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# An Investigation of Pre-Service Chemistry Teachers' Learning Approaches and Inorganic Chemistry Achievements

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**Abstract:** The inorganic chemistry is one of the essential courses in the education of pre-service chemistry teachers. This study investigates the differences between the adopted learning approaches and achievements of Turkish pre-service chemistry teachers' who received the inorganic chemistry course from the same lecturer. The purposes of this study are to explore the relationship between the inorganic chemistry achievements and the adopted learning approaches of pre-service chemistry teachers and to examine the effect of their learning approaches on their inorganic chemistry achievements. This study was conducted with 127 pre-service chemistry teachers from the Department of Chemistry Education at one of the public university in Turkey. "The Study Process Questionnaire" and "The Inorganic Chemistry Achievement Exams" were used as the data collection tools. The descriptive statistics and chi-square test were used for the data analysis. The results of the study displayed that (1) there is a significant relationship between the pre-service chemistry teachers' inorganic chemistry achievement and their learning approach; (2) their learning approach has 34 % effect on their inorganic chemistry achievements according to Somers'd value.

**Keywords:** *Achievement, learning approaches, inorganic chemistry, pre-service chemistry teachers.*

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## Introduction

In the past few decades, the researchers have focused on the effect of variables such as the individuals' general ability, cognitive process, feelings, motivation, developmental characteristics, and preliminary information, past experiences, social environment, and family on the learning. All of these different variables reveal the individual differences and differentiate the learning processes (Erden & Altun, 2006). Moreover some of the students in the same learning environment during the teaching process are successful at the end of the process, while some of them fail. Feeling anxiety about the exams that are important in evaluating the achievement of students (Hancock, 2001; Hill & Wigfield, 1984), having not the efficient and effective study skills and using the inadequate study strategies causes students to fail (Kucukahmet, 2000; Yesilyaprak, 2000). Students who acquire the effective study skills do not only learn one particular topic, but also they learn how to learn (Thomas, 1993). The meaningful or rote learning is another factor that affects the success of students. When learners are integrated the preliminary information with the new information presented to them, meaningful learning is provided through reorganizing (Ausubel, 1968, as cited in Acikgoz, 2008). The students' rote or meaningful learning is associated with learning approaches (Chin & Brown, 2000). The learning approach has also been investigated in relation to the academic achievement, as an individual-difference variable (Zhang, 2000).

The students' approaches based on the learning (deep or surface) are described as incorporating both the strategy and the reasons of adopting the strategy (Prosser & Millar, 1989). The learning approaches state how learners approach to academic tasks (Mattick, Dennis & Bligh, 2004). The constructs of deep and surface approaches related to the learning were introduced firstly by Marton and Säljo (1976). The third approach was then added in addition to these two approaches. Biggs (1979) described this approach as an "achieving approach" and Entwistle and Ramsden (1983) described it as a "strategic approach". "The Study Process Questionnaire" which is used in this study examines the learners' learning approaches in deep and surface. Learners adopting the surface approach have the minimum interaction with the learning task (Smith & Colby, 2007). Learners do not connect the learned topics with their individual experiences. The most frequently strategy which is used by students who adopt the surface approach is the memorization without the meaningful learning (Beattie, Collins & McInnes, 1997; Biggs, 1993; Entwisle, 2000; Marton

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& Säljo, 1997). The desire on passing the course or the fear of failure at the course are the motivating factors for students who adopt the surface learning approach. They memorize and repeat the topics that can be asked in the exams (Newble & Entwistle, 1986). The students adopting the deep approach configure a new information with the current knowledge meaningfully and correlate the concepts to the experiences in their daily life. Their main objectives are to learn by understanding. The students adopting the deep approach enjoy in learning, and they hold the information in long-term memory. The deep learners examine the rationale of the claims and interpretations which are presented to them (Ashcroft & Foreman-Peck, 1994; Beattie et al., 1997; Entwistle, 2000; Newble & Entwistle, 1986; Ramsden, 2000; Williams, 1992). The individuals who adopt the deep approach use also the metacognitive strategies such as self-questioning, self-evaluation of ideas and detection of errors (Marshall & Case, 2005).

In the study, pre-service chemistry teachers' inorganic chemistry achievements and their learning approaches are intended to examine. The chemistry plays an important role in explaining many events that occur in the daily life. As it contains the abstract concepts, the chemistry course is found difficult by the students and they have difficulties in understanding the chemistry (Abraham, Grzybowski, Renner & Marek, 1992; Beerenwinkel, Parchmann & Gräsel, 2011; Boo & Watson, 2001; Bradley & Mosimege, 1998; Garnett, Garnett & Hackling, 1995; Johnstone, 2000; Kizilaslan, 2013; Nakhleh, 1992; Orgill & Bodner, 2004). A significant part of the chemistry field is the inorganic chemistry. The inorganic chemistry is a branch of chemistry that examines the characteristics of substances (elements and compounds) that are not organic, such as nonliving matter and minerals which are found in the earth's crust, their chemical and physical properties, and their tendency to react. The recent developments have shown that it is not only integrated with the other areas of chemistry such as organic, analytical and physical chemistry however covers areas of science such as physics, biology and geology. The Inorganic Chemistry I and Inorganic Chemistry II courses are compulsory courses which are taught in the chemistry teacher program in Faculty of Education.

One of the main goal of the educational psychology is also to teach teachers to be a good learner and a good teacher. The teacher who is a good learner namely who is aware of his/her own learning process, will gain these skills effectively to their students. Thus, it will happen spontaneously that the teacher is a good teacher (Dembo, 2001). For this reason, it is important that the pre-service teachers who will become teachers in the future being successful in their undergraduate educations and which learning approaches they adopted. In the study, the pre-service chemistry teachers have taken the Inorganic Chemistry I course in the same content and with the same teaching methods and techniques, from the same lecturer. However, it has been determined that there were differences between the inorganic chemistry achievement levels of the pre-service chemistry teachers. It has been indicated that there is a positive relationship between the individuals' learning approaches and academic achievements (Albaili, 1995; Bernardo, 2003; Biyikli, 2016; Byrne, Flood & Willis, 2002; Diseth & Martinsen, 2003; Mayya, Rao & Ramnarayan, 2004; Murphy & Alexander, 2002; Stiernborg & Bandaranayeke, 1996; Trigwell & Prosser, 1991). This study addressed the gap in literature about the effect of learning approaches on the pre-service chemistry teachers' inorganic chemistry achievements. In this regard, the purposes of this study are to explore the relationship between the inorganic chemistry achievement and the adopted learning approach of pre-service chemistry teachers and to examine the effect of their learning approaches on their inorganic chemistry achievement. The following research questions were addressed:

1. What are the adopted learning approaches of pre-service chemistry teachers?
2. What are the inorganic chemistry achievement levels of pre-service chemistry teachers?
3. Is there any significant correlation between pre-service chemistry teachers' inorganic chemistry achievement levels and their adopted learning approach?
4. Is there any effect of learning approach on the pre-service chemistry teachers' inorganic chemistry achievement?

## Methodology

*Research Model*

In this study, the correlational research was used to determine the relationships between the inorganic chemistry achievements and learning approaches of pre-service chemistry teachers. The main purpose of a correlational research is determining the relationships between two or more variables or using them to make predictions (Gay & Airasian, 2000).

*Study Group*

This study was conducted with 127 pre-service chemistry teachers (42 male and 85 female) from the Department of Chemistry Education at one of the public university in Turkey. The participants were approximately at 19-22 years old and have taken the inorganic chemistry I course from the same lecturer.

*Content and Teaching of Inorganic Chemistry I Course*

The pre-service chemistry teachers have taken inorganic chemistry I course in the fall semester of the second-class. In teaching of inorganic chemistry course, direct instruction, question and answer, class discussion and modelling methods and techniques are used.

Inorganic Chemistry I course contains the topics such as the electron structure of atom, chemical bonding, transition metals and coordination compounds, nomenclature of coordination compounds, chemical bonding in coordination compounds, theories of chemical bonding, effective atomic number (EAN) rule, valence bond theory (VBT), molecular orbital theory (MOT) and crystal field theory (CFT).

*Data Collection Tools*

"The Study Process Questionnaire" and "Inorganic Chemistry Achievement Exams" were used as the data collection tools in the current study.

*The Study Process Questionnaire (SPQ):* SPQ which was developed by Biggs (1987), revised by Biggs, Kember and Leung (2001) and adapted into Turkish by Yilmaz and Orhan (2011) was used to determine the pre-service chemistry teachers' learning approaches. The adapted SPQ consists of 20 items with a five-point Likert-type scale and 2 factors which are the deep approach (10-item) and surface approach (10-item). Cronbach Alpha coefficients values were calculated for the deep approach factor as 0.79 and the surface approach factor as 0.73 (Yilmaz & Orhan, 2011).

*Inorganic Chemistry Achievement Exams:* During the semester, the pre-service chemistry teachers have two midterm exams and one final exam in the inorganic chemistry course. The examples of inorganic chemistry exam questions are given in Table 1. In the determination of achievement level, 50% of midterm exams levels and 50% of final level have been taken. The course achievement level of the pre-service chemistry teachers is labelled according to alphabetical system. In this system, "A" is very successful, "B" is successful, "C" is middle level, "D" is passing grade and "F" is failure. The score's interval which is represented by the alphabetical system is as: A: 100-85, B: 84-70, C: 69-55, D: 54-50 and F: 49-0.

*Table 1. The examples of inorganic chemistry questions*

| | |
|---|---|
| Name the given coordination compounds. | **A.** $[Cr\ (en)_3]^{3+}$<br>**B.** $[Co\ (SCN)_2\ (NH_3)_4]SO_4$<br>**C.** $K_3\ [Fe\ (CN)_6]$ |
| Write the formulas of the given coordination compounds. | **A.** Sodiumpentachloridonitridoosmate(VI)<br>**B.** Dichloro bis-(methylamine) copper (II)<br>**C.** Tetraamminesulphatocobalt(III) nitrate |
| Explain the given complexes according to EAN and VBT. | **A.** $[Co\ (en)_3]^{3+}$<br>**B.** $Ni(CO)_4$ |
| Explain the given complexes according to VBT and CFT. | **A.** $[Cr\ (NH_3)_5Cl]^{2+}$ (low spin)<br>**B.** $[FeF_5H_2O]^{2-}$ (high spin) |
| Explain the given molecules according to MOT. | **A.** $O_2$ **B.** $O_2^-$ **C.** $O_2^{2-}$ |

*Analyzing of Data*

Descriptive statistics and chi-square test were used for analyzing of data.

## Results

Total scores for each group of learning approaches were computed in order to determine the learning approach of pre-service chemistry teachers. It has been determined that they prefer the learning approach which they get high scores. Table 2 shows the distribution of pre-service chemistry teachers' learning approach groups.

*Table 2. The distribution of learning approaches of pre-service chemistry teachers*

| Learning approach | Frequency | Distribution % |
|---|---|---|
| Deep approach | 75 | 59.1 |
| Surface approach | 52 | 40.9 |
| Total | 127 | 100 |

It was determined that 59.1 % of the pre-service teachers adopted the deep learning approach and 40.9 % of them adopted the surface learning approach.

The distribution of achievement levels of inorganic chemistry of the pre-service teachers at the end of the semester, is presented in Table 3.

*Table 3. The distribution of inorganic chemistry achievement level*

| Final Note | Frequency | Distribution % |
|---|---|---|
| A | 45 | 35.4 |
| B | 40 | 31.5 |
| C | 25 | 19.7 |
| D | 7 | 5.5 |
| F | 10 | 7.9 |
| Total | 127 | 100 |

It was determined that 35.4 % of pre-service teachers had "A", 31.5 % of them had "B", 19.7 % of them had "C", 7.9 % of them had "F" and 5.5 % of them had "D" achievement level.

The cross tabulation showed the distribution between the inorganic chemistry achievement of pre-service teachers and their adopted learning approach is given in Table 4.

*Table 4. The learning approach * inorganic chemistry achievement level*

| | | | Inorganic Chemistry Achievement Level (ICAL) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **A** | **B** | **C** | **D** | **F** | **Total** |
| Learning approach (LA) | Deep approach | Count | 33 | 26 | 11 | 2 | 3 | 75 |
| | | % within LA | 44.0% | 34.7% | 14.7% | 2.7% | 4.0% | 100.0% |
| | | % within ICAL | 73.3% | 65.0% | 44.0% | 28.6% | 30.0% | 59.1% |
| | | % of Total | 26.0% | 20.5% | 8.7% | 1.6% | 2.4% | 59.1% |
| | Surface approach | Count | 12 | 14 | 14 | 5 | 7 | 52 |
| | | % within LA | 23.1% | 26.9% | 26.9% | 9.6% | 13.5% | 100.0% |
| | | % within ICAL | 26.7% | 35.0% | 56.0% | 71.4% | 70.0% | 40.9% |
| | | % of Total | 9.4% | 11.0% | 11.0% | 3.9% | 5.5% | 40.9% |
| Total | | Count | 45 | 40 | 25 | 7 | 10 | 127 |
| | | % within LA | 35.4% | 31.5% | 19.7% | 5.5% | 7.9% | 100.0% |
| | | % within ICAL | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| | | % of Total | 35.4% | 31.5% | 19.7% | 5.5% | 7.9% | 100.0% |

According to Table 4, 44 % of pre-service teachers who adopted deep approach had the level A, 34.7 % of them had the level B, 14.7% of them had the level C, 2.7% of them had the level D and 4% of them had the level F. 23.1 % of pre-service teachers who adopted the surface approach had the level A, 26.9% of them had the level B, 26.9% of them had the level C, 9.6% of them had the level D and 13.5% of them had the level F.

73.3 % of the pre-service teachers had the level A adopted the deep approach and 26.7% of them had the level A adopted the surface approach; 65% of them had the level B adopted the deep approach and 35 % of them had the level B adopted the surface approach; 44 % of them had the level C adopted the deep approach and 56% of them had the level C adopted the surface approach; 28.6 % of them had the level D adopted the deep approach and 71.4 % of them had the level D adopted the surface approach; 30% of pre-service teachers had the level F adopted the deep approach and 70% of them had the level F adopted the surface approach. The results which are obtained to examine whether this distribution is statistically significant or not are presented in Table 5.

*Table 5. Chi-square tests*

| | **Value** | **df** | **Asymp.Sig(2-sided)** |
|---|---|---|---|
| Pearson Chi-Square | 12.904[a] | 4 | .012 |
| Likelihood Ratio | 12.993 | 4 | .011 |
| Linear-by-Linear Association | 12.010 | 1 | .001 |
| N of Valid Cases | 127 | | |

a. 3 cells (30,0%) have expected count less than 5. The minimum expected count is 2,87.

When Table 5 is examined, it has been seen that the number of pores which are smaller than the expected value of 5 in this analysis exceeds 20% (30%) of the total number of pores. However, when the expected count value is above of 2 ($E_{ij} \geq 2$), it is possible to interpret the significance test because the chi-squared distribution assumption is valid (Saracbasi & Aktas-Altunay, 2016). According to the results which were obtained; it has been determined that the differences which are observed in the inorganic chemistry achievement levels of pre-service chemistry teachers who adopted the different learning approaches are significant in the positive direction [$\chi^2 = 12.904$, $p < .05$]. There is a significant relationship between the inorganic chemistry achievement levels of pre-service chemistry teachers and their adopted learning approaches.

According to Somers'd value could be said that the adopted learning approach of pre-service teachers has 34% effect on their inorganic chemistry achievement [Somers'd value $_{(\text{achievement dependent})} = .341$, $p = .000$; $p \leq .01$].

## Discussion and Conclusion

The current study examined the relationship between the pre-service chemistry teachers' inorganic chemistry achievements and their adopted learning approaches and explored the effect of learning approaches on their inorganic chemistry achievements. Consequently, the greater part of pre-service chemistry teachers adopted the deep learning approach and the others adopted the surface learning approach. In the literature, it has been determined that most of teacher candidates adopt the deep learning approach (Besoluk & Onder, 2010; Sezgin-Selcuk, Caliskan & Erol, 2007). Ilkorucu (2017) and Oguz and Karakus (2017) reported that most of pre-service science teachers adopted the deep approach.

As a result of this study, it was found that pre-service chemistry teachers' inorganic chemistry course achievement levels were mostly A (35.4 %), followed by B (31.5 %), C (19.7 %), F (7.9 %) and D (5.5 %) respectively. The pre-service teachers who had A and B levels adopted mostly the deep approach (73.3 % - 65%) but those who had C, D and F levels adopted mostly the surface approach (56 %- 71.4 % - 70%). Furthermore, it was found that there was a significant relationship between the inorganic chemistry achievement levels of the pre-service chemistry teachers and their adopted learning approach, and the adopted learning approach had 34 % effect on their inorganic chemistry achievement according to Somers'd value. The surface learning refers to the rote learning and more temporary learning. However, the deep learning involves the learning with real understanding and the deep learning is related to sophisticated learning outcomes than the surface approaches (Case & Gunstone, 2003; Entwisle, 2000; Newble & Entwistle, 1986; Williams, 1992). Gordon and Debus (2002) stated that the higher quality learning would be with the greater usage of deep approaches. The results of this study are corroborated with the earlier studies in which a positive correlation was found between high achievement grades and the deep learning approach (Bernardo, 2003; Booth, Luckett & Mladenovic, 1999; Byrne et al., 2002; Gow, Kember & Cooper, 1994). As the results of studies, there was a meaningful relationship between the achievements and learning approaches of the students (Albaili, 1995; Bernardo, 2003; Biyikli, 2016; Diseth & Martinsen, 2003; Duff, 2004; Mayya et al., 2004; Murphy & Alexander, 2002; Sezgin-Selcuk et al., 2007; Stiernborg & Bandaranayeke, 1996; Trigwell & Prosser, 1991).

Although it was found that the majority of the pre-service chemistry teachers adopted the deep learning approach (59.1 %), the proportion of them who adopted the surface learning approach (40.9 %) are also high. It was stated in the literature that being a good instructor will be achieved by being a good learner and the educators who are aware of their own learning process can effectively gain these skills to their students (Dembo, 2001; Thomas, 1993). Students could change their approach depending on their interests and perceptions towards the subjects to learn (Duff, Boyle, Dunleavy & Ferguson, 2004). The learning approach is influenced by the variables such as the subject area, learning environment, the relationship between the learners and subject of study and the evaluation criteria in the learning-teaching process (Aydogdu & Ergin, 2010; Biyikli, 2016; Dart et al., 2000; Nelson Laird, Shoup, Kuh & Schwarz, 2008; Reid, Duvall & Evans, 2007). It was found that when learners have positive perceptions about the nature of learning environments and are in the student-centered learning environments, they mostly adopt the deep approach. It was also determined when they have negative perceptions about the nature of learning environments and are only in the teacher-centered learning environments, they adopt mostly the surface approach (Pimparyon, Caleer, Pemba & Roff, 2000; Beausaert, Segers & Wiltink, 2013; Trigwell, Prosser & Waterhouse, 1999). Gibbs and Coffey (2004) stated that after their teachers had been trained about the teaching skills, the teaching approaches and learning approaches of students, the students adopted a surface approach to significantly lesser extent. Shahri, Rahman and Hussain (2017) stated that the Jigsaw technique in the cooperative learning improves the students' deep learning approach.

In the interventions aimed at improving the quality of student learning in higher education, it is needed to modify the perceptions of students about learning and studying for modifying to their behaviour (Richardson & Price, 2003). These efforts are significant for individuals to be successful in their lives and to be life-long learner.

## Recommendations

It could be said that this study is unique in terms of determining the adopted learning approaches of pre-service chemistry teachers and the relationship between the learning approaches and the inorganic chemistry achievements. The result of study displays that there is a relationship between the achievements and learning approaches of pre-service chemistry teachers. Providing meaningful learning for inorganic chemistry is important for the pre-service teachers who will become the chemistry teachers since it is the basis for the other chemistry courses such as analytical chemistry, organic chemistry, physical chemistry that they will take during the undergraduate education. Thus, they could teach chemistry to their students meaningfully and effectively. It is expected that individuals will prefer the deep learning approach for meaningful learning. For this reason, the pre-service teachers should be trained in the student-centered learning environments during their undergraduate education and they should be directed to adopt the deep approach and to use strategies towards this approach. Thus, they will create the learning environments that will direct their students to deep approach and provide the meaningful learning for them. In the further research, the learning approaches of learners could be determined and the interventions could be made in order to improve their learning approaches.

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