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Learning Styles and High School Students' Chemistry Achievement

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ABSTRACT *The aim of the present study was to investigate the effect of students' learning styles on their chemistry achievement, and whether matching between teaching and learning style also affects students' chemistry achievement. Two hundred and sixty-five tenth-grade students enrolled in a chemistry course and seven chemistry teachers participated in the study. Grasha-Riechmann Student Learning Style Scale was used to determine students' learning styles. This scale consists of four clusters obtained from six learning styles as dependent/ avoidant /participant /competitive; participant/ dependent / collaborative; collaborative/ participant/ independent and independent/collaborative/participant learning styles. In order to assess teachers' teaching styles, Teaching Styles Inventory was used. This inventory has four clusters obtained from five teaching styles. The first cluster consists of expert/formal authority; second cluster includes personal model/expert/formal authority; third one contains facilitator/personal model/expert, and the fourth cluster consists of delegator/ facilitator/expert teaching styles. Results showed that there was a statistically significant difference among students with different learning styles with respect to chemistry achievement. Students in facilitator/personal model/expert teaching style and delegator/ facilitator/expert teaching style had better understanding of chemistry concepts, but there was no statistically significant effect of matching between students' learning styles and teachers' teaching styles on students' chemistry achievement.*

Key-words: *Chemistry achievement, learning styles, teaching styles.*

Introduction

In recent years, there has been an increase in the number of studies examining individual differences in learning. From this perspective, learning occurs by actively processing the new information, thinking and using strategies to construct knowledge (Shuell, 1986), and develop cognitive structures that are systematically organized. Individuals differ in the strategies they use during the process of learning. These differences in mode of gaining, processing, and storing information identify one's *learning style* (Davidson, 1990; DeBello, 1990), but there exist different definitions for learning styles. James and Gardner (1995) defined learning styles as the conditions where the learners most effectively perceive, process, store, and recall what they are trying to learn. Processing strategies, regulation strategies, mental models of learning, and learning orientations are among the constituent elements of learning style (Vermunt, 1998). Grasha and Yangarber-Hicks (2000) describe learning style as an individual's preference about how to learn.

Individuals possess a variety of learning styles, but every style is present to varying degrees. For example, some students may prefer more independent learning styles, while others may prefer collaborative styles. Learners should develop a repertoire of styles, so that they can be aware of their own preferences and abilities, and use them in different instructional activities (Coffield, Moseley, Hall, &

Ecclestone, 2004). Kolb (1984) claimed that one's learning style depends on heredity factors, life experiences, and the environment. Thus, due to genetic factors (nature), and educational and other experiences (culture), some learning styles are better developed and more preferred (Grasha & Yangarber-Hicks, 2000). Therefore, when dealing with learning styles, physiological, cognitive, and affective aspects should be taken into consideration. Cognitive aspects involve the processes of encoding, processing, storing, and retrieving information. Physiological aspects involve sensory perceptions, environmental characteristics, times of day for learning and need for food during study. Affective aspects include emotional and personality characteristics, such as motivation, attention, locus of control, interest, persistence, responsibility, and sociability (Cornett, 1983). Dunn (1996) stated that one's preferred learning style includes characteristics, such as, quiet or background noise, bright of low light, formal or causal seating, uninterrupted study or intermittent breaks, perceptual modes, no intake or intake, specific periods during the day, passivity or mobility, global or analytic processing styles. Therefore, learning style inventories that are used for assessing individuals' learning styles should cover all these characteristics. Thus, there exist different inventories developed by different researchers (Kolb, 1984; Honey & Mumford, 1986, Dunn, Dunn, & Price, 1987; Grasha, 1996) for identifying learning styles.

On the other hand, there is a debate on learning style literature among researchers. While some researchers support the idea that learning styles are fixed and stable, it is also claimed that learning styles are "flexibly stable," that previous learning experiences and environmental factors may create preferences, strategies or approaches, which cannot be labeled as styles, and that learning styles depend on context and task (Coffield et al., 2004). Bloomer and Hodkinson (2000, as cited in Coffield at al., 2004) criticize learning style research in that the research explains only a small part of students' dispositions in a learning environment where learners interact with teachers. According to Bloomer and Hodksinson (2000, as cited in Coffield at al., 2004), dispositions are constructed by the contexts and are not simply personal reactions to these contexts. They also claim that dispositions are contextual, cultural, and relational issues, and thus they cannot be measured by the existing learning style instruments.

This debate relates to the question whether learning styles can be measured by using a valid and reliable instrument. Some researchers use learning style instruments to differentiate students quickly and simply, whereas others think that the same instruments are not reliable and valid (Coffield et al., 2004). Other researchers (Kolb, 1984; Honey & Mumford, 1986, Dunn, Dunn, & Price, 1987; Grasha, 1996) developed different inventories to identify individuals' learning styles. Validity and reliability of some of these instruments has been discussed by Coffield et al. (2004). For example, Dunn and Dunn's Model of Learning Styles (1987), which focuses on visual, auditory, kinesthetic, tactile modalities, is a model of instructional preferences, but not learning preferences per se. This model is supported for its validity and reliability, but there are also critics about the design, reliability, and evidence of its validity. In Gregorc's Learning Style Delineator (1985), which considers the same modalities as Dunn and Dunn's Model, there are problems for its psychometric properties, but there is no empirical evidence related to its construct validity. More research is also needed for Honey and Mumford

Learning Style Inventory(1986), which views learning styles as being flexibly stable learning preferences, in order to describe validity and reliability issues. There are also many arguments on Kolb's Learning Style Inventory (1984) in terms of its reliability and validity. Coffield et al. (2004) concluded that all these models are not useful, that there is no consensus on their use in practice, and that every inventory should be used with caution.

In the present study, Grasha-Riechmann Student Learning Style Scale (1996) was used to assess students' learning styles. This scale presents a shift from learning styles to learning approaches, strategies, orientations, personal preferences, and conceptions of learning (Coffield et al., 2004; Grasha, 1996). It views that learning styles are flexible, are not inborn characteristics, and thus they can be changed by instruction (Grasha, 1996). The scale has been extensively used for over two decades (Grasha, 1996), but more research is still needed to validate the instrument.

Research studies also revealed that individuals' learning styles influence their school or academic achievement. Collison (2000) compared learning styles and school achievement of 110 elementary school students. The results indicated that when compared with middle and high achievers, low achievers preferred more formal learning environment that includes wooden, steel or plastic chairs and desks, like those found in most traditional classrooms. Low achievers also preferred to learn with one or more peers compared to high achievers who favored learning alone. High achievers also liked informal learning environments, studying alone, and having self-direction, and flexibility, and they were also more self-motivated, persistent, and responsible.

Snyder (2000) found similar results for high school students. According to her study, students with high GPA were more self-motivated, persistent, and preferred to study alone. On the other hand, students' perceptions of their own academic achievement differed with different learning styles. Mathews (1996) founded that high school students with a converger learning style, who liked to use abstract conceptualization and active experimentation, perceived higher academic performance than other students. Students with a diverger style, who preferred to use reflective observations and concrete experiences, had lower academic performance than students having other styles.

In another study that investigated the relationship between learning styles and achievement, it was additionally examined whether different types of instruction (i.e., technology-based or traditional) are associated with learning styles. The learning styles were classified as dependent, avoidant, participant, collaborative, independent and competitive. The results indicated that students who got A in the traditional courses were less dependent learners. In the technology-based course, the more successful students tended to be more abstract in their thinking. In both courses, there was no relation between competitive learning style and achievement (Grasha & Yangarber-Hicks, 2000).

However, academic achievement depends not only on learning styles but also on teaching styles. Gregorc (1985) defined teaching style as a set of attitudes and actions that mediate student learning formally or informally. Teaching styles shape and guide the teaching-learning process, the ways teachers perceive and organize the content to be taught, and influence how they interact with students and how

they manage classroom tasks. Grasha (1994) specified several factors that affect teaching styles, such as, nature of the course, size of class, subject-mature, level of students, students' attitudes, time pressure, need to prepare students for standard exams, willingness to take risks, and information about alternative ways to teach. Teaching styles depend on different combinations of these factors that determine teachers' variety of teaching styles. Learning and teaching styles are part of one's personality. They are the representations of needs, motives, beliefs, and attitudes toward learning and teaching. Therefore, any teaching strategy will either support the learning style or pressure it to change (Grasha &Yangarber-Hicks, 2000). As a result of longitudinal study, Vermunt and Minnaert (2003) concluded that students' learning patterns, which were assessed by inventory of learning style, changed within the first year of higher education. Several studies indicated that matching students' learning styles with teachers' teaching styles enhance learning (Dunn & Giannitti, 1990; Jerkins, 1991; Hancock, Bray, & Nason, 2002). Moreover, Dunn and Griggs (1989) claimed that retention increases when students are taught through their learning strengths. On the other hand, Stahl (1999) argued that there is no effect of matching students' learning styles with teachers' teaching styles on learning. In fact, the related literature lack consensus about whether matching students' learning styles with teaching styles would improve achievement (She, 2005).

To illustrate the effect of instructional methods and students' conceptual levels on achievement, Hancock, Bray, and Nason (2002) studied with university students taking a computer technology course. Students' conceptual levels were described as their ability to differentiate and integrate information. The researchers identified instructional methods as either teacher-centered or student-centered. In teacher-centered instruction, the teacher was dominant in the classroom. (S)he established the rules, organized learning task, stated and explained concepts, asked convergent questions, directed students' responses by giving feedback or clues, and summarized the lesson. In student-centered instruction, the teacher helped students establish their own rules. (S)he encouraged them to state additional responses, asked divergent questions, favored them to choose the learning task and summarized the lesson. The findings showed that students with high conceptual level had greater achievement in a student-centered instruction group than students with high conceptual level in the teacher-centered instruction group did. In other words, student-centered instruction enhanced the achievement of students who have more complex cognitive structures and tend to think more abstractly (high-conceptual-level students), whereas the students who seek to avoid ambiguity and tend to think more concretely (low-conceptual-level students) benefited from teacher-centered instruction. These findings suggest that both personality characteristics and the learning environment affect learners' achievement. There should be a match between high-conceptual persons and student-centered instruction. Students who think concretely can be successful in the class, if instructional strategies are designed according to their preferences. For this reason, in order to improve students' learning outcomes, teachers should modify their instructional activities in accordance with their students' orientations toward processing information that directly relate to their learning styles. Angeli and Valanides (2004) also indicated that the effectiveness of instructional materials depends on students' cognitive differences. The materials that included visuals in

a spatial and timely coordination with the textual information enhanced the learning of students who were more able to isolate target information from a complex whole, to analyze, and reorganize ideas.

In order to adapt teaching styles to learning styles, teachers should identify their own teaching styles and their students' learning styles as well. For this reason, the main purpose of the present study was to determine tenth-grade students' learning styles, investigate whether and how learning styles affect students' chemistry achievement, and whether any matching between teaching styles and learning styles can affect students' chemistry achievement.

Method

Subjects of the Study

Two hundred and sixty-five tenth-grade students from nine classes in a high school participated in the study. The classrooms included diverse populations with a mixture of white, African American, and Hispanic students. Of the 265 students, 119 were males and 146 were females. The seven teachers of these classes had teaching experience that ranged from 5 years to 17 years.

Instruments

In this study, Grasha-Riechmann Student Learning Style Scale was used to identify students' learning styles, and Teaching Style Inventory was used to determine teachers' teaching styles.

Grasha-Riechmann Student Learning Style Scale (Grasha, 1996) was administered to all students in the study. This instrument consists of 60 Likert-type items with a five 5-point scale, from strongly disagree to strongly agree. Based on the scale, six different learning styles can be identified (competitive, collaborative, avoidant, participant, dependent, and independent) with the following characteristics.

Competitive: Students learn material in order to perform better than other students in the class. They compete with other students in the class to get rewards. They like to be the center of attention and to receive recognition for their accomplishments in class.

Collaborative: Students learn by sharing their ideas and talents. They enjoy cooperating with teachers and other students.

Avoidant: Students are not enthusiastic about learning. They are uninterested in classroom activities. They do not like attending classes and cooperating with teachers and other students.

Participant: Students like to attend classes and participate in class activities. They are eager to learn and try to be a good member in the class.

Dependent: Students have little or no intellectual curiosity. They learn only what is required. They see the teacher and other students as sources of structure and support, and as authorities giving specific guidelines about what to do.

Independent: Students think for themselves and prefer to work alone on course projects, instead of studying with other students. They are confident in their learning abilities. They study what they think important.

According to Grasha (1996), an individual does not have exclusively one learning style, but rather a combination of learning styles. Therefore, Grasha (1996) developed clusters using these six learning styles. He obtained teaching style clusters by thematic analysis of observations of teachers in the classroom, interviews with researchers, and workshops. The order of each style in the cluster shows the importance of that style. In addition, it is stated that students' learning style preferences often change depending on how the teacher structures his/her class. Thus, Grasha proposed certain learning style groups that consist of varying combinations of teaching styles. These learning style clusters are:

- dependent/ avoidant/ participant/ competitive (Group 1)
- participant/ dependent/collaborative (Group 2)
- collaborative/ participant/ independent (Group 3)
- independent/collaborative/participant (Group 4) learning styles.

In order to assign students to the groups, first students' mean scores for each group of learning styles were computed. Then, the mean scores were marked as low, moderate, or high, according to the ranges suggested by Grasha (1996). These ranges are in Table 1.

Table 1

The Ranges for High, Moderate, or Low Scores for Each Learning Style

Learning style type	Low	Moderate	High
Independent	1.0-2.7	2.8-3.8	3.9-5.0
Avoidant	1.0-1.8	1.9-3.1	3.2-5.0
Collaborative	1.0-2.7	2.8-3.4	3.5-5.0
Dependent	1.0-2.9	3.0-4.0	4.1-5.0
Competitive	1.0-1.7	1.8-2.8	2.9-5.0
Participant	1.0-3.0	3.1-4.1	4.2-5.0

The groups with high mean scores were clustered based on Grasha's categories. For example, group 3 and group 4 seem similar, but they are different, because, in group 4, the independent learning style is more dominant than the others, while in group 3, the collaborative learning style is more dominant than the others. The reliability (Cronbach's alpha) of this scale was found to be 0.74. Some sample items from the scale are as follows:

- I prefer to work by myself on assignments in my courses (independent)
- I would prefer that teachers ignore me in class (avoidant)
- I enjoy hearing what other students think about issues raised in class (collaborative)
- I like it whenever teachers clearly state what is required and expected (dependent)
- To do well, it is necessary to compete with other students for the teacher's attention (competitive)
- I try to participate as much as I can in all aspects of a course (participant)

Teaching Style Inventory

This inventory was developed by Grasha (1996). It included 40 items in 7-point likert type scale from strongly agree to strongly disagree. According to this inventory, there are 5 teaching styles as expert, formal authority, personal model, facilitator, and delegator:

Expert: This teaching style displays detailed knowledge and challenges students to improve their competence. It deals with transmitting knowledge. Teachers using this style try to maintain their status among students as an expert.

Formal authority: This teaching style gives importance to the teachers' status among their students stemming from their knowledge and role as a faculty member. These teachers provide positive and negative feedback and establish learning goals, expectations and rules of conduct for their students. They are concerned with the correct, acceptable and standard ways of learning.

Personal model: It emphasizes teaching by personal example. It directs students' learning by establishing a prototype for how to think and behave. These teachers guide students by showing them how to do things and encourage them to observe and imitate the instructor's approach.

Facilitator: This teaching style focuses on teacher-student interaction. These teachers guide students by asking questions, exploring questions, making suggestions for alternatives and encouraging students to take responsibility for their learning. These teachers encourage cooperative as well as independent activities.

Delegator: This style believes that in order to develop students' capacities they should work independently; the teacher should act as a resource person. This style aims at having students become self-directed, self-initiating learners.

Grasha (1996) clustered teaching styles into four groups as expert/formal authority (group 1), personal model/expert/formal authority (group 2), facilitator/personal model/expert (group 3) and delegator/facilitator/expert (group 4). Sample items from this inventory are as follows:

- Facts, concepts, and principles are the most important things that students should acquire (expert).
- I provide very clear guidelines for how I want tasks completed in this course (formal authority).
- Students might describe me as a "coach" who works closely with someone to correct problems in how they think and behave (personal model).
- I guide students' work on course projects by asking questions, exploring options, and suggesting alternative ways to do things (facilitator).
- Activities in this class encourage students to develop their own ideas about content issues (delegator).

Grasha (1996) suggests that the clusters of learning styles are associated with the clusters of teaching styles. The teaching styles listed below help to reinforce and develop the learning styles of students in that cluster:

- Expert/formal authority teaching style cluster supports dependent/ avoidant/ participant/ competitive learning style cluster.

- Personal model/expert/formal authority teaching style cluster supports participant/ dependent/collaborative learning style cluster.
- Facilitator/personal model/expert teaching style cluster supports collaborative/ participant/ independent learning style cluster.
- Delegator/facilitator/expert teaching style cluster supports independent/collaborative/participant learning style cluster.

Procedure

Grasha-Riechmann Student Learning Style Scale was administered to all students, and Teaching Style Inventory was administered to all teachers in the study during a class hour. Students' last-term chemistry grades indicating their overall performance in chemistry class were used as a variable representing their chemistry achievement.

Results

The data obtained from Grasha-Riechmann Student Learning Style Scale and Teaching Style Inventory were analyzed using SPSS (Statistical Package for Social Sciences) program. Students' learning styles distribution was as indicated in Table 2.

Table 2
Students' Clusters of Learning Styles

Clusters	Combinations of Learning Styles	Students (%)
Group 1	dependent/ avoidant/participant/ competitive	24.2
Group 2	participant/dependent/collaborative	40.0
Group 3	collaborative/ participant/ independent	17.7
Group4	independent/collaborative/participant	18.1

The results in Table 2 indicate that 40% of the students were categorized as belonging in group 2 and held participant/ dependent/collaborative styles. Students in groups 1 and 2 had more dependent styles of learning and exhibited little intellectual curiosity to learn. They considered their teacher as an authority and studied the materials in order to be more successful than the other students in the class. They enjoyed classroom activities and tended to share their ideas with other students. On the other hand, students in groups 3 and 4 had more independent styles of learning and preferred to work on projects. They wanted to take responsibility in classroom activities and share their ideas with their friends, while they were also more confident in their learning abilities. From this perspective, most of the students (64.2%) had more dependent learning styles.

In order to investigate whether matching between learning styles of students and teaching styles of teachers had an influence on the students' levels of chemistry achievement, a new variable was constructed by grouping students according to a match between their learning styles and their teachers' teaching styles. Table 3 presents mean and standard deviation scores for students' chemistry grades (out of 100) with respect to learning styles, and Table 4 and 5 present the mean and standard deviation scores for the match/mismatch groups.

Table 3
Mean and SD Scores for Students' Chemistry Grades with respect to Learning Style Clusters

Clusters	Combinations of Learning Styles	Number of Students	Mean	SD
Group 1	dependent/ avoidant/participant/ competitive	64	75.94	7.67
Group 2	participant/dependent/collaborative	106	81.32	6.56
Group 3	collaborative/ participant/ independent	47	86.17	5.95
Group4	independent/collaborative/participant	48	89.81	6.34

Table 4
Mean and SD Scores for Students' Chemistry Grades with Respect to Match Groups

Teaching Style Clusters	Learning Style Clusters	Number of students Mean	Mean SD	SD
Group 1	Group 1	18	74.28	4.09
Group 2	Group 2	12	77.92	7.95
Group 3	Group 3	10	87.20	5.63
Group 4	Group 4	32	89.94	6.72
Total		72	83,64	9.22

Table 5
Mean and SD Scores for Students' Chemistry Grades with Respect to Mismatch Groups

Learning Style Clusters	Number of students	Mean	SD
Group 1	46	76.59	8.63
Group 2	94	81.75	6.28
Group 3	37	85.89	6.07
Group 4	16	83.64	9.22
Total	193	81.96	7.79

A 4 (learning clusters) x 2 (match/ mismatch) analysis of variance (ANOVA) was consequently performed. Table 6 summarizes the ANOVA results.

Table 6
Summary of Two-Way ANOVA for the Effects of Learning Styles on Chemistry Achievement

Source	df	SS	MS	F	p	n^2
Learning Style (A)	3	5634.537	1878.179	41.980	0.000	0.329
Match (B)	1	50.846	50.846	1.136	0.287	0.004
Interaction (A x B)	3	165.168	55.056	1.231	0.299	0.014
Error	257	11498.032	44.739			
Total	265	1817951.000				

The results demonstrated that there was no statistically significant interaction effect between learning style groups and matching between teaching and learning styles. However, a statistically significant mean difference was found among the students with different learning styles with respect to their chemistry achievement.

The strength of the relationship between learning styles and chemistry achievement assessed by *eta* squared (n^2) was strong. Learning styles accounted for 32.9 percent of the variance in chemistry achievement levels. Follow-up analysis was conducted to evaluate pairwise differences among the means. Post-hoc tests (Tukey HSD) revealed that there was a significant mean difference among all learning style groups. In order to investigate whether matching between learning styles of students and teaching styles of teachers had an influence on the students' levels of chemistry achievement, a new variable was constructed by grouping students according to a match between their learning styles and their teachers' teaching styles, and this variable was included in a two-way ANOVA. As summarized in Table 6, this analysis revealed that there was no statistically significant influence of matching on students' chemistry achievement. Students whose learning style matched with their teachers' teaching style had a mean chemistry score of 83.64 and standard deviation of 9.22; students whose learning style did not match with their teachers' teaching style had a mean chemistry score of 81.96 and standard deviation of 7.79.

Conclusions and Implications

The main purpose of this study was to investigate the effect of tenth-grade students' learning styles on their chemistry achievement. The results showed that there was a statistically significant difference among students with different learning styles in terms of chemistry achievement. Students with learning styles of independent/collaborative/participant had higher achievement scores than the students from the other three groups. This result supported the findings of other studies in the literature indicating that students' learning style had a significant influence on their achievement (Mathews, 1996; Cano-Garcia & Hewitt-Hughes, 2000; Beishuizen & Stoutjesdijk, 1999; Collison, 2000; Synder, 2000; Boyle, Duffy, & Dunleavy, 2003; She, 2005). However, although a significant difference in achievement by learning styles was found in these studies, there are some differences with the present study in terms of the grade level, the criteria chosen for an indicator of achievement, and the relationship between the type of learning style and achievement. For example, Collison (2000) study with elementary school students and revealed that high achieving students were independent learners, who prefer to study alone, need less structured learning environment, and benefit from self-selected objectives, procedures, and evaluations. Cano-Garcia and Hewitt-Hughes (2000) concluded for college students that concrete experience learning style best predicts achievement; the students with concrete experience learning style in their study had higher academic achievement. Boyle, Duffy, and Dunleavy (2003) also found a relationship between university students' learning styles and their academic performance. Snyder (2000) used high school students' Grade Point Average (GPA) and Metropolitan Achievement Test (MAT-7) scores in order to explain the relationship between learning styles and achievement, pointing out a positive correlation between GPA scores and tactile/kinesthetic learning style, between MAT-7 scores and visual learning style. On the other hand, Matthews (1996) examined the relationship between perceived academic achievement and learning styles for high school students, and reported that there was a significant effect of learning styles on perceived academic achievement (self-rating); convergers rated themselves as high achievers.

When the mean chemistry scores for students in different learning style groups were examined, it was found that there was an increase in students' mean scores from learning style groups 1 and 2 to learning styles groups 3 and 4. Learning style groups 1and 2 are dependent styles, whereas learning style groups 3 and 4 are independent styles. In other words, students' with independent learning styles were more successful that the other students having dependent learning styles. Students having independent learning style seem to be more confident in their learning abilities. They prefer to learn subjects that are important to them. They like to study alone on a project, term paper, or classroom presentations. They see the teacher as a facilitator and want her to help them when needed. On the other hand, although some research studies indicate that higher achievement is observed when learning styles and teaching styles are matched (Dunn & Giannitti, 1990; Hancock, Bray, & Nason, 2002), in the present study, no effect of matching teaching styles with learning styles on students' chemistry achievement was found. This finding corroborates the results of another study by She (2005).

The higher achievement of students with more independent learning styles might be attributed to the fact that these styles favor taking responsibility for learning, asking divergent questions, and finding alternative ways, which may have caused better acquisition of chemistry concepts. Thus, it can be concluded that when students are given opportunity to think critically about situations, they become more successful. Thus, teachers should use techniques that facilitate students' thinking. Students should be involved in the learning process actively instead of being passive listeners trying to absorb information. Learner-centered teaching methods should be also implemented, and teachers should put more emphasis on interaction among students and guide their students by asking divergent questions. They may also use case studies, cognitive maps, panels, self-discovery activities, small group work teams, student teacher methods, or role-playing. From this point of view, inquiry method is very helpful. It encourages students to investigate and construct scientific knowledge by allowing them to test their explanations and compare them with their existing conceptions. In short, this study implies that students should be encouraged to develop their capacity to be independent learners in order to not only improve their chemistry achievement, but also their learning in general.

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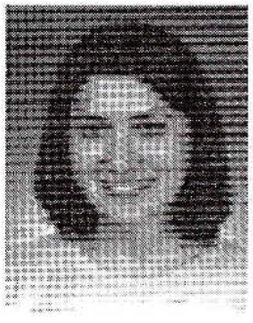

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