

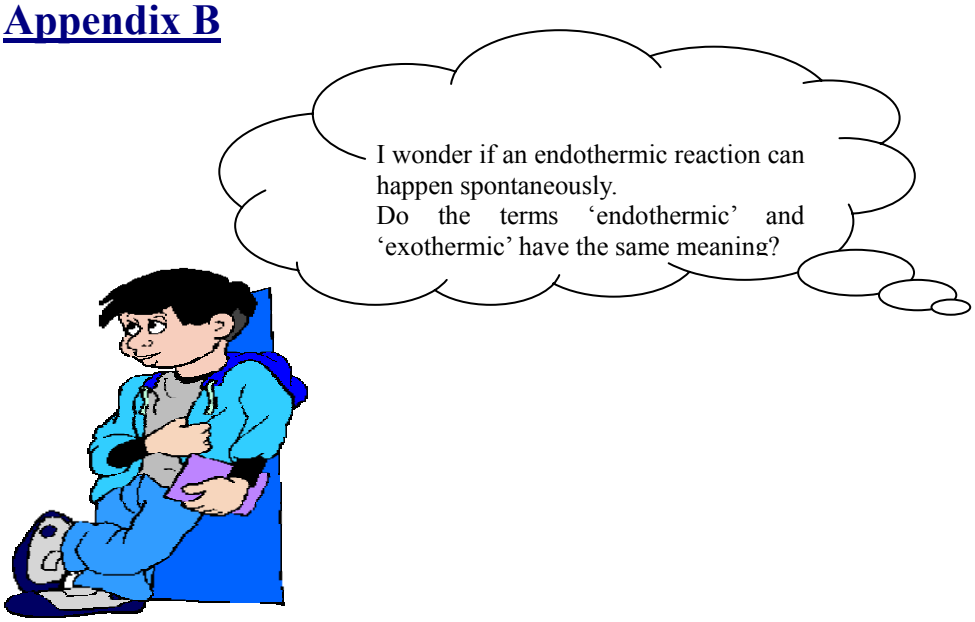
1. Please list the subsequent phenomena's types (endothermic or exothermic)

Condensation of rain from water vapor:
Burning sugar:
Conversion of frost to water vapor:
Cooking an egg:

2. Could you outline what you learned?

……
……
……

Appendix B



Some of the students' alternative conceptions are:

Students are unable to comprehend and differentiate the relationship between exothermic and endothermic reactions

Endothermic reactions take place spontaneously

Students have difficulty discriminating the activation energy from the total enthalpy change of the reaction.

Some students think that any endothermic reaction may happen spontaneously. Such an idea is incorrect. To decide if a reaction is either endothermic or exothermic, we look at the total energy as a consequence of releasing energy in bond formation and absorbed energy in bond breaking. Similarly, the terms 'endothermic' and 'exothermic' do not have the same meaning because these terms reflect the type of reaction based on enthalpy change. Further, activation energy and total enthalpy energy are different from each other. That is, activation energy, also called threshold energy, is defined as the energy that must be overcome in order for a chemical reaction to take place. However, total enthalpy change is a result of chemical reactions.