Alternative Conceptions about Heat and Temperature among Upper Primary School Students: A Longitudinal Study

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Abstract- *The purpose of the present study was to identify various alternative conceptions about heat and temperature among upper primary school students as they moved to classes 6, 7 and 8 respectively. Thermal Concept Evaluation, a standardised questionnaire, was used on a sample of 300 upper primary school students. The results of a one-way repeated measures ANOVA revealed that there was a gradual decrease in alternative conceptions among students with the passage of time but they still persisted. The findings of this study imply that innovative and alternative teaching approaches should be adopted for preventing and remediating students' alternative conceptions in Physics.*

Keywords: *Alternative Conceptions, Heat, Temperature, Upper Primary Students, Longitudinal Study*

Introduction

Physics is the branch of science concerned with the nature and properties of matter and energy. The subject matter of Physics includes mechanics, heat, light and other radiation, sound, electricity, magnetism and the structure of atoms. The study of Physics can help students to understand the laws and rules that govern the physical world. Heat and temperature are the most basic concepts that are applicable in many fields of Physics and Chemistry. The knowledge and understanding of these concepts can enable them to navigate their uses and applications in everyday life. But if their daily life experiences related to these concepts are not explained and interpreted in the light of scientifically accepted understandings, then this leads to the development of defective knowledge that contradicts scientific claims and has been variously described as misconceptions, alternative conceptions, alternative frameworks, intuitive beliefs, preconceptions and naive beliefs.

A number of researchers have reported alternative conceptions about heat and temperature among students (Driver, 1989; Linn and Songer, 1991; Lewis and Linn, 1994; Harrison et al., 1999; Newell and Ross, 1996). Review of related literature has revealed a number of reasons for the formation of alternative conceptions among students such as ineffective classroom teaching strategies that do not take students' prior knowledge and daily life experiences into account (Driver et al. 1994; Köse 2008; Ozay and Oztas, 2003);conventional teaching methods (Chittleborough et al. 2005; Treagust et al. 2010); information provided in the

textbooks (Abraham et al. 1992) and the use of everyday language (Osborne and Whittrock, 1983). But such studies in general and longitudinal studies in particular are not being conducted in India for diagnosing alternative conceptions among school students. Therefore, the researcher has conducted this study in order to fill this research gap

Objectives

The objectives of the present longitudinal research study are:

- To study the change in achievement scores of upper primary school students at three time periods as they moved to classes 6, 7 and 8 respectively
- To identify various alternative conceptions about heat and temperature among upper primary school students as they moved to classes 6, 7 and 8 respectively

Research Questions

- Is there any significant change in achievement scores of upper primary school students at three time periods as they moved to classes 6, 7 and 8 respectively?
- What are various alternative conceptions about heat and temperature among upper primary school students as they moved to classes 6, 7 and 8 respectively?

Methods and Procedure

Research Method

Descriptive method of research was employed for the present longitudinal study.

Variables

- Dependent variable was achievement.
- Independent variable (categorical) was time (Time 1, Time 2, Time 3)

Sample

A sample of 300 upper primary students was randomly selected from six CBSE affiliated schools in Aligarh, Uttar Pradesh.

Tool used for Data Collection

Thermal Concept Evaluation, used in this study, was developed by Shelley Yeo and MarjanZadnik (2001). It consists of 26 items. Three types of validity, namely, content, face and construct were established by them. Its reliability, determined using a split half-correlation with Spearman-Brown correction, was 0.81. This tool was administered over the same sample three times at the end of their academic session, when they were in classes 6, 7 and 8 respectively. In previous researches, a time interval of more than three months has been considered sufficient enough for controlling memorisation effect on the same sample (Rettig and Blom, 2021).

Statistical Techniques used for Data Analysis

Percentage and one-way repeated-measures ANOVA were employed for analysing the quantitative data in accordance with the nature of variables involved and objectives of the study.

Results and Discussion

A one-way repeated measures ANOVA was conducted to compare achievement scores on Thermal Concept Evaluation at Time 1 (Class 6), Time 2 (Class 7) and Time 3 (Class 8). The means and standard deviations are presented in Table 1. There was a significant effect for time [Wilks' Lambda=.25, $F(2, 298)=41.17$, $p< .0005$, multivariate partial eta squared = .75].

Pairwise comparisons showed that the mean difference for Time 1 and Time 2, Time 1 and Time 3 and Time 2 and 3 were 6.80, 9.80 and 3.00 respectively. All these mean differences were significant at .05 level of significance. This indicated that students' alternative conceptions had decreased and their achievement had increased significantly with the passage of time, as mentioned in Tables 1 and 2 respectively.

Table 1

Descriptive Statistics for Achievement Scores of Primary School Students at Time 1, Time 2 and Time 3 respectively

Time	N	Mean	Standard Deviation
Time 1 (Class 6)	300	8.70	2.59
Time 2 (Class 7)	300	15.50	2.90
Time 3 (Class 8)	300	18.50	2.90

Table 2

Alternative Conceptions about Heat and Temperature among Upper Primary School Students at Time 1, Time 2 and Time 3 respectively

S. No.	Alternative Conceptions	Time 1 (Class 6) %	Time 2 (Class 7) %	Time 3 (Class 8) %
1.	Heat is a substance.	40.00	30.33	18.33
2.	Heat is not energy.	38.33	32.66	19.33
3.	Heat and cold are different, rather than opposite ends of a continuum.	36.33	31.00	21.66
4.	Heat and temperature are the same thing.	37.00	30.00	22.66
5.	Heat is proportional to temperature.	41.66	37.00	30.33
6.	Heat only travels upward (Heat rises).	30.00	22.66	18.33
7.	Heat and cold flow like liquids.	29.66	26.66	21.66
8.	A cold body contains no heat.	43.33	39.00	33.33
9.	Perceptions of hot and cold are unrelated to energy transfer.	33.33	30.00	23.33
10.	Heating always results in an increase in temperature.	48.33	43.33	35.00

11.	The temperature of an object depends on its size or amount.	50.00	40.00	26.00
12.	Temperature can be transferred.	46.66	36.00	26.66
13.	Objects at different temperatures that are in contact with each other do not necessarily move towards the same temperature.	33.33	26.66	21.66
14.	Boiling point is the maximum temperature a substance can reach.	45.00	38.66	32.00
15.	The temperature at boiling does not remain constant.	45.00	40.00	31.66
16.	The boiling point of water is 100°C only.	50.00	41.00	34.33
17.	Steam above boiling water in a kettle is at a temperature lower than 100°C.	48.66	42.66	33.33
18.	Steam above boiling water in a kettle is at a temperature greater than 100°C/ waters' temperature.	49.66	41.66	35.00
19.	Ice is always at 0°Cand/or cannot change temperature.	50.00	43.33	36.33
20.	Water cannot be at 0°C.	51.66	45.00	36.66

It appears from the findings that the students had developed conceptual understandings about only those aspects of heat and temperature due to the similarities between personal experiences in their daily life and scientific conceptions. However, they might face problems in giving correct scientific reasons behind their personal experiences. The findings also seem to reveal that most of the students held alternative conceptions about heat and temperature. They seem to be so confused about the concepts of heat and temperature that they could not explain the differences between them. Some students also considered the terms "heat" and "temperature" as the same concepts. This may be due to the contrast between personal experiences and scientific conceptions.

Conclusion and Implications

The findings have clearly proved the prevalence of alternative conceptions about heat and temperature among upper primary school students. It may be suggested that teachers should emphasise upon: developing students' conceptual understanding by relating personal life experiences of students with scientific concepts using suitable illustrations and experimentations or activities; encouraging students to express their experiences by using the technical terms and concepts so as to ensure transfer of learning about heat and temperature; making a comprehensive list of all sorts of experiences the students are likely to have about heat and temperature through their lives outside school; developing diagnostic test to find out which ones of these experiences are different from their corresponding scientific facts; and planning, designing and implementing suitable teaching strategies for developing conceptual understanding and remediating alternative conceptions about heat and temperature among students.

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