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ORIGINAL PAPER

# Effectiveness of teaching strategies for engaging adults who experienced childhood difficulties in learning mathematics

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**Abstract** We investigated whether the introduction of a variety of activity-based teaching strategies into college-level mathematics classes in the United Arab Emirates was effective in terms of the nature of the classroom learning environment and students' satisfaction. In addition, we investigated how the use of personally-relevant and concrete activities changed the learning environment in ways that were perceived to be beneficial by adults who had experienced failure. For a sample of 84 students from eight classes in the Higher Colleges of Technology, the learning environment was assessed with a modified Arabic version of four scales (Involvement, Task Orientation, Personalisation and Individualisation) from the College and University Classroom Environment Inventory (CUCEI) and Satisfaction was also measured with a scale from the same instrument. As well, five case-study students were involved in assessing the learning environment through observations, semi-structured interviews and focus-group interviews in order to link qualitative information with the constructs assessed by the CUCEI.

**Keywords** Activity-based teaching · Adult learners · College and University Classroom Environment Inventory (CUCEI) · Learning environment · Satisfaction · United Arab Emirates

## Introduction

In our experience, students often lack enthusiasm when it comes to learning mathematics and this, in turn, can affect their success. Therefore, we implemented activity-

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based classrooms in which students were positioned as inquirers rather than as receptors of facts and procedures. In this respect, activity-based learning aimed to provide students with the opportunity to make significant decisions about their learning (Nayak and Rao 2002).

We investigated the effectiveness of these teaching strategies for engaging college students who had experienced childhood difficulties in learning mathematics in the United Arab Emirates (UAE) in terms of the nature of the classroom learning environment and students' satisfaction. It has been noted, with concern, that poor-quality instruction exists in some tertiary institutions in the UAE and that, on the whole, teaching methods are based on rote memorisation (Gaad et al. 2006; Shaw et al. 1995). The development of the activity-based strategies that were evaluated in our study drew on the results of past studies that suggest that using games, puzzle worksheets and hands-on activities in mathematics can improve students' outlook (Bragg 2007; Massey et al. 2005). Past research also indicates that activity-based strategies that involve playing games and solving problems related to real-life situations have the potential to draw students into the learning process and to reassure them by allowing them to participate in a more collaborative environment (Gosen and Washbush 2004; Proserpio and Gioia 2007; Zantow et al. 2005).

Tolman (1999) suggests that activity-based methods encourage hands-on discovery, which can enhance the development of valuable learning skills through direct experiences. This method of teaching requires that all students, whatever their age, be active mentally and/or physically during the entire lesson (Rowland and Birkett 1992). According to Hendricks (1997), during activity-based teaching, the classroom environment is considered to be authentic because it is based on activities that are planned with the students' interests in mind. During the process of activity-based learning, it is important that the teacher respects students by upholding their rights to their feelings, ideas and opinions. An important component of activity-based learning is the need to provide scope for students to inquire and to interact (Hendricks 1997).

Although research supports the notion that activity-based teaching strategies can encourage students' interest and enthusiasm (Gough 1999; Owens 2005), only a few studies have been carried out to investigate the effectiveness of these teaching strategies at the tertiary level and none of these studies were conducted in the UAE. Therefore we undertook this evaluation of the use of activity-based mathematics instruction in terms of its impact on the learning environment and students' satisfaction, which were measured using the College and Classroom Environment Inventory (CUCEI).

## Aims of the study

1. Is a modified Arabic version of the CUCEI valid for assessing classroom environment among tertiary students in the UAE?
2. Are activity-based teaching strategies effective in terms of:
    a. the nature of the classroom learning environment
    b. students' satisfaction?
3. Can qualitative research methods be used to examine how using a range of personally-relevant and concrete activities change the learning environment in ways that are perceived to be beneficial by adults who had experienced failure?

## Background

### Field of learning environments

The learning environment involves the psychological and emotional conditions of the classroom, as well as social and cultural impacts. The concept of a human environment has existed since Lewin's (1936) seminal work in non-educational settings recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour. Past studies conducted over the previous 40 years had consistently confirmed that the quality of the classroom environment is an important determinant of student learning (Dorman and Fraser 2009; Fraser 2007, 2012).

The study of learning environments grew out of earlier work in social psychology in the USA. In the 1920s, researchers such as Hartshorne and May (1928) proposed that behaviour is specific to the situation, which is a central concept in learning environments research. The idea that behaviour is situational is the very reason why contemporary researchers often investigate people within their environment rather than either in isolation.

Researchers have developed and validated numerous questionnaires for measuring perceptions of a range of dimensions pertinent to the learning environment (Fraser 1998), including the Constructivist Learning Environment Survey (CLES; Taylor et al. 1997), the What Is Happening In this Class? (WIHIC; Aldridge et al. 1999), My Class Inventory (MCI; Fisher and Fraser 1981) and the College and University Classroom Environment Inventory (CUCEI; Fraser and Treagust 1986; Fraser et al. 1986). Our study involved the use of five of the seven CUCEI scales, namely, Involvement, Task Orientation, Personalisation, Individualisation and Satisfaction.

Our study was inspired by past evaluations of educational innovations (Maor and Fraser 1996; Wolf and Fraser 2008; Nix et al. 2005; Martin-Dunlop and Fraser 2008) that drew on the field of learning environments. However, our research was the first investigation of the effectiveness of activity-based teaching strategies in mathematics with adult male students in the UAE in terms of the nature of the classroom learning environment and student satisfaction.

### Adult learners

Adult learning is a process through which adults go to learn a new concept or skill. This can be through formal learning situations such as colleges or workplace training, or more informally through reading a daily newspaper or life experiences. McCannon and Crews (2000) reported that, once an adult educator is aware of the theories associated with adult learning principles, he/she might implement these in the classroom, therefore creating a better learning environment for the adult student. Adult learning theories have profound implications for the content of mathematics instruction, its pedagogy and how learning should be assessed (Forman and Steen 1999). Definition, theory and instruction are thus tied together. That is, one's view of what numeracy is leads to a theory of learning and this theory affects preferred approaches to instruction. According to Forman and Steen (1999), however, there remains some controversy with respect to how theory should be translated into practice because there is little empirical research which demonstrates the effects of an instructional approach on how adults learn. Our study attempted to fill this gap by investigating the effectiveness of using teaching strategies with adult males as they learned mathematics.

Over the last 30 years or so, it has become generally accepted that, both in official reports (Cockcroft 1982; Her Majesty's Inspectorate [HMI] 1985) and in academic writing related to 'good practice' (Cooper 2001; Cooper and Dunne 2000; Hayman 1975), the teaching and learning of mathematics should be related to its uses in everyday life and work settings. According to Cooper (2001), the majority of students find mathematics more interesting and relevant when it is set in and related to realistic settings and contexts.

According to Knowles (1984), adult learners quite often need to know why they are learning new knowledge before they are willing to participate. Unlike youth, who tend to have a more subject-centred orientation to learning (in which they focus on learning content to pass a test), by virtue of their life and work experiences, adults tend to develop a task-centred or problem-centred orientation to learning (Knowles 1984). It has also been proposed that adults, unlike children, are more likely to take responsibility for their own learning and would prefer not to be directed by the lecturer during class (McGrath 2009).

## Research methods

### Sample

Our study involved Work Readiness Program (WRP) students in one of the Higher Colleges of Technology (HCT) in the UAE. From this college, a sample of 84 adult male students in 8 classes participated in the study. The participants' ages ranged from 19 to 45 years. Potential participants were invited by their lecturer to volunteer to be involved in the study, and only those wishing to be involved were included.

The instrument that was used to gather data for this study was a modified version of the CUCEI (Fraser et al. 1986) which assesses students' perceptions of their classroom learning environment and their satisfaction. Qualitative methods, including observations and interviews, were also used to provide more in-depth information about how the use of personally-relevant, concrete activities changed the learning environment in ways that were perceived to be beneficial by the adult male students.

Qualitative case studies were used to enable us to study complex phenomena within the context of mathematics class (Baxter and Jack 2008). The use of qualitative case studies facilitated evaluation of the activity-based strategies within this unique context, ensuring that the effectiveness of using multiple instructional strategies was not explored only through one lens, but rather using a variety of lenses to allow multiple facets of the phenomenon to be revealed and understood. In addition, a variety of other data sources was utilised, such as semi-structured interviews, observations and focus-group interviews.

The five case-study students, one student from each of five classes, were purposefully selected. These five students were 22, 29, 30, 35 and 41 years of age. All of the students in the five classes were studying the same course and were all taught using the same activity-based strategies. As recommended by Patton (1990), we carefully selected case-study students who tended to be confident and verbally skilful in order to maximise our chances of obtaining information-rich and insightful comments.

The case studies were built upon interviews, focus-group interviews and observations, including a request for students to 'tell their stories' about the new teaching methods compared with previous methods. Interviews were conducted by a teacher–researcher and were based on observations and answers to initial and simple questions (e.g. "Did you like mathematics at school?").

## College and University Classroom Environment Inventory (CUCEI)

Our study involved modifying the CUCEI for use in tertiary-level mathematics classroom in the United Arab Emirates and then translating it into Arabic. The original version of the CUCEI has seven items in each of seven scales. The CUCEI was first validated in Western Australia (Fraser et al. 1986) and has been cross-validated subsequently in further research in Australia (Fraser et al. 1987) and New Zealand (Logan et al. 2006). Modifications were made to the CUCEI to ensure its suitability for use in our study (e.g. the scales of Student Cohesiveness and Innovation subsequently were omitted in the light of factor analyses reported later in this article).

As a first step, the scales and items of the CUCEI were examined to make certain that they were suitable for examining the effectiveness of activity-based teaching strategies in mathematics at the tertiary level. The learning environment in our study was assessed with a modified Arabic version of all scales of the CUCEI (Personalisation, Involvement, Student Cohesiveness, Task Orientation, Innovation and Individualisation) that were administered as both a pretest and a posttest. However, the two scales of Student Cohesiveness and Innovation were omitted later because they appeared to be problematic during the factor analyses described later and their elimination enhanced the reliability and factor structure of the instrument. Satisfaction was measured with a modified Arabic version of this scale from the CUCEI. As a second step, each item was scrutinised to ensure the suitability of its language and phrasing for the UAE setting.

Table 1 clarifies the meaning and nature of the original form of the CUCEI by providing, for each scale, both a scale description and a sample item. As indicated in the footnote to this table, items are scored using a five-point Likert agreement scale and some items are negatively worded and require reverse scoring.

## Translation of CUCEI into Arabic and back translation

The CUCEI was originally developed in English. Because all participants involved in our study spoke English as a second language, an Arabic translation was created to ensure that students were able to understand the items. The questionnaire was translated into the Arabic language using a standard research method involving translation, back-translation, modification and verification as recommended by Ercikan (1998) and Warwick and Osherson (1973). Each item was translated into Arabic by a professional translator. The next step involved an independent back-translation of the Arabic version into English by another translator who was fluent in both English and Arabic but had not been involved in the original translation. Items of the original English version and the back-translated version were then compared by the authors to ensure that the Arabic version maintained the meanings and concepts in the original English version. Historically, in studies in which both English and a translated versions of a questionnaire are used, researchers have administered separate English and translated versions (MacLeod and Fraser 2010). Because the first language of the HCT students in the UAE is Arabic, but they are taught in English, it was felt that having both languages presented to the students using a dual layout would increase the comprehensibility and reliability of the questionnaire. This approach has been used successfully in learning environment research in South Africa by Aldridge et al. (2006). Therefore, each item in Arabic was placed beneath the corresponding English item in our questionnaire.

**Table 1** Scale description and sample item for each scale of original CUCEI

| Scale | Description | Item |
|---|---|---|
| Personalisation | Emphasis on opportunities for individual students to interact with the instructor and on concern for students' personal welfare | The instructor helps each students who is having difficulty with the work (+) |
| Involvement | Extent to which students participate actively and attentively in class discussions and activities | There are opportunities for students to express opinions in this class (+) |
| Student cohesiveness | Extent to which students know, help and are friendly towards each other | Students in this class get to know each other well (+) |
| Satisfaction | Extent of enjoyment of classes | This class is a waste of time (−) |
| Task Orientation | Extent to which class activities are clear and well organised | Getting a certain amount of work done is important in this class (+) |
| Innovation | Extent to which the instructor plans new, unusual class activities, teaching strategies, and projects | New and different ways of teaching are hardly used in this class (−) |
| Individualisation | Extent to which students are allowed to make decisions and are treated differently according to ability, interest and rate of working | Students are generally allowed to work at their own pace (+) |

Items designated (+) are scored 5, 4, 3, 2 and 1, respectively, for the responses Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. Items designated (−) are scored in the reverse manner

## Analyses and results

### Validity and reliability of modified CUCEI

To examine the validity of the modified CUCEI when translated into Arabic and used at the tertiary level in the UAE, principal axis factoring with oblique rotation was used. Oblique rotation was selected because one can assume that the scales of the CUCEI are related (Coakes and Steed 2005). As a first step, factor analysis identified those items whose removal would improve the factorial validity of the CUCEI scales. The criteria for retaining any item were that its factor loading must be at least 0.40 with its own scale and less than 0.40 with all other scales. The application of these criteria led to the deletion of numerous items, including all items in the two scales of Student Cohesiveness and Innovation. The optimal factor solution was found for a refined version of the CUCEI with four items each in the four scales of Involvement, Task Orientation, Personalisation and Individualisation.

The factor analysis results in Table 2 for the learning environment scales from the modified CUCEI revealed that all 16 items had a factor loading of at least 0.40 on their own scale and less than 0.40 on the other three scales. The total proportion of variance accounted for was 58.65 %, with the variance for the different scales ranging from 7.92 to 38.11 %. The eigenvalue for different scales ranged from 1.27 to 5.30.

The Cronbach alpha reliability coefficient was used as an index of scale internal consistency. Table 2 reports that the Cronbach alpha coefficient for each of the learning environment scales ranged from 0.64 to 0.79 for the posttest with the students as the unit of analysis. For Satisfaction, the alpha reliability (not reported in Table 2) was 0.68.

### Evaluation of teaching strategies in terms of pretest–posttest changes

To reduce the Type I error rate, the statistical significance of pretest–posttest changes initially was explored using Multivariate Analysis of Variance (MANOVA) with repeated measure. Because the multivariate test yielded significant results overall for the set of five dependent variables using Wilks' lambda criterion, the univariate ANOVA was interpreted separately for each of the five scales. Table 3 reports the ANOVA results together with two descriptive statistics: the average item mean and the average item standard deviation for each group. The average item mean, or the scale mean divided by the number of items in that scale, provides a basis for comparing the average scores from scales which could have different numbers of items.

Whereas MANOVA was used to investigate the statistical significance of changes between pretest and posttest, effect sizes were used to describe the magnitude, or educational importance, of those differences, as recommended by Thompson (1998) and Cohen (1977). The effect size, which is calculated by dividing the difference between means by the pooled standard deviation, expresses a difference in standard deviation units. Table 3 includes effect sizes.

Table 3 shows that, for each of the five scales, pretest–posttest differences were statistically significant ($p < 0.01$) for all scales. Furthermore, the effect size was very large for each scale and ranged from 1.40 standard deviations for Individualisation to 2.88 standard deviations for Satisfaction. These are large magnitudes according to Cohen (1977). These large improvements between pretest and posttest support the effectiveness of using the activity-based teaching strategies.

**Table 2** Factor loadings, percentage of variance, eigenvalue and internal consistency reliability (Cronbach alpha coefficient) for the modified CUCEI

| Item | Factor loadings | | | |
|---|---|---|---|---|
| | Involvement | Task Orientation | Personalisation | Individualisation |
| INV9 | 0.41 | | | |
| INV23 | 0.65 | | | |
| INV37 | 0.71 | | | |
| INV44 | 0.47 | | | |
| TO5 | | 0.46 | | |
| TO12 | | 0.44 | | |
| TO33 | | 0.40 | | |
| TO47 | | 0.42 | | |
| PERS1 | | | 0.41 | |
| PERS8 | | | 0.61 | |
| PERS15 | | | 0.53 | |
| PERS22 | | | 0.46 | |
| IND14 | | | | 0.45 |
| IND21 | | | | 0.72 |
| IND28 | | | | 0.48 |
| IND35 | | | | 0.40 |
| % Variance | 33.11 | 9.44 | 8.18 | 7.92 |
| Eigenvalue | 5.30 | 1.27 | 3.24 | 2.01 |
| α reliability | 0.64 | 0.79 | 0.71 | 0.62 |

$N = 84$

Factor loadings smaller than 0.40 have been omitted from the table. Principal axis factoring with varimax rotation and Kaiser normalisation

**Table 3** Average item mean and average item standard deviation for pretest and posttest and pretest–posttest difference (effect size and ANOVA result) for each learning environment and satisfaction scale

| Scale | Average item mean | | Average item standard deviation | | Difference | |
|---|---|---|---|---|---|---|
| | Pretest | Posttest | Pretest | Posttest | Effect size | *F* |
| Involvement | 2.82 | 4.32 | 0.72 | 0.51 | 2.40 | 3.74** |
| Task Orientation | 2.71 | 4.34 | 0.81 | 0.53 | 2.38 | 3.82** |
| Personalisation | 2.58 | 4.43 | 0.97 | 0.46 | 2.44 | 4.00** |
| Individualisation | 2.91 | 3.93 | 0.75 | 0.71 | 1.40 | 2.89** |
| Satisfaction | 2.47 | 4.59 | 0.94 | 0.45 | 2.88 | 4.27** |

$N = 84$

** $p < 0.01$

## Case studies

The results obtained from using the CUCEI were supplemented by qualitative information collected from case-study students through class observations, interviews with participants and narrative stories which allowed us to triangulate these insights with results from using the CUCEI in Table 3. The interpretation of the quantitative data became more meaningful when combined with data gathered using other research methods (e.g. a narrative indicated that students at school were experiencing teacher-centred lessons during which they appeared to play a very passive role). However, when students experienced activity-based teaching strategies, they had opportunities to discuss their ideas and they became more engaged in the learning process (pre-post changes for Involvement = 2.40 standard deviations in Table 3).

All students interviewed had similar opinions about being on task because the activity-based teaching strategies allowed them to acquire mathematical thought through collecting information, making notes of facts and hypotheses and discussing the results with their peers or teacher (pre-post changes on Task Orientation = 2.38 standard deviations in Table 3).

The feedback that we received from these students is that we created a supportive learning environment for them through being friendly and approachable, which led to effective learning (pre-post changes on Personalisation = 2.44 standard deviations in Table 3).

One of the intentions of applying the activity-based teaching strategies was to overcome the fear and anxiety that students had towards mathematics. Interviews revealed that students felt relaxed and enthusiastic during the activities and that we were careful in ensuring that each student could work at his own pace and to apply strategies that work for each individual (pre-post changes on Individualisation = 1.40 standard deviations in Table 3). In general, students were satisfied with the activity-based teaching strategies because they felt that they were enjoyable, engaging, motivating, interesting and encouraging and were satisfied with the mathematics learning process (pre-post changes on Satisfaction = 2.88 standard deviations).

The qualitative data provided valuable insights about how the activity-based teaching strategies changed adult male students' perceptions towards learning mathematics after experiencing failure in the past. The magnitudes and statistical significance of pre-post changes in the quantitative questionnaire data, together with qualitative data, supported the effectiveness of the activity-based teaching strategies.

## Conclusion

A major contribution of this study is that the College and University Classroom Environment Inventory (CUCEI) was translated into the Arabic language and validated. The modified Arabic version of the CUCEI has 16 items in four scales (four items per scale) assessing four learning environments dimensions that are important in mathematics classrooms, namely, Involvement, Task Orientation, Personalisation and Individualisation. A Satisfaction scale from the CUCEI also was translated into Arabic and used in our study.

The main purpose of this study was to investigate the effectiveness of teaching strategies that engage college students who had experienced childhood difficulties in learning mathematics in the UAE in terms of the nature of the classroom learning environment and students' satisfaction. In addition, we investigated how the use of personally-relevant and concrete activities changed the learning environment in ways that were perceived to be beneficial by adults who had experienced failure.

A sample of 84 students from eight classes in the Higher Colleges of Technology (HCT) responded to the CUCEI as both a pretest and a posttest. Satisfaction was measured with a modified Arabic version of this scale from the CUCEI. Moreover, five case studies students were conducted to assess the learning environment through observations, semi-structured interviews and focus-group interviews and to link qualitative information with findings for the constructs assessed by the CUCEI.

Principal axis factoring with varimax rotation and Kaiser normalisation supported an optimal factor structure for a 16-item four-scale version (four items per scale) of the CUCEI assessing Involvement, Task Orientation, Personalisation and Individualisation. The total percentage of variance accounted for by the four CUCEI scales was nearly 60 %. The internal consistency reliability, using Cronbach's alpha coefficient, was calculated for each learning environment scale and Satisfaction for two units of analysis (the individual student and the class mean) and separately for pretest and posttest data. Alpha coefficients for the four scales ranged from 0.61 to 0.75 for the pretest and from 0.64 to 0.79 for the posttest with the student as the unit of analysis. With the class mean as the unit of analysis, alpha coefficients ranged from 0.61 to 0.77 for the pretest and from 0.63 to 0.82 for the posttest.

MANOVA and effect sizes were used to provide information about the statistical significance and magnitude of the pretest–posttest changes for each of the five scales. Changes were statistically significant and large in magnitude for Involvement (effect size of 2.40 standard deviations), Task Orientation (2.38 standard deviations), Personalisation (2.44 standard deviations), Individualisation (1.40 standard deviations) and Satisfaction (2.88 standard deviations).

Data from the CUCEI were complemented by qualitative information gathered from case-study students through class observations, interviews with participants and narratives, which allowed triangulating the results from the two methods. The qualitative data provided valuable insights about how the activity-based teaching strategies changed adult male students' perceptions towards learning mathematics after experiencing failure in the past. Overall, the effectiveness of the activity-based teaching strategies was supported by the magnitudes and statistical significance of pre–post changes in the quantitative questionnaire data, together with the qualitative data.

This research is significant because it is one of the first studies of learning environments conducted in the UAE and because a carefully modified and translated version of the CUCEI was validated and made available to educators and researchers in the UAE. The research also represents one of the few learning environment studies anywhere in the world that focused on the effectiveness of activity-based teaching strategies in mathematics in terms of the classroom environment perceived by adult male students.

Educators' enthusiasm to integrate activity-based teaching strategies into their lessons was a key to success in enhancing the classroom learning environment and students' satisfaction towards mathematics. However, some teachers find these strategies time consuming and prefer traditional activities, such as paper-and-pencil worksheets, because they perceive the inflexibility of the curriculum and time pressures as major impediments. Hopefully, the outcomes of the present research will motivate educators of mathematics to use more creative pedagogical practices that can help to improve the classroom learning environment and students' satisfaction.

Activity-based teaching strategies which involve games, puzzles and hands-on activities provide students with experience in experimentation, exploration, simulation, imagination and trial-and-error (Khine and Saleh 2009). Also researchers draw attention to the potential of activities to support participation, competencies and collaboration (Kirriemuir and McFarlane 2004). Khine and Saleh (2009) suggest that the challenges that lie ahead for educators are to draw on teaching strategies to alter traditional approaches to a new learning model that involves the use of activities that involve educational games and simulations in the formal curriculum. They also recommend that teachers capitalise on the motivational power of activities in the classrooms to promote a more enjoyable learning environment.

Educators are likely to be interested in our finding that our Arabic version of the CUCEI was valid and reliable when used with college adult male students in the United Arab Emirates. This study could guide educators in the future in assessing and improving learning environments and students' satisfaction in mathematics in colleges in the UAE and elsewhere.

Our study adds to the richness of learning environment research with a primary focus on the mathematics learning environment classroom (e.g. Chionh and Fraser 2009; Dorman 2001; Kilgour 2006; Majeed et al. 2002; Mink and Fraser 2005; Moldavan 2007; Ogbuehi and Fraser 2007; Spinner and Fraser 2005). Relatively few past learning environment studies have focused specifically on mathematics classes, and none of these focused on college-level adult male students who had experienced difficulties learning mathematics when they attended school.

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