

Learning Science through the PDEODE Teaching Strategy: Helping Students Make Sense of Everyday Situations

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The aim of this study was to investigate effectiveness of PDEODE (Predict-Discuss-Explain-Observe-Discuss-Explain) teaching strategy in helping students make sense of everyday situations. For this, condensation concept was chosen among many science concepts since it is related to many everyday-life events. Forty-eight eleventh graders students were involved in this study. In order to assess students' application of their knowledge to problem solving in everyday situations, a test including two everyday problems were presented to them as pre- and post-test. As an intervention phase, two PDEODE tasks were utilized to teach condensation. The test scores were analyzed both qualitative and quantitative methods. Statistical analysis using paired t-test of student test scores point to statistically significant differences in tests and total scores ($p < 0.05$) suggesting that the PDEODE teaching strategy either facilitates students to help students make sense of everyday situations or helps students to achieve better conceptual understanding for the concept of condensation.

Keywords: Conceptual Change, Condensation, Everyday-Life Experiences, PDEODE Teaching Strategy

INTRODUCTION

Most instruction in science does focus on helping students amass information about scientific ideas, but does not foster development of understanding of these ideas, nor does it help them learn how to apply the concepts outside of school in the real world in which they live (Jarman & McAleese, 1996; Soudani et al, 2000). It is not surprising that most of students could not apply their science knowledge learned in schools to everyday-life events, because they do not have opportunity to do so in schools (Gallagher, 2000). Whereas, connecting science to students' everyday-life

experiences has been an important issue in science education and this should be included in science lessons (Ogborn et al, 1996). Several reasons have been given for incorporating everyday-life experiences and focusing on everyday-life applications of science (Driver et al., 1994; Campbell & Lubben, 2000). Firstly, as argued by Campbell & Lubben (2000), everyday-life experiences are a way to make science meaningful to students. Secondly, there is another argument is that if it is wished to educate students as scientifically literate citizens, everyday-life theme related to science is necessary (Harlen, 2002). Finally, it is also an argument about constructivist view on learning in which students' alternative conceptions derived from their everyday-life experiences before the formal instructions has been seen as a starting point in teaching (e.g. Smith et al, 1993). Studies in the area of students' alternative conceptions have showed that isolating the school science from students' everyday-life could make students develop two unconnected knowledge systems related to science: one is used to solve science problems

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in schools, and the other is used for their everyday-lives (e.g. Osborne & Freyberg, 1985). Similarly, several studies have focused on the effect of including everyday science applications into school science on the students' mastery of school science (e.g. Driver et al, 1994). However, this study focused on the unexplored area of students' use of science knowledge from teaching in everyday situations.

Because of the importance of everyday-life applications, both researchers and teachers wish to emphasize on this issue in teaching science. Although they focused on the connecting science to students' everyday-life experiences and taught their students in similar ways, they still fail to provide for students to apply their science knowledge to make sense of everyday situations (e.g. Jarman & McAleese, 1996). Thus, teaching strategy should be developed for teachers in order to provide students to make connection between their knowledge of science and related everyday situations. The present study tries to assess effectiveness of PDEODE teaching strategy on the degree to which students accept scientific concepts and use them for interpreting the phenomena in their everyday-life. In order to reach this, condensation concept was chosen among many science concepts since it is related to many everyday-life events. The study presented here mainly focused on phenomena about condensation on cool surfaces due to having seen many alternative conceptions in students' minds (see e.g. Osborne & Cosgrove 1983; Bar & Travis 1991; Chang 1999; Gopal et al, 2004; Paik et al, 2004). These studies show that students have several alternative conceptions and difficulties about this topic despite science teachers' extensive efforts in teaching. The alternative conceptions identified by the previous researches are summarized in Table 1.

According to popular opinions, many of them are caused by daily life experiences of chemical phenomena which students bring into science classes (e.g. Driver & Easley, 1978). Hence, PDEODE tasks were developed based on this topic.

PDEODE Teaching Strategy

PDEODE strategy initially is suggested by Savander-Ranne & Kolari (2003) and firstly used by Kolari et al., (2005) in engineering education. This is an important teaching strategy in which there is an atmosphere that supports discussion and diversity of views. Hence, it is intended that this strategy is used as a vehicle in helping students make sense of everyday situations.

The PDEODE teaching strategy used here consisted of six steps. In the first step (P: Prediction), teacher presented a phenomenon about condensation to students so as to predict the outcome of the phenomenon individually and to justify their prediction.

Table 1. Students' alternative conceptions and difficulties about condensation on cool surfaces

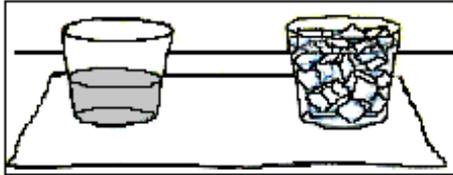
<i>Condensation on the cool surface (a beaker filled with ice) in an open system</i>
Particles of air form drops on the cool surface due to cooling
Drops are formed due to the difference in temperature (or when cold surface encountered heat, drops are formed or when cold and hot air meet each other, drops are formed)
Ice on the surface melts and forms drops of water
Sweating happens (similar to human beings) and drops are formed
The coldness caused hydrogen and oxygen to change into water
Drops are made of water particles from inside penetrated the cool surface
Cold water evaporated when encountering heat
Drops of water on the outside of the cold surface comes from inside the beaker
The cold surface and dry air (oxygen and hydrogen) react to form water

In the second step (D: Discuss), it is wanted the students to discuss in your group to share their ideas in own group and to ponder together. In the third step (E: Explain), students in each group are asked to reach a mutual solution about phenomenon and to give their result to other groups through whole-class discussions. Afterwards, the students worked in groups perform hands-on experiment and record individually their observations what happened. In this step (O: Observe), the students observe changes in the phenomenon and teacher should guide them to make observations that are relevant to target concepts. In the fifth step (D: Discuss), the students are asked to reconcile their predictions with their actual observations made in the early step. Here the students were asked to analyze, compare, contrast and criticize their classmates in the groups. In the last step (E: Explain), the student confronts all discrepancies between observations and predictions. Doing these, the students begin to resolve the contradictions that may exist between their beliefs. A sample PDEODE teaching activity sheet containing the six steps mentioned above was presented in Figure 1.

In accord with this theoretical background, the aim of this paper was to investigate PDEODE teaching strategy about condensation in helping students make sense of everyday situations. It was expected that by following this teaching strategy:

(a) The majority of students will interpret everyday phenomena about condensation after teaching with PDEODE tasks (hypothesis 1).

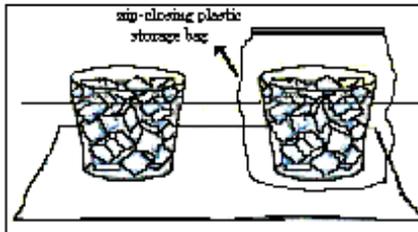
Task 1. Condensation on a beaker filled with water and on a beaker filled with ice cubes.



- ✓ Have 2 clear plastic cups
- ✓ Fill in one of the plastic cup lots of ice cubes. Do not add any ice to the other cup. Place the cups on a paper towel.
- ✓ Wait a few minutes

- What happens to the outside of each plastics cup, a few minutes later? Predict? State and explain the reason(s) for your prediction.
.....
- Discuss your prediction and the reason(s) in your group. Then explain your reasons in detail.
.....
- Observe changes in the outside of each plastics cup. What happened? Do you notice any difference between them? State your observation.
.....
- Why do you think these happen? Discuss in your group. Then explain your reasons in detail.
.....
- Compare your observation with your prediction. Are they in agreement or disagreement? Explain with your reason(s). What did deduce from the above experiences? Please write your deduction below.
.....

Task 2. Condensation on a beaker filled with ice cubes and on plastic bag in which there is a beaker filled with ice.



- ✓ Have 2 clear plastic cups
- ✓ Fill in the cups with lots of ice cubes.
- ✓ Put one of the cups in a zip-closing plastic storage bag. Place both cup on a paper towel.
- ✓ Wait a few minutes.

- What happens to the outside of each plastics cup and plastic storage bag, a few minutes later? Predict? State and explain the reason(s) for your prediction.
.....
- Discuss your prediction and the reason(s) in your group. Then explain your reasons in detail.
.....
- Observe changes in the outside of each plastics cup and plastic storage bag. What happened? Do you notice any difference between them? State your observation.
.....
- Why do you think these happen? Discuss in your group. Then explain your reasons in detail.
.....
- Compare your observation with your prediction. Are they in agreement or disagreement? Explain with your reason(s). What did deduce from the above experiences? Please write your deduction below.
.....

Figure 1. PDEODE teaching tasks used in this study as an intervention

Problem 1.

In a cold day, you have noticed that dampness occurs on the windows surface of a house or a car. Why? Explain your reasons in detail.

.....
.....

Problem 2.

You have noticed smokes rising form a huge ice cube taken from a refrigerator. Actually ice cube give off smoke? How the smokes occur? Explain your reasons in detail.

.....
.....

Figure 2. Test items used in this study

Table 2. The criteria for the classification of students' responses to test items

<i>Level of understanding</i>	<i>Criteria for the classification of student responses</i>	<i>Score</i>
Sound understanding (SU)	Responses that included all components of the validated response.	4 points
Partial understanding (PU)	Responses that included at least one of the components of validated response, but not all the components	3 points
Partial Understanding with Specific Misconception (PUSM)	Responses that showed understanding of the concept, but also made a statement, which demonstrated a misunderstanding	2 points
Specific Misconceptions (SM)	Responses that included illogical or incorrect information	1 points
No Understanding (NU)	Repeated the question; contained irrelevant information or an unclear response; left the response blank	0 point

(b) Students who held alternative conceptions about condensation will show a conceptual change after teaching unit with PDEODE tasks (hypothesis 2).

METHODS AND MATERIALS

Subjects

Participants in this study comprise of 48 eleventh grader students (25 girls and 23 boys, whose ages were ranged from 17 to 19 years) at a secondary school in Turkey. The students in this investigation all had been taught the concept of condensation.

Data Collection

In order to test hypotheses, an exploratory test designed without control groups was chosen. The test including two everyday problems was developed based on the alternative conceptions about condensation on cool surfaces in open systems. Each item posed an everyday, science-based problem and students were asked to suggest solutions to them. The test was presented in Figure 2.

The test was validated by a panel consisting of two chemistry teachers and one teacher educator. The final form of the test was administered to the sample seven weeks before (pre-test) and after the teaching (post-test). It is assumed that duration between application of the same test as pre- and post- tests is sufficient for students to forget the items.

Teaching Intervention

As teaching intervention, it is used two PDEODE tasks about condensation given earlier. Teaching intervention based on two PDEODE tasks was administered to the sample in groups (total twelve groups: four students in each). At the beginning of each teaching activity, the activity sheet on which students would write down their explanations was handed out to each group. Students worked collaboratively in groups

and they filled in each activity sheet individually. These sheets were collected at the end.

Data Analysis Procedure

The test items were analyzed under the following categories and headings (see Table 2), which were suggested by Abraham et al, (1994).

The categorizations of students' into the Table 2 were decided by a panel of three experts, all of whom are experienced science and science education. These qualitative responses and their categorization were subsequently validated by the same panel. Any disagreements were resolved by discussions and the categorizations presented here represent consensual agreement of the panel. Differences in pre-and post-intervention evaluation scores were investigated by conventional statistical means using paired t-test and a Windows version of Statistical Package for the Social Sciences (SPSS), and thematic analysis of reasons as described above. In addition, students' responses were analyzed qualitatively. In this analysis, it was taken into consideration the changes in students' responses from pre-test to post-test.

RESULTS

The results from the test items are shown in Table 3. Here it can be seen that more students gave responses that were classified in the sound understanding (SU) category, after the teaching intervention. For example, the percentage of students' responses in this category for problem 1 changed from 12%, to 90% for pre- and post-test scores. Similarly, students' responses that were classified as specific misconceptions (SM) decreased from pre-test to post-test. For example, the percentage of students' responses in this category for problem 2 changed from 86%, to 29% for pre- and post-test scores.

Students' responses were also analyzed in order to determine specific alternative conceptions or difficulties and their changes through pre- and post- test. These are presented in Table 4.

Table 3. Frequency and proportion of students' responses for test items for categories of understanding

Category	Problem 1				Problem 2			
	Pre-Test (N=48)		Post-Test (N=48)		Pre-Test (N=48)		Post-Test (N=48)	
	f	%	f	%	f	%	f	%
	SU*	6	12	43	90	1	2	14
PU*	20	42	2	4	2	4	16	34
PUSM*	7	14	1	2	0	0	4	8
SM*	14	29	2	4	41	86	14	29
NU*	1	2	0	0	4	8	0	0

SU: Sound understanding, **PU:** Partial understanding, **PUSM:** Partial understanding with specific misconception, **SM:** Specific misconception, **NU:** No understanding.

Table 4. Students' alternative conceptions and difficulties elicited by analyzing each test. Conceptual changes about SAC through each test.

Students' alternative conceptions and difficulties (SAC)	Pre-Test		Post-Test		Conceptual Changes
	f	%	f	%	
For problem 1					
1. When hot and cold air encountered, condensation occur	*S2, S5, S6, S8, S9, S17, S20, S21, S25, S29, S40	23	S17, S21	4	+ 19
2. Air condensed as water	S10, S11, S15, S19, S32, S39	13	-	0	+ 13
3. Condensation occur due to pressure changes	S22	2	-	0	+ 2
4. Not understand the water itself can exist as a vapor	S10, S11, S15, S19, S24, S32, S39	15	S24	2	+ 13
For problem 2					
5. Ice cube melts when it taken from the refrigerator and forms drops of water on it. The water drops evaporated and smoke gave off.	S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S13, S14, S17, S19, S23, S25, S26, S29, S30, S32, S34, S36, S38, S39, S42, S44, S45	56	S1, S3, S5, S6, S7, S9, S10, S14, S17, S19, S22, S28	25	+ 31
6. Ice changed in to water vapor. That is, it sublimated.	S11, S12, S16, S21, S24, S33, S40, S43	17	S11, S21	4	+ 13
7. Air condensed as water vapor.	S15, S20, S41	6	S20, S41	4	+ 2
8. Condensation occur due to pressure changes	S35, S37	4	S37	2	+ 2

Note: S1, S2 ... refer to the particular students in the study

As seen from Table 4, students' alternative conceptions (SAC) and their difficulties changed over time (pre-, and post-test), which are generally positive. Their frequency varied considerably, and this data is also presented in the Table 4. As seen from the Table 4, positive conceptual changes occurred in students' minds. This shows that students' alternative conceptions and difficulties decreased after the intervention. For

example, percentage of the 5nd SAC decreased from 56% to 25% for pre- and post-tests. These differences were examined for statistical significance with paired sample t-test (see, Table 5).

As can be from the Table 5, there are statistically significant differences between the pre- and post-test scores in favor of post-test ($t(48) = -12.214, p < 0.05$).

Table 5. The summary of the paired sample t-test

	Subject (N)	Mean	Std. Deviation	df	t	p
Pre-test	48	42.19	19.06	47	-12.214	.000
Post-test	48	80.21	19.09			

DISCUSSION AND CONCLUSIONS

The main purpose of this study was to evaluate the effectiveness of PDEODE teaching strategy in helping students making sense of everyday situations. The study answered the two hypotheses given in the introduction, the first of which is related to effectiveness of the teaching intervention on students' interpretations everyday phenomena about condensation. Results obtained suggested that the teaching strategy was an effective means of providing students to make sense of everyday situations. Data presented in Tables 3 and 4 clearly show that after the intervention students improved their interpretations of everyday problems in the test. Furthermore, this positive result strengthened with statistical analysis which was found to be statistically significant (Table 5). The success of the teaching strategy in this study could be attributed to the inclusion of verbal and non-verbal actions (Van Oers, 1998) embedded within the context of inter and intra-group class discussions among peers (Howe et al, 1992; Lee & Anderson, 1993). The discussions provide students to examine either own or classmates' pre-conceptions and experiences about everyday problems. Hence, they have chance to realize explanation of everyday problems in variety of perspectives and afterwards they learn scientific explanations of them guided with teacher.

With respect to the second hypothesis, this study provided evidence that the teaching strategy used in the present study was effective in altering students' alternative conceptions towards scientific ones (name as conceptual change) and facilitated greater conceptual understanding about condensation. The findings presented in Tables 3 and 4 suggest that after the intervention the students' understanding improved. Furthermore, the students' alternative conceptions (see Table 4) were reduced from the pre-test to the post-test and this conceptual change was found to be statistically significant (see Table 5). These findings are consistent with respect to the research literature on conceptual change in various topics (e.g. Başer, 2006; Case & Fraser, 1999; Chiu et al, 2002; Niaz, 2002; Çalık et al, 2007; Dilber & Düzgün, 2007). The success of this strategy stems from the fact that the PDEODE tasks helped the students to evaluate their prior knowledge and to re-examine their ideas within their groups and in whole-class discussions. As outcome of the PDEODE tasks, the students became dissatisfied with their existing knowledge through their observations in the tasks, and

this helped them to accept better, more scientific, explanations to the problems presented. Finally, they modified their ideas towards the scientific ones and enhanced their newly structured knowledge about condensation from discussions after the observations.

To sum up, the study provides some evidence that PDEODE teaching strategy as used in the present study can be an effective means both of helping students make sense of everyday situations and conceptual change for condensation. Teachers or researchers may wish to consider such an approach in their own classrooms, for this topic and perhaps other related topics.

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