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Development and Application of the Democratic Chemistry Classroom Environment Inventory (DCEI) in Iranian Universities

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Abstract

This article reports the development and application of the Democratic Chemistry Classroom Environment Inventory (DCEI) which assesses students' perceptions of six dimensions of their actual and preferred classroom environment: Equality, Important knowledge, Participatory decision-making, Inclusiveness, Rights and Authority. The DCEI was field tested with a sample of 510 Iranian first and second year undergraduate students in 23 chemistry classes. Various analyses attested to each scale's reliability, factorial validity, and ability to differentiate between the perceptions of students in different classes. The data from this instrument is equally valid in its actual and preferred versions. In addition, comparison of Iranian university students' scores on actual and preferred forms of the questionnaire revealed that students, within a democratic education framework, were not satisfied and preferred a more positive chemistry environment on all scales. The work is unique because it is the first classroom environment study which is concerned about democratic education ideas in chemistry classrooms and provides one of the few classroom environment studies conducted in Iran.

Keywords: Democratic Education, Chemistry Classroom Environment, the DCEI, Learning Environments Research, Students' Satisfaction

Introduction

Education should make individuals aware of their responsibilities towards their state and themselves, and to carry out these responsibilities. Students should be taught their constitutional rights of freedom and equality of opportunity, and justice should be provided while applying those rights. One of the places to teach individual rights and responsibilities is the classroom but one cannot teach democracy through non-democratic methods and the principles of a democratic society have to be 'lived' in the classroom if learners are going to understand the full impact of their meaning (Sartor & Brown, 2004).

Becoming an engaged democratic citizen begins by practicing democracy in the classroom. It is in this first community that students should learn to exercise voice; to make choices and take responsibility for their own learning; and to understand, give, and receive fair, equitable and respectful treatment. It is in this environment that they should feel safe to express ideas, explore leadership, and to participate in guiding the classroom community. In the everyday life of the classroom, students should experience democracy at every opportunity, and should cultivate an appreciation of the democratic process.

Democratic education is a relatively new topic in the educational research field. The theoretical aspects of the idea are already well explored and a large number of studies propose different attributes and principles of democratic education (Knight & Pearl, 2000), its

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significance (Veugelersa, 2007; Harber, 1997), and the strategies to realize it in the classroom (Marri, 2005). Democratic education can make a difference in chemistry education. Currently, chemistry education is mostly framed around traditional models, where classrooms limit students to being consumers of knowledge who are expected to memorize facts selected as important by their teacher (Basu, Barton & Tan, 2011). The traditional relationship between teachers and students leave students with limited opportunities to participate in classroom decisions. In addition, current teaching approaches in chemistry education pay little attention to students' intellectual property, the prior knowledge of science that students bring to the classroom from their cultures and home lives, their "funds of knowledge" (Basu, Barton & Tan, 2011).

Some instruments could be provided to assist researchers not only to investigate how democratic education affects the students' final outcomes but also to assess the effects of democratic education ideas on students' perceptions of and satisfaction with their chemistry classroom environments. It is a good idea to provide researchers and educators with some instruments so that they can assess the degree to which a particular chemistry classroom's environment is consistent with democratic education ideas. Some instruments could be elaborated to assist educational practitioners to reflect on their assumptions and change their teaching practice and policies towards more democratic ones in chemistry education.

This paper describes the development of a new instrument for assessing students' perceptions of the psychosocial environment that should exist in democratic chemistry classrooms, and reports comprehensive validation information for a large sample of chemistry university students from Iran. It also explores, in a democratic education framework, Iranian university students' satisfaction with their chemistry classroom environment. The work is distinctive because it is the first classroom environment study which is concerned about democratic education ideas in chemistry classrooms. It also provides one of the few classroom environment studies conducted in Iran.

Democratic education

One of the places to teach individual rights, and responsibilities is the classroom, and the classrooms should be places where students' needs are met, and their rights are guaranteed in a safe and active learning environment. A democratic climate is essential to growing and nurturing democratic values and practices. Democracy cannot be mass delivered to classrooms but has to emerge in the classroom and should be developed from classroom to classroom (Knight, 2001). Kelly (1995) believes that one of the major tasks that education must perform in a democratic society is the proper preparation of young citizens for the roles and responsibilities they must be ready to take on when they reach maturity. One of the purposes of democratic education is to make individuals aware of their responsibilities towards their country, family, local and global community and themselves. To carry out these responsibilities, students should be taught their constitutional rights of freedom, and equality of opportunity, and justice should be provided while applying those rights.

A democratic classroom creates a positive education process for the students and an effective relationship is constructed between the teacher and the students. In order to construct an effective relationship in the classroom, teachers should create a cooperative learning environment, respect the students, plan the class objectives with their students and motivate the students to achieve sufficiency in their social relations (Alobiedat & Saraierh, 2009).

In a democratic learning environment, students' beliefs and values are respected, and also the students respect one another's beliefs and values. Students' cognitive and perceptive awareness level is increased by teaching them democratic values (Henderson, 2001). Making

students feel they are valuable and supporting their autonomy are among the aims of democratic education. Meeting the needs of the students is among the duties of a democratic teacher, as well. Glasser (1996) indicates these needs as belonging, power, freedom, and fun. If these needs are met, students not only will be successful but also they will gain internal motivation (Erwin, 2003; Hardin, 2004).

In a democratic educational setting, students have the sense they are free and they have the right to express their ideas. Students' individual features are respected and they should have the responsibility to sustain their features in the classroom. In order to allow students more freedom, a democratic teacher should appreciate democratic values and adopt appropriate teaching methods where students can easily express their thoughts and ideas (Selvi, 2006). We need to allow democracy to fully operate with all its components so that the spheres of freedom can continue and expand, and, thus, allow individuals to enjoy equality and have faith in the equal opportunities offered them. A teacher who cares about equality in the classroom gives equal opportunity of education to each student, and in doing so, the teacher meets each student's education needs. Therefore, democratic education gives equal opportunity to students so that all students can be successful.

However, some students may need some more special help but this special help should not mean inequality. This means that in order for all students to be successful, the needs of the students should be met, since equality does not mean treating all students in the same way. Equality means to meet the needs of all students (Gathercoal, 2001). Freedom, equality, and justice are applied and emphasized in a democratic classroom. The following are also among the benefits of democratic education (Davies, 2006):

- Students in more democratic learning environments are happier and they feel more in control of their learning.
- If students give feedback on the teaching process, this has the twin effect of teachers' practice improving and students gaining in awareness of the learning process.
- Participation enhances skills of communication and competence among students.
- Skills in different curriculum areas are improved.
- Students' self-esteem and confidence are improved. This comes from taking responsibility and having a sense of ownership of various aspects of school life.
- Interpersonal and political skills are enhanced, particularly through community and voluntary work. Participation in school and outside is an apprenticeship in democracy, where skills of speaking, listening to the views of others, advocacy, argument, negotiation, compromise and teamwork are practiced.
- A final aspect of personal impact is that of agency and efficacy. Students feel they could influence events and school structures, and have a greater sense of direction of their own lives.

Although democratic education ideas are not extensively explored in action, there are a host of studies which are concerned about its theoretical aspects.

Knight and Pearl (2000) present six attributes of democracy that have been generally recognized and apply them to education: (1) the determination of important knowledge; (2) the nature of educational authority; (3) the ordering and inclusiveness of membership; (4) the definition and availability of rights; (5) the nature of participation in decisions that affect one's life; and (6) equality. It is how each of these six democratic components are developed or advanced that will determine whether classrooms move to greater democracy. And it is through their intertwining that students are provided the opportunity to absorb the necessary principles of a democracy and thus are prepared to assume the responsibility of democratic citizenship.

To the best of our knowledge, no comprehensive study exists that explores the effects of democratic education on students' perception and outcomes in chemistry classroom environments. The present study appears to be the first learning environment study concerning the application of democratic education ideas in chemistry classrooms The study specifically uses the ideal of democratic education in chemistry education to call attention to ways of being in the classroom that positions youth as important and powerful participants in their own learning and that of their peers and teachers, and also as members of a larger global society who can leverage their lives in classrooms towards making a change.

Learning environments research

Two lines of research stand out in learning environment research. Walberg and Anderson (1968) developed the Learning Environment Inventory (LEI). Moos (Moos, 1968; Moos & Houts, 1968) developed a number of social climate scales.

The concept of learning environment involves three types of dimensions (Moos, 1974). Moos's three basic types of dimensions for classifying human environments are Relationship Dimensions (which identify the nature and intensity of personal relationships within the environment and assess the extent to which people are involved in the environment and support and help each other), Personal Development Dimensions (which assess basic directions along which personal growth and self-enhancement tend to occur) and System Maintenance and System Change Dimensions (which involve the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change) (Moos, 1974).

A large number of researchers and educators believe that the field of learning environments is of interest and value. Numerous research studies have revealed that student perceptions of the classroom environment account for appreciable amount of variance in learning outcomes, often beyond that attributable to background student characteristics (Dorman, 2001). Fraser (1998) states that the quality of the classroom environment is a significant determinant of student learning and students' positive perceptions of learning environments will lead to meaningful learning.

Decades of research in the field of learning environments have led to the development of a variety of economical and widely-applicable questionnaires for assessing students' perceptions of classroom environments. There are now hundreds of research studies which explore learning environments at various grade levels (primary, secondary, tertiary) and in a variety of classrooms such as science and mathematics, chemistry, computer, biology, geography, physics and language.

Studies on science and mathematics classroom environments have a long tradition in the field and studies such as Yang et al., (2002), Wolf and Fraser (2008) and Fraser et al. (2010) focused on science and mathematics learning environments. Studies such as Maor and Fraser (1996) provide insightful ideas about the nature and promotion of computer classrooms environments. Among the rest, Fisher et al. (1995) focused on biology classroom environments. Geography is another subject area which has been explored in a number of learning environment studies (e.g., Fraser & Chionh, 2009). Psychosocial environments of physics classrooms have also been the subject of studies such as McRobbie et al. (1997) and Terwel et al. (1994). Chemistry classroom environments have also been the target of exploration in different studies (e.g. Hofstein et al., 1996; Hofstein et.al. 1979; McRobbie & Fraser, 1993; Wong et al., 1997). In addition, further studies tried to explore the relationship between learning environments and other educational concepts and in this way they expanded the scope of learning environment research. For example, Trigwell and Prosser (1996), for the

first time, focused on the relationship between qualitative differences in learning outcomes, perceptions of the learning environment and approaches to study. In the following part a brief account of those studies that focus on chemistry classroom learning environments will be presented.

McRobbie and Thomas (2001) report an attempt to change the learning environment in a year 12 chemistry classroom and document changes in participants' perceptions of their learning environments and the corresponding changes in a teacher's and her students' perceptions of their reasoning and understanding that such changes facilitated. A community of learners in which students and teachers began to understand the processes and the value of reasoning in terms of theories and evidence was developed as a result of the involvement of the researchers with the teacher and her class of students.

Quek et al. (1998) cross-validated the Questionnaire on Teacher Interaction (QTI) among 497 tenth grade chemistry students, reported some gender and stream (gifted versus non-gifted) differences in perceptions of teacher-student interaction, and established associations between QTI scales and student enjoyment of chemistry lessons.

Riah and Fraser (1997) used a modified version of the What Is Happening In This Class (WIHIC) questionnaire in Brunei, and reported associations between perceptions of learning environment and attitudinal outcomes. Simple and multiple correlations showed that there was a significant relationship between the set of environment scales and students' attitudes towards chemistry theory classes. The Student Cohesiveness, Teacher Support, Involvement and Task Orientation scales were positively associated with students' attitudes.

In another study, Hofstein and Lazarowitz (1986) compared the actual and preferred classroom learning environment in biology and chemistry as perceived by high school students. With the premise that "the greater the degree of concordance between one's ideal classroom and the actual classroom within which one finds oneself, the greater the degree of satisfaction there is likely to be" (Williams & Burden, 1998), they found that there was a significant difference between students' scores on actual and preferred form.

The present study is among those that report evaluation, exploration or promotion of chemistry classroom learning environments and it is the first study which investigates the application of democratic education ideas for chemistry classrooms.

The growth of learning environment studies can also be viewed from another perspective. Interest in learning environments spread from the USA to the Netherlands where it was picked up by Theo Wubbels and colleagues (2006), and to Britain, where it was carried forward by Ramsden and Entwistle (1981) and led to the development of the Course Perceptions Questionnaire to obtain self-reports on eight aspects of the academic context. In Australia, Barry Fraser appeared to be the prominent figure of the field (Fraser, 2007, 1998). Learning environment research has since spread further afield to Asia (Fraser, 2002) and South Africa (Aldridge et al., 2006).

In Australia, Fraser and colleagues initially elaborated the College and University Classroom Environment Inventory (CUCEI) (Fraser & Treagust, 1986) but this was followed by other widely used instruments such as the Individualized Classroom Environment Questionnaire (ICEQ), the Science Laboratory Environment Inventory (SLEI), the Constructivist Learning Environment Survey (CLES) and the What Is Happening In This Class (WIHIC) questionnaire (Fraser, 1998).

In Asia, the study of learning environments has been undertaken in Malaysia (Scott & Fisher, 2004), Taiwan (Aldridge et al., 1999), Singapore (Khoo & Fraser, 2008), Japan (Hirata & Sako, 1998), India (Koul & Fisher, 2005) and Korea (Lee et al., 2003). It should be noted

that the present study is one of the few learning environment studies concerning chemistry classroom settings in Iran.

Learning environment research is a comprehensive and well-established field and can thus present a holistic picture of the effects of democratic education in action and is able to show us how to move towards more democratic practices.

Initial development of instrument

The initial development of the new instrument described in this paper, called the Democratic Chemistry Classroom Environment Inventory (DCEI), was guided by four criteria:

1) Consistency with the literature on democratic education. A review of literature identified dimensions considered important in democratic classrooms.

2) Consistency with other instruments in the field of learning environment research. Guidance was obtained by examining all scales in existing classroom environment instruments.

3) Coverage of Moos' general categories. The DCEI takes into account the three general categories of dimensions identified by Moos (1974) for conceptualizing all human environments. These are "Relationship Dimensions" (the nature and intensity of personal relationships), "Personal Development Dimensions" (directions of personal growth and self-enhancement), and "System Maintenance and System Change Dimensions" (the extent to which the environment is orderly, clear in expectation, maintains control, and is responsive to change). Since a reasonably complete picture of environment includes Relationship Dimensions, Personal Development Dimensions, and System Maintenance and System Change Dimensions, the DCEI included scales in each of these categories.

4) Economy. To achieve economy in terms of the time required for answering and scoring, the DCEI has six scales, each containing eight items.

This study utilizes quantitative research methods. Initially, the above criteria led to an instrument containing six scales, and all the six scales, described as follows, survived factor analyses and appear in the final version.

- *Authority* assesses the extent to which the teacher is the right person to lead, organize, give orders, determine procedures and structure the classroom situation.
- *Inclusiveness* assesses the extent to which students have attentive interest, participate in class and are involved with other students in assessing the viability of new ideas.
- *Participatory decision-making* assesses the extent to which students have opportunities to explain and justify their ideas, and to test the viability of their own and other students' ideas.
- *Important knowledge* assesses the extent to which classroom activities and knowledge is relevant to students' everyday out-of-classroom experiences. Education is not democratic when the students are coerced to master what they find irrelevant and learn things for utilitarian reasons - as a necessary means to succeed in a credential society (i.e., to attain a competitive advantage).
- *Equality* assesses the extent to which the teacher treats students equally, including distributing praise, question distribution and opportunities to be included in discussions.
- *Rights* assess the extent to which students' rights are analyzed and practiced in the classroom.

Regarding Moos's (1974) three general categories, Equality, Authority and Rights are related to System Maintenance and System Change Dimension, Important knowledge and

Inclusiveness are related to Relationship Dimension and Participatory decision-making is related to Personal Development Dimension.

By writing new items and rewriting existing ones, we redefined and modified scales selected from other inventories such as WIHIC questionnaire, SLEI, CLES to suit them to chemistry classes. We based further revisions of items on reactions from eight colleagues with expertise in questionnaire construction and in chemistry teaching at higher education levels, paying careful attention to suit each item for measuring both actual and preferred classroom environments.

Description of the DCEI

DCEI is an instrument in Persian. The initial version of the DCEI contained 48 items altogether, with 8 items in each of six scales. However, extensive field-testing and validation later led to a more economical final version with 36 items, with 6 items in each of the six original scales. Each item's response alternatives are Almost Never, Seldom, Sometimes, Often, and Very Often. Also we developed parallel actual and preferred forms as in other instruments available in the field of learning environment research. Respondents use the actual form to report on the actual situation in the classroom learning environment and the preferred form to report on what they would prefer in an ideal situation. Existence of actual and preferred forms allows assessing whether or not students are satisfied with their classroom environment. The idea is that "the greater the degree of concordance between one's ideal classroom and the actual classroom within which one finds oneself, the greater the degree of satisfaction there is likely to be" (Williams & Burden, 1998). A typical item in the actual form of the Equality scale is: "I am treated the same as other students in this class." The wording of the preferred version is almost identical except for the use of such words as "should." For example, the item "I help the teacher to decide which activities I do" in the actual version is reworded in the preferred version to read "I should help the teacher to decide which activities I do." For a complete listing of all items in the first version of the DCEI, see Appendix A.

Field-testing and validation

Samples and data collection

Field-testing of the original 48-item, six-scale version of the DCEI involved 510 (M= 248 and F=262) Iranian university students in 23 chemistry classes in six universities in the academic year 2011-2012. Both actual and preferred versions were given at the same time to each participant and the participants were directed to complete the actual form before the preferred form. The participants were asked to complete both versions in relation to the chemistry course they were taking at that time. Paper-based surveys were used and total completion time for students ranged from approximately 25 to 45 minutes. All of the 510 students participated in the study on a voluntary basis. At the beginning of the data collection process in each class the researcher explained the purpose of the questionnaires, read the instructions and answered any individual questions that the students asked. Assurance for complete anonymity of answers was given. Among these 23 classes, seven were related to Islamic Azad University of Arsanjan (N=116, 22.74%), five to Islamic Azad University of Marvdasht (N=110, 21.56%), four to Shiraz University (N=57, 11.17%), two to Islamic Azad University of Abadeh (N=69, 13.52%), three to University of Kashan (N=65, 12.74%) and two to Yasouj University (N=93, 18.23%). With regard to age, most of the participants were from 20 to 23 (N=409). With regard to years of study and major, students were mainly first and second year undergraduates and were studying different fields including civil

engineering, mechanical engineering, biochemistry, physics, biology, genetics, nuclear engineering, and chemistry. The number of students in each class ranged from 27 to 48.

Factor analyses

The students' responses to the Likert scale including almost never, seldom, sometimes, often and very often alternatives, were scored 1, 2, 3, 4 and 5 respectively. Item 12 was reverse-scored. The data were analyzed through the Statistical Package for the Social Sciences (SPSS, Release 16.0.0) and various analyses were conducted to check the validity aspects and reliability of the DCEI: factorial validity, internal consistency reliability and the ability to differentiate between the perceptions of students in different classrooms.

Before conducting the factor analysis, the strength of the relationship among the variables should be explored (Pallant, 2005). If the items of the questionnaire are measuring the same underlying trait they shall correlate with each other. For inspecting the inter-correlation among the items, the correlation matrices for actual and preferred forms of the DCEI were provided. Tabachnick and Fidell (2001) and Pallant (2001) recommend an inspection of the correlation matrix for evidence of coefficients greater than 0.3. Few correlations above this level may make factor analysis inappropriate. There is no exact specification as to the proportion of the coefficients that should be above 0.3 but, in this study, the number greater than 0.3 was 1854 and 1785 out of 2256 in the correlation matrices provided for the actual and preferred forms of the DCEI respectively. This number was judged to be satisfactory.

Two statistical measures were also generated by SPSS to help assess the factorability of the data: Bartlett's test of sphericity and Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (Pallant, 2005). For the factor analysis to be considered appropriate, the Bartlett's test of sphericity should be significant ($p<0.05$). The KMO index ranges from 0 to 1 and the minimum value for a good factor analysis is 0.6 (Pallant, 2001).

The KMO index was higher than 0.6 (.81 and .84 for actual and preferred forms respectively) and the result of the Bartlett's test of sphericity was significant for both forms ($p=0.00$). These two measures also attested to the factorability of the data for factor analysis.

In the present study, validation of data has been provided for the individual as unit of analysis. The use of the individual as the unit of analysis can provide spurious results because an unjustifiably small estimate of the sampling error is employed in tests of statistical significance (Dorman, 2001).

Using SPSS, principal component analysis with varimax rotation led to the generation of orthogonal factors. The results of factor analyses for actual and preferred forms are provided in Table 1 and Table 2 respectively. Loadings of less than 0.30, a commonly used cut-off, have been eliminated. As it can be seen from Tables 1 and 2, most items load strongly on their hypothesized scale. There are exceptions, however. With regard to the actual form, Item 11, 28 and 33 has factor loading lower than 0.30. Item 6, 8, 14, 17, 18, 34, 46 and 47 have somehow different factor loadings on both their own scales and other scales (Authority, Rights, Rights, Inclusiveness, Rights, Equality, Participatory decision-making, Participatory decision-making respectively). In the preferred form, Item 8, 14, 28, 33 and 34 has factor loading lower than 0.30 and item 6, item 17, item 18, item 29, item 44 and item 47 have different factor loadings on both their own hypothesized scales and other scales (Authority, Rights, Rights, Participatory decision-making, Inclusiveness and Rights respectively).

Table 1: Factor loadings for the first draft of the DCEI (actual form)

	EQ	IN	PD	IC	RT	AT
A1	.736					
A2	.736					
A3	.585					
A4	.580					
A5	.580					
A6	.730					.367
A7	.611					
A8	.449				.432	
A9		.886				
A10		.886				
A11						
A12		.396				
A13		.313				
A14		.421			.534	
A15		.318				
A16		.510				
A17			.516	.665		
A18			.516		.665	
A19			.647			
A20			.789			
A21			.609			
A22			.712			
A23			.789			
A24			.774			
A25				.774		
A26				.749		
A27				.784		
A28						
A29				.502		
A30				.784		
A31				.748		
A32				.749		
A33						
A34	.487				.651	
A35					.773	
A36					.591	
A37					.558	
A38					.773	
A39					.648	
A40					.792	
A41						.749
A42						.651
A43						.748
A44						.784
A45						.792
A46			.665			.346
A47			.367			.523
A48						.712

Note. EQ = Equality; IN = Important knowledge; PD = Participatory decision-making; IC = Inclusiveness; RT= Rights; AT= Authority.

Table 2: *Factor loadings for the first draft of the DCEI (preferred form)*

	EQ	IN	PD	IC	RT	AT
P1	.553					
P2	.634					
P3	.435					
P4	.721					
P5	.653					
P6	.474					.542
P7	.534					
P8						
P9		.656				
P10		.572				
P11		.465				
P12		.674				
P13		.721				
P14						
P15		.543				
P16		.345				
P17			.543		.529	
P18			.653		.721	
P19			.762			
P20			.542			
P21			.718			
P22			.739			
P23			.691			
P24			.701			
P25				.672		
P26				.719		
P27				.452		
P28						
P29			.433	.629		
P30				.701		
P31				.696		
P32				.592		
P33						
P34						
P35					.708	
P36					.482	
P37					.562	
P38					.721	
P39					.782	
P40					.621	
P41						.490
P42						.672
P43						.721
P44				.466		.692
P45						.729
P46						.562
P47					.435	
P48						.618

Note. EQ = Equality; IN = Important knowledge; PD = Participatory decisionmaking; IC = Inclusiveness; RT= Rights; AT= Authority.

Quantitative data analysis revealed that items number 6, 8, 11, 14, 17, 18, 28, 33, 34, 46 and 47 in the actual form and items number 6, 8, 14, 17, 18, 28, 29, 33, 34, 44 and 47 in the preferred form do not contribute appropriately to the underlying structure of the instrument.

First, items number 6, 8, 14, 17, 18, 28, 33, 34 and 47 in the actual and preferred forms were removed. To have parallel actual and preferred forms, items number 11, 46 and 29 in both forms were also deleted. Item number 44 was retained so that the number of items in Authority scale remains six.

Through the above process, 12 items in both actual and preferred forms were removed. So, the refined version of the DCEI consisted of six six-item scales.

Internal consistency reliability of the refined DCEI

Table 3 reports the internal consistency (alpha reliability coefficient) for the refined 36-item version of the DCEI, with separate reports for actual and preferred forms and for the use of the individual student as the unit of analysis. Table 3 suggests that each scale of the refined DCEI has acceptable internal consistency in all cases. These reliabilities are satisfactory for economical scales containing only 4–8 items each (Sinclair & Fraser, 2009).

Table 3. Internal Consistency Reliability (Alpha Coefficient) for Actual and *Preferred Forms of the Refined DCEI*

Scale	Alpha Reliability	
	Actual Form	Preferred Form
Equality	.82	.85
Important knowledge	.86	.87
Participatory decisionmaking	.86	.82
Inclusiveness	.78	.75
Rights	.79	.77
Authority	.81	.83

The ability of the refined DCEI to differentiate between classrooms

Another desirable characteristic of the actual form of any classroom environment instrument is that it must be capable of differentiating between the perceptions of students in different classrooms (Fraser & Griffiths, 1992). That is, students in the same class should perceive their class relatively similarly, while mean within-class perceptions should vary from classroom to classroom. This characteristic was explored for each scale of the actual form of the refined DCEI for the total sample of 510 Iranian university students in chemistry classrooms described previously. This involved performing for each scale a one-way ANOVA, with class membership as the main effect and using the individual as the unit of analysis. The results of these analyses, reported in Table 4, indicate that each scale differentiated significantly ($p<.001$) between classrooms. The Eta^2 statistic, which is a ratio of 'between' to 'total' sums of squares (Cohen & Cohen, 1975), indicated that the proportion of variance explained by class membership ranged from 12% for the Important knowledge scale to 22% for the Rights scale.

Table 4. Discriminant Validity (Mean Correlation with Other Scales) and Ability to Differentiate between Classrooms for Individual as the Unit of Analysis for the Refined DCEI

Scale	Mean correlation with other scales		ANOVA Results Eta^2
	Actual Form	Preferred Form	Actual Form
Equality	.14	.29	0.13*
Important knowledge	.28	.32	0.12*
Participatory decision-making	.28	.39	0.21*
Inclusiveness	.25	.43	0.18*
Rights	.23	.35	0.22*
Authority	.25	.36	0.19*

*p<0.001

Based on the analyses reported above, it is clear that the refined DCEI exhibited satisfactory factorial validity and internal consistency reliability and that actual form of each scale was able to differentiate between classes.

Differences between actual and preferred learning environment

Data collected among 510 Iranian students described above were used in a research application involving investigation of whether there were differences between students' actual and preferred classroom environment scores on the scales of Equality, Important knowledge, Participatory decision-making, Inclusiveness, Rights and Authority.

The previous data was used again. However, the data from the items that were retained during factor analysis (i.e. those items that formed the refined version of the DCEI) were used here. The average item mean and average item standard deviation were calculated for each actual and preferred scale of the refined version of the DCEI for the individual as the units of analysis.

Table 5: The Results of Different Paired-sample T-Tests between the Scores of All Participants on the Six Dimensions of Actual and Preferred Forms of the Refined DCEI

		PAIRED DIFFERENCES					t	df	sig. P<0.05
		Mean dif	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	EQ (Actual) – EQ (Preferred)	-.69	1.10	.04	-.78	-.59	-14.2	509	.000
Pair 2	IN (Actual) – IN (Preferred)	-.64	.89	.03	-.72	-.56	-16.2	509	.000
Pair 3	PD (Actual) – PD (Preferred)	-.95	1.11	.04	-1.05	-.86	-19.4	509	.000
Pair 4	IC (Actual) – IC (Preferred)	-.81	1.13	.05	-.91	-.71	-16.3	509	.000
Pair 5	RT (Actual) – RT (Preferred)	-1.13	1.22	.05	-1.24	-1.02	-20.8	509	.000
Pair 6	AT (Actual) – AT (Preferred	-.96	.99	.04	-1.05	-.87	-21.8	509	.000

Note. EQ = Equality; IN = Important knowledge; PD = Participatory decisionmaking; IC = Inclusiveness; RT= Rights; AT= Authority.

The six pairs of scores were computed using SPSS for conducting different paired-sample t-tests between the scores of the same scales of the actual and preferred forms. The idea here is that "the greater the degree of concordance between one's ideal classroom and the actual classroom within which one finds oneself, the greater the degree of satisfaction there is likely to be" (Williams & Burden, 1998). The results of these paired-sample t-tests are provided in Table 5. As it is clear, there are significant differences ($p<0.05$) between scores on Equality, Important knowledge, Participatory decision-making, Inclusiveness, Rights and Authority dimensions in the actual and preferred classroom environments.

Overall the results reported in this section clearly reveal that students preferred a more positive classroom environment than the one that they perceived as being actually present in terms of the six dimensions of Equality, Important knowledge, Participatory decision-making, Inclusiveness, Rights and Authority. These differences between students' actual and preferred environments in our study in Iran are consistent with past research which has explored the congruence between actual and preferred environments in a number of countries around the world (Yarrow et al., 1997; Dorman, 2008; Fisher et al., 1995).

Conclusion

This paper aims to stimulate and to facilitate further research on democratic education in chemistry classrooms by developing a new instrument, the Democratic Chemistry Classroom Environment Inventory (DCEI), which assesses six dimensions of the actual and preferred climate of chemistry classes at higher education levels. The DCEI is originally in Persian but its English translated version has been provided in Appendix B.

The DCEI was field-tested and its aspects of validity were explored with a sample consisting of 510 Iranian university students in 23 chemistry classes. Factor analyses led to a refined version with satisfactory internal consistency reliability, discriminant validity, and factorial validity in both its actual and preferred versions. Noteworthy features of the DCEI include its consistency with the literature, specific relevance to chemistry classes, and economy of administration and scoring time. The DCEI development process meets all the standards of instrument development in the field of learning environment research but it is different in that it is the first learning environment instrument that is related to democratic education.

The effects of democratic education on the teaching and learning process in chemistry classrooms have not been explored yet and no due studies are available. We hope educational researchers and teachers will use the DCEI to pursue several research and practical applications of democratic education ideas in chemistry classrooms. Researchers should consider the DCEI to monitor students' views of their chemistry classes, investigate the impact of democratic chemistry classroom environments on student outcomes, and provide a basis for improving these learning environments. In particular, there is scope for future research with the DCEI which replicates common lines of past research such as: using learning environment scales as dependent variables in studies of determinants of classroom environment (Aldridge & Fraser, 2008); investigation of associations between student outcomes and classroom learning environment (Wong et al., 1997); use of learning environment criteria in assessing educational programs (Wolf & Fraser, 2008; Martin-Dunlop & Fraser, 2008); and combining qualitative and quantitative methods in learning environment research (Aldridge et al., 1999); using feedback on students' perceptions of actual and preferred learning environment to direct improvements in classrooms (Aldridge et al., 2004).

The DCEI also provides the impetus for further studies on democratic education in university, primary level and secondary level chemistry classroom environments. Studies that

provide cross-validation data from other countries' universities are needed to verify its generalizability. There is also the possibility to modify and then explore the psychometric characteristics of the DCEI to suit primary level and secondary level chemistry classrooms. In addition, this study can be inspiring for educators in other fields of study. If relevant, the DCEI can be modified and explored to see how it can provide valid data for classrooms other than chemistry.

Furthermore, this study was a response to the lack of learning environment research in chemistry classrooms in Iran. Available studies (e.g., Eskandari & Ebrahimi, 2013) eveal that chemistry classrooms in Iran are not learner-centered and are dominated by objectivist ideas negatively affecting students' learning. Studies like the present one can help the Iranian chemistry educators to think critically about the current approaches and move towards more efficient democratic learner-centered classrooms. By reporting data specifically for an Iranian sample, it paves the way for future research on chemistry classroom learning environments in this country. Using the DCEI, this study showed that the Iranian university students participating in this study were not satisfied and preferred a more positive chemistry environment on all scales. This study is of great help for those educators who want to create more efficient chemistry classroom environments in Iranian universities.

To increase students' satisfaction, to improve chemistry education and to move towards more democratic chemistry learning environments in Iranian universities, some ideas could be presented based on the results of this study. The students should be persuaded that the teacher is the right person to lead, organize, give orders, determine procedures and structure the classroom situation (i.e., Authority). The classes should be organized in a way that students have attentive interest, participate in class and are involved with other students in assessing the viability of new ideas (i.e., Inclusiveness). A classroom is democratic to the extent to which it welcomes all students as equally valued members of a problem-solving community. The students should be given the opportunities to explain and justify their ideas, and to test the viability of their own and other students' ideas (i.e., Participatory decision-making). For an education to be democratic all students have to be prepared equally to be informed responsible citizens, and all have to be equally skilled in the participation process. In addition, classroom activities and knowledge should be relevant to students' everyday out-of-classroom experiences (i.e., important knowledge). No education can be even minimally democratic if no persuasive case can be made for it. No teacher can be minimally democratic if they cannot make a persuasive case that what is being taught is worth learning. Even when students accept the value of the curriculum, it becomes democratic only if the teacher makes a persuasive case that all students in the class are capable of mastering what is being taught. Teachers should treat students equally, including distributing praise, question distribution and opportunities to be included in discussions (i.e., Equality). To have more democratic chemistry classroom environments, students' rights need to be analyzed and practiced in the classroom and students should be guaranteed a finite number of very specific rights (i.e., Rights).

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Appendix A- the first draft of the DCEI (translated into English)

Actual form

No	Category	Statements	AN	S	ST	O	VO
1	Equality	The instructor gives as much attention to my questions as to other students' questions.					
2		I get the same amount of help from the instructor, as do other students.					
3		I am treated the same as other students in this class.					
4		I receive the same encouragement from the instructor as other students do.					
5		I get the same opportunity to contribute to class discussions as other students.					
6		The instructor helps me how to do my assignments.					
7		My work receives as much praise as other students' work.					
8		I receive the same attention from the instructor as the other students do.					
9	Important knowledge	I learn about the world outside of classroom.					
10		My new learning starts with problems about the world outside of classroom.					
11		Some of my assignments are related to the world outside of classroom.					
12		I learn how chemistry can be part of my out-of-classroom life.					
13		I get a better understanding of the world outside of classroom.					
14		I can propose questions about the world outside of classroom.					
15		I learn interesting things about the world outside of classroom.					
16		What I learn has nothing to do with my out-of-classroom life.					
17	Participatory decision making	The instructor asks me to plan for some parts of the class.					
18		The instructor gives me the opportunity to decide for the class.					
19		I help the instructor to plan what I'm going to learn.					
20		I help the instructor to decide how well I am learning.					
21		I help the instructor to decide which activities are best for me.					
22		I help the instructor to decide how much time I spend on learning activities.					
23		I help the instructor to decide which activities I do.					
24		I help the instructor to assess my learning.					
25	Inclusiveness	I give my opinions during class discussions.					
26		The instructor asks me questions.					
27		My ideas and suggestions are used during classroom discussions.					
28		I have my own ideas for the class.					
29		The students ask me their questions.					
30		I ask the instructor questions.					
31		I explain my ideas to other students.					
32		Students discuss with me how to go about solving problems.					
33	Rights	My rights are important in the class.					

34		All students have special rights.					
35		I have the right to express my own ideas.					
36		I am allowed to practice the rights I am told I have in the class.					
37		I have the right to be treated fairly.					
38		We talk about students' rights in the classroom.					
39		The students have their own rights in this class.					
40		I have the right to be protected against unfair and unusual punishment.					
41	**Authority**	The instructor is able to bring order and security.					
42		The instructor is able to manage conflicts peacefully and fairly.					
43		The instructor is able to protect important rights and freedom.					
44		The instructor is able to distribute benefits and burdens fairly.					
45		This instructor knows everything that goes on in this classroom.					
46		The instructor asks the students to be well-organized in the class.					
47		The students are disciplined because the instructor wants them to be.					
48		We learn a lot from this instructor.					

Preferred form

No	**Category**	**Statements**	**AN**	**S**	**ST**	**O**	**VO**
1	**Equality**	The instructor should give as much attention to my questions as to other students' questions.					
2		I should get the same amount of help from the instructor, as do other students.					
3		I should be treated the same as other students in this class.					
4		I should receive the same encouragement from the instructor as other students do.					
5		I should get the same opportunity to contribute to class discussions as other students.					
6		The instructor should help me how to do my assignments.					
7		My work should receive as much praise as other students' work.					
8		I should receive the same attention from the instructor as the other students do.					
9	**Important knowledge**	I should learn about the world outside of classroom.					
10		My new learning should start with problems about the world outside of classroom.					
11		Some of my assignments should be related to the world outside of classroom.					
12		I should learn how chemistry can be part of my out-of-classroom life.					
13		I should get a better understanding of the world outside of classroom.					
14		I should be able to propose questions about the world outside of classroom.					

15		I should learn interesting things about the world outside of classroom.					
16		What I learn should have nothing to do with my out-of-classroom life.					
17	**Participatory decision making**	The instructor should ask me to plan for some parts of the class.					
18		The instructor should give me the opportunity to decide for the class.					
19		I should help the instructor to plan what I'm going to learn.					
20		I should help the instructor to decide how well I am learning.					
21		I should help the instructor to decide which activities are best for me.					
22		I should help the instructor to decide how much time I spend on learning activities.					
23		I should help the instructor to decide which activities I do.					
24		I should help the instructor to assess my learning.					
25	**Inclusiveness**	I should give my opinions during class discussions.					
26		The instructor should ask me questions.					
27		My ideas and suggestions should be used during classroom discussions.					
28		I should have my own ideas for the class.					
29		The students should ask me their questions.					
30		I should ask the instructor questions.					
31		I should explain my ideas to other students.					
32		Students should discuss with me how to go about solving problems.					
33	**Rights**	My rights should be important in the class.					
34		All students should have special rights.					
35		I should have the right to express my own ideas.					
36		I should be allowed to practice the rights I am told I have in the class.					
37		I should have the right to be treated fairly.					
38		We should talk about students' rights in the classroom.					
39		The students should have their own rights in this class.					
40		I should have the right to be protected against unfair and unusual punishment.					
41	**Authority**	The instructor should be able to bring order and security.					
42		The instructor should be able to manage conflicts peacefully and fairly.					
43		The instructor should be able to protect important rights and freedom.					
44		The instructor should be able to distribute benefits and burdens fairly.					
45		This instructor should know everything that goes on in this classroom.					
46		The instructor should ask the students to be well-organized in the class.					
47		The students should be disciplined because the instructor wants them to be.					
48		We should learn a lot from this instructor.					

Appendix B- The DCEI (translated into English)

Actual Form

No	Category	Statements	AN	S	ST	O	VO
1	Equality	The instructor gives as much attention to my questions as to other students' questions.					
2		I get the same amount of help from the instructor, as do other students.					
3		I am treated the same as other students in this class.					
4		I receive the same encouragement from the instructor as other students do.					
5		I get the same opportunity to contribute to class discussions as other students.					
6		My work receives as much praise as other students' work.					
7	Important knowledge	I learn about the world outside of classroom.					
8		My new learning starts with problems about the world outside of classroom.					
9		I learn how chemistry can be part of my out-of-classroom life.					
10		I get a better understanding of the world outside of classroom.					
11		I learn interesting things about the world outside of classroom.					
12*		What I learn has nothing to do with my out-of-classroom life.					
13	Participatory decision making	I help the instructor to plan what I'm going to learn.					
14		I help the instructor to decide how well I am learning.					
15		I help the instructor to decide which activities are best for me.					
16		I help the instructor to decide how much time I spend on learning activities.					
17		I help the instructor to decide which activities I do.					
18		I help the instructor to assess my learning.					
19	Inclusiveness	I give my opinions during class discussions.					
20		The instructor asks me questions.					
21		My ideas and suggestions are used during classroom discussions.					
22		I ask the instructor questions.					
23		I explain my ideas to other students.					
24		Students discuss with me how to go about solving problems.					
25	Rights	I have the right to express my own ideas.					
26		I am allowed to practice the rights I am told I have in the class.					
27		I have the right to be treated fairly.					
28		We talk about students' rights in the classroom.					
29		The students have their own rights in this class.					
30		I have the right to be protected against unfair and unusual punishment.					
31	Authority	The instructor is able to bring order and security.					
32		The instructor is able to manage conflicts peacefully and fairly.					
33		The instructor is able to protect important rights and					

		freedom.					
34		The instructor is able to distribute benefits and burdens fairly.					
35		This instructor knows everything that goes on in this classroom.					
36		We learn a lot from this instructor.					

Preferred Form

No	Category	Statements	AN	S	ST	O	VO
1	**Equality**	The instructor should give as much attention to my questions as to other students' questions.					
2		I should get the same amount of help from the instructor, as do other students.					
3		I should be treated the same as other students in this class.					
4		I should receive the same encouragement from the instructor as other students do.					
5		I should get the same opportunity to contribute to class discussions as other students.					
6		My work should receive as much praise as other students' work.					
7	**Important knowledge**	I should learn about the world outside of classroom.					
8		My new learning should start with problems about the world outside of classroom.					
9		I should learn how chemistry can be part of my out-of-classroom life.					
10		I should get a better understanding of the world outside of classroom.					
11		I should learn interesting things about the world outside of classroom.					
12*		What I learn should have nothing to do with my out-of-classroom life.					
13	**Participatory decision making**	I should help the instructor to plan what I'm going to learn.					
14		I should help the instructor to decide how well I am learning.					
15		I should help the instructor to decide which activities are best for me.					
16		I should help the instructor to decide how much time I spend on learning activities.					
17		I should help the instructor to decide which activities I do.					
18		I should help the instructor to assess my learning.					
19	**Inclusiveness**	I should give my opinions during class discussions.					
20		The instructor should ask me questions.					
21		My ideas and suggestions should be used during classroom discussions.					
22		I should ask the instructor questions.					
23		I should explain my ideas to other students.					
24		Students should discuss with me how to go about solving problems.					
25	**Rights**	I should have the right to express my own ideas.					
26		I should be allowed to practice the rights I am told I have in the class.					
27		I should have the right to be treated fairly.					
28		We should talk about students' rights in the classroom.					

29		The students should have their own rights in this class.					
30		I should have the right to be protected against unfair and unusual punishment.					
31	**Authority**	The instructor should be able to bring order and security.					
32		The instructor should be able to manage conflicts peacefully and fairly.					
33		The instructor should be able to protect important rights and freedom.					
34		The instructor should be able to distribute benefits and burdens fairly.					
35		This instructor should know everything that goes on in this classroom.					
36		We should learn a lot from this instructor.					

*Reverse-scored item.

The response alternatives are Almost Never, Seldom, Sometimes, Often, and Very Often.