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The effect of inquiry based learning on gifted and talented students' mental states in learning the concepts of acids-bases

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Abstract

The purpose of this study was to investigate the effect of inquiry based learning approach on students' mental states in learning the concepts of acids-bases. A nonequivalent control group design was used in this study. Eight grade gifted and talented students were participated in the study. The students were applied Mental State Conceptual Learning Inventory (MSCLI) which was developed by Liu, Hou, Chiu and Treagust (2014) and adapted into Turkish by Dinçol Özgür (2016) to determine their mental states in learning the concepts of acids-bases. The inventory includes four factors: emotions, intentions, internal mental representation and external mental representation. During the implementation, inquiry based learning approach was used in the experimental group and the traditional instruction was used in the traditional group. The results showed that there was a statistical significant difference between the experimental and control groups in internal mental representation and external mental representation factors.

Keywords: Acids-bases, inquiry based learning, mental states in learning the concepts of acid-base.

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1. Introduction

Education today should focus on helping students to learn how to learn so that they can cope with continuously changing knowledge, technology and social condition demands (Barron & Darling-Hammond, 2008). Learner-centred constructivist approach – which encourages students to research and inquire in attaining the goals set and to share their experiences (Brooks, 1990) so as to uncover their prior knowledge, and in which they are responsible for their learning (Loyens & Gijbels, 2008) - has been gaining importance. Inquiry based learning, which is based on constructivist approach, helps students to improve their research skills and upper order thinking skills and thus it aims to enable students to learn to learn, and it considers research process rather than output important (Lim, 2001). Inquiry based learning is described as the process of learning by inquiring, researching and analysing the knowledge and thus transforming the data into usable knowledge (Perry & Richardson, 2001). The inquiry activities learners do by collecting evidence and creating arguments, by researching the answers to the unknown and indefinite situations just like real scientists enable them to understand more easily the process that scientist go through in their research (Hofstein, Kipnis & Kind, 2008). It is pointed out that the main strategy to use in improving the learning of the gifted and talented students – who have the cognitive and affective potential to solve multifaceted and complicated problems (Clark, 2013) is inquiry (VanTassel-Baska & Brown, 2007).

Mental states are defined as type of energy individuals which activate and generate observed mental habits, thinking and techniques (Perner, 1991). Students' mental states are an important starting point for teachers to help them teaching the scientific concepts and students' mental states can influence not only their motivation and attitudes to learn and also their conceptual learning outputs in learning science (Liu et al., 2014). Since science trigger curiosity and imagination that gifted and talented students have in relation to their natural environment and objects around them, they have interest in science (Smutny & von Fremd, 2004). Effective and differentiated learning environments to be created in this field will be influential in their curiosity, interests, desire to research, abilities to make inferences and solve problems and in their mental states.

1.1. Aim of the study

In the literature, there are no studies in which activities for gifted and talented students in relation to guided inquiry based learning environments are designed, implemented and results are evaluated in the subject of Acids-Bases. Therefore, this study aims to research the effects of guided inquiry based learning activities on gifted and talented students' mental states in learning the concepts of Acids-Bases. In this aspect, we are guided by the following research questions:

1) Is there any statistically significant difference between Mental States Conceptual Learning Inventory (emotions, intentions, internal mental representation and external mental representation) scores of the experimental and control group students according to the methods of teaching employed?

2) Is there any statistically significant difference between Mental State Conceptual Learning Inventory total scores of the experimental and control group students according to the methods of teaching employed?

2. Method

Nonequivalent control group design (Table 1) was used in the study.

Table 1. Nonequivalent control group design of the table

Groups	Pretest	Treatment	Post-test
Experimental Group	MSCLI	Guided inquiry based learning approach	MSCLI
Control Group	MSCLI	Traditional teacher- centered instruction	MSCLI

Mental State Conceptual Learning Inventory (MSCLI)

2.1. Study group

40 eight grade gifted and talented students from one Science and Art Center in Ankara, are included in the study.

2.2. Data collection tools

Mental State Conceptual Learning Inventory (MSCLI): In order to determine the students mental states in learning the concepts of Acids-Bases, Mental State Conceptual Learning Inventory originally developed by Liu, Hou, Chiu and Treagust (2014) and adapted into Turkish by Dincol Ozgur (2016) was used.

The original inventory is composed of a total of 40 items with 5-point Likert-type scale under four factors: Emotions, Intentions, Internal Mental Representation, and External Mental Representation. The Cronbach's α reliability coefficients calculated for emotions factor as 0.88, intentions factor as 0.79, internal mental representation as 0.71 and external mental representation as 0.70 (by Liu et al., 2014).

Confirmatory factor analysis was performed by trying the four models one by one for construct validity in adapting the scale, and it was found that the best fit values were yielded by the "hierarchical" model. Having made the necessary modifications and having removed the 4 items which needed to be removed [$\chi 2$ (585, n= 700) = 2730.29, p< 0.000, RMSEA = 0.072, GFI = 0.75, CFI = 0.90, NNFI = 0.89], the model had good fit in analyses performed. Cronbach's Alpha values calculated for the scale of 4 factors and 36 items are shown in Table 2.

Table 2. Cronbach' s α values and item number on MSCLI (N=700)

Scale	Item number	Cronbach'sα
Emotions	10	.835
Intentions	8	.816
Internal mental representation	8	.835
External mental representation	10	.844
Total	36	.911

2.3. Procedure

The topics under the title of Acids-Bases on which designing the application process and preparing the activities were based were as in the following: The Properties of Acids and Bases, the Names and Formulas of Acids and Bases, Acid-Base Reactions, the Measurement of Acidity and Basicity, Acids and Bases in Daily Life, and Acid Rains.

The subject of Acids-Bases was taught through Guided Inquiry activities in the experimental group. Inquiry cycle (Figure 1) which was designed by Llewellyn (2007) as a guide in planning the inquiry based learning environments was used in performing the guided inquiry activities.

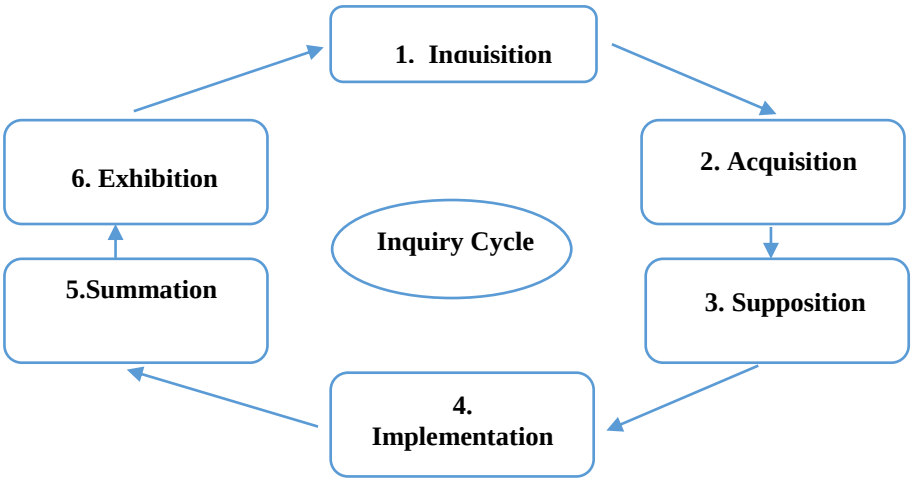

Figure 1. The inquiry cycle

Traditional method, in which the teacher is active, was used in the teaching of "Acids-Bases" to the control group. The data collection tools were given to the students as a pre-test two weeks before teaching the subject of Acids-Bases, and as a post-test one week after the applications.

2.4. Data Analysis

The SPSS statistics package programme was used in analysing the research data. Having checked whether or not the assumptions of normality, equality of variance, equality of covariance matrices and independency of observation were met; Multivariate analysis of variance (MANOVA) was performed. Prior to the applications in the experimental and the control groups, MANOVA and independent sample t-test analyses were done in order to find whether or not there were any differences between scores for dependent variables (Emotions, Intentions, Internal Mental Representation, External Mental Representation factors and total score of MSCLI). MANOVA analysis was done so as to find whether or not there was any statistically significant difference between the experimental group and the control group students' MSCLI scores (Emotions, Intentions, Internal Mental Representation, External Mental Representation), whereas independent samples t-test was done in order to find whether there was any statistically significant difference between MSCLI total scores.

3. Results

Prior to the applications in the experimental and the control groups, the analysis results on whether or not there is any difference between scores for dependent variables are presented below.

The MANOVA results for emotions, intentions, internal mental representation and external mental representation show that there is no significant difference between the gifted and talented students'

pre-test scores for emotions, intentions, internal mental representation and external mental representation in the experimental group and the control group, Wilks Lambda (^)= .541, F(4,35)= 0.541,p = .707, p>.01.

According to independent sample t-test analysis, it was found that there was no statistically significant difference between the experimental group and the control group students' MSCLI total pre-test scores, t (38)= .796,p = .431, p >. 01.

In relation to the first research question, it was found in consequence of the MANOVA for emotions, intentions, internal mental representation and external mental representation that there were significant differences between the gifted and talented students' post-test scores for emotions, intentions, internal mental representation and external mental representation according to learning through guided inquiry and learning in traditional method, Wilks Lambda (^)= .552, F(46,353)=7.096, p= .00, p<.01. This result shows that the scores obtained from the linear components containing post-test scores for emotions, intentions, internal mental representation and external mental representation differ according to the method of teaching employed.

Table 3 shows the dependent variables on which the differences emerging in the experimental and control group students' post-test scores for emotions, intentions, internal mental representation and external mental representation are dependent.

Table 3. Tests of between subject effects

Source	Dependent variable	Type III Sum of Squares	df	Mean Square	F	p	Partial eta squared
Group	**Emotions**	416.025	1	416.025	4.954	.032	.115
	Intentions	46.225	1	46.225	.711	.405	.018
	Internal mental representation	291.600	1	291.600	7.520	.009	.165
	External mental representation	372.100	1	372.100	23.352	.000	.381

Pallant (2001) says that a more reliable level of alpha level should be determined while examining variance analysis tables, and suggests that the standard alpha level should be divided by the number of analyses done, and the tables should be examined according to the alpha value found. In this study, the alpha value was found to be 0.0125 on dividing the normal alpha level by the number of tests given (.05/4).

An examination of Table 3 according to this value demonstrates that there are significant differences between experimental group and control group students' post-test scores for internal mental representation and external mental representation.

Besides, partial eta-square values given demonstrate the extent to which method of teaching (independent variable) accounts for emotions, intentions, internal mental representation and external mental representation post-test scores (dependent variables). Accordingly, the situation may be interpreted as that teaching method accounts for 38% of external mental representation post-test scores, and that it accounts for 16.5% of internal mental representation post-test scores.

And finally, the sources for the significant difference between groups can be examined in the table of Estimated Marginal Means.

Table 4. Estimated marginal means

Dependent variable	Group	Mean	Std.Error	%95 Confidence Interval	
				Lower Bound	Upper Bound
Emotions	**Experimental**	43.200	2.049	39.052	47.348
	Control	36.750	2.049	32.602	40.898
Intentions	**Experimental**	19.950	1.804	16.299	47.348
	Control	17.800	1.804	14.149	21.451
Internal mental representation	**Experimental**	34.050	1.392	39.052	47.348
	Control	28.650	1.392	25.831	31.469
External mental representation	**Experimental**	45.650	.893	43.843	47.457
	Control	39.550	.893	37.743	41.357

According to Table 4, the significant difference between the experimental group and the control group students' post-test scores for internal mental representation and external mental representation shown in Table 3 is in favour of the experimental group students.

In regard to the second research question, the results for independent samples t-test- which was performed so as to find whether or not there were any statistically significant differences between the experimental group and the control group students' MSCLI post-test total scores- are shown in Table 5.

Table 5. Independent sample t-test results

Group	N	$\bar{X}$	sd	df	t	p	Levene's Test for Equality of Variances	
							F	p
Experimental	20	157.10	16.638	38	4.530	.000	. 2.776	.104
Control	20	130.55	20.249					

There are statistically significant differences between students' MSCLI post test results in the experimental group and the control group according to the method of teaching, t (38) = 4.530, p<.01. Thus, the experimental group students' scores ($\overline{X} = 157.10$) are higher than those of control group students' scores ($\overline{X} = 130.55$). The interpretation for this finding may be that there are significant correlations between MSCLI total scores and the method of teaching.

Following the analyses, the value for partial eta-square (effect size, η^2) was calculated as η2=0.35. The value shows how much of the variance in the dependent variable is explained by the independent variable, and accordingly, the values in the .01-.06 range mean small, .06 and above mean medium, and .14 and above mean large (Cohen, 1988; cited in Akbulut, 2010). Thus, the size of the effect is quite high.

4. Conclusion and Discussion

In this study, the effect of guided inquiry based learning approach on gifted and talented students' mental states in learning the concepts of Acids-Bases has been examined. The results for MANOVA which was performed in relation to post-test scores for emotions, intentions, internal mental representation and external mental representation show that there are significant differences between gifted and talented students' emotions, intentions, internal mental representation and external mental representation post-test scores according to being exposed to guided inquiry learning environment or to traditional learning environment, Wilks Lambda (^)= .552, F(46, 353)= 7.096, p<.01. According to the new alpha level calculated, significant differences were found between the experimental group and the control group students' post-test scores for internal mental representation and external mental representation in favour of the experimental group students (p<.0125). The interpretation for this situation might be that 38% of external mental representation post-test scores and 16.5% of internal mental representation post-test scores are explained by the method of teaching. According to the results for independent samples t-test which was performed so as to find whether or not there were any statistically significant differences between the experimental group and the control group students' MSCLI post-test total scores (on the basis of teaching method)- it was found that there were significant differences, t (38) = 4.530, p<.01. Thus, the experimental group students' scores ($\overline{X} = 157.10$) are higher than those of control group students' scores ($\overline{X} = 130.55$).

The results obtained showed that guided inquiry learning approach was influential in the increase of gifted and talented students' total scores for MSCLI and in their scores for the factors of internal mental representation and external mental representation. When students participate in a science class to learn scientific concepts, they have differing mental states each of which is about a scientific concept; and those mental states contain their emotions for scientific concepts, their aims in learning the concepts, and the mental representations of the scientific concepts. Those mental states affect students' understanding of scientific concepts, and they also influence the learning activity of ensuring conceptual change in students (Liu et al. 2014). Items associated with the factors of internal mental representation and external mental representation contain statements about picturing the abstract concepts about acids and bases in mind, concretising them and applying them to daily life, and using the relevant data in the solution of the problems. In the process of guided inquiry learning, students' asking questions and researching accordingly helped them to learn the relevant concepts by internalising them, their researching helped them to associate the topic with their daily life; and all these resulted in an increase in students' positive responses to the factors of internal mental representation and external mental representation. These factors are related in general with students' understanding the subject of Acids-Bases. Therefore, research results which indicate that inquiry learning improves students' abilities to interpret and transfer what they learn into other fields, and that they learn in-depth and meaningfully (Bodner, 1990; Colburn, 2004; Hand & Treagust, 1991; Laverty & McGarwey, 1991; Leonard 2000; Mullen, Rutledge & Swain, 2003) are supportive of our results.

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