www.scirp.org/journal/ce

ISSN: 2151-4755

Vol.1, No.2, September 2010

Creative Education

ISSN: 2151-4755

Scientific Research

Journal Editorial Board

ISSN: 2151-4755 (Print), 2151-4771 (Online)

http://www.scirp.org/journal/ce

Creative Education, 2010, 1, 69-133
Published Online September 2010 in SciRes (http://www.SciRP.org/journal/ce/)

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Volume 1 Number 2 September 2010

Creative Education (CE)

Journal Information

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Creative Education, 2010, 2, 69-74
doi:10.4236/ce.2010.12011 Published Online September 2010 (http://www.SciRP.org/journal/ce)

The Elephant in the Room: Understanding Barriers to Students' Articulation of Diversity

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Received May 11th, 2010; July 13th, 2010; July 20th, 2010.

ABSTRACT

A scholarship competition designed to foster classroom discussion and introspection about diversity had few participants despite its cash prize. This paper explores undergraduates' view of the project via focus groups and reveals surprising depth in students' answers to the question of why students did not participate. Analysis uncovered emergent themes related to emotional discomfort with diversity in general and self reflection in particular. Implications include the conceptualization of "diversity," teaching methods, and instructors' professional development.

***Keywords*:** *undergraduate*, *diversity*, *higher education*, *cultural competency*

1. Introduction

Vast differences in race, gender, ethnicity and many other variables increasingly characterize the face of the university; this diversity is generally seen as both necessary — due simply to demographics — and desirable — due to its potential for enhancing intellectual, social and personal development of students [1]. Unfortunately, neither the creation of a diverse student body nor education about diversity is simple. In response to the challenge, a social work program on a rapidly diversifying campus developed a scholarship program — *The Social Work Prize: Celebrating Diversity* to help undergraduates reinforce classroom learning and promote self reflection about diversity and cultural competence. The contest charged students to articulate some "celebration" of diversity in their own lives, and in return they could win a cash prize. Given the cash prize, organizers were astonished to find that few students applied for the prize. Students did not wish to participate, even when a classroom assignment corresponded exactly to the scholarship's specifications. Despite student input in tweaking the prize and refining its marketing to students over a five year period, each year fewer than ten of the 150-200 undergraduate students applied. Rate of participation began to be seen as a possible bellwether of students' comfort with the diversification of the campus and the curriculum. Consequently, it is the purpose of this paper to begin to identify the factors related to student participation in the prize in the hopes of identifying some educational characteristics of successful discussion of diversity.

2. Literature Review

Issues in "diversity" in higher education curricula and programming were reviewed. During the project, the issue of students' anxiety surrounding diversity became a clear and significant theme. Consequently, anxiety and its subsequent resistance in the process of teaching and learning about diversity were examined as an iterative inquiry during the interview period. In addition, the effective pedagogy of diversity became a significant area of literature review, in part to avoid inadequate disconfirming evidence [2]. For the purposes of this paper, "diversity" is understood as it is presented in the primary textbook used by this group of students: "Diversity refers to the vast range of differences among people, including those related to race, ethnicity, cultural background, place of origin, age, physical and mental ability, spirituality, values, sexual orientation, and gender" [3].

2.1. Benefits of Campus Diversity

The educational benefits of a diversified campus are now under legal scrutiny, thus, researchers are beginning to fully explore the benefits of a diversified campus. Outcomes may be judged based on economics — graduation rates and graduates' income level [4], the analysis of faculty opinions [5], specific education outcomes [6],

and student subjective assessments of interaction [7]. Methods for assessment of students' perceptions vary, including self reflection of personal beliefs and expectations upon entering college and in comparison to senior year experiences. A meta-analysis conducted by Gurin, *et al.* (2002) [7] concluded that whether the method was retrospective or longitudinal, using different samples and reporters, a wide variety of benefits to individuals and to campuses occurred as a result of campus diversification.

A self-report study focused on both interpersonal and skill-acquisition outcomes followed two cohorts totaling 1, 293 respondents of Asian-American, African-American, and Caucasian-Americans [8]. The first cohort graduated in 1989 with a diversity composition of 3% Asian-American, 1% Hispanic, 3% African-American, and 94% Caucasian-American. The second cohort graduated in 1994 with the minority population doubled [8]. The cohorts were questioned on interracial student interactions, and their alma mater's contribution to skill development.

Results suggested that all groups benefited from the increased diversity; however, Caucasians benefited most [8]. It is most important to note that the study found a diverse student body not only increased the likelihood of same race interactions but an overall development of skills and academic achievement for all groups [8]. This study and others [9] support the Gurin *et al.* (2002) [7] conclusion that the presence of diverse student combined with student-student interaction reaps skill and academic benefits.

2.2. Pedagogy of Diversity

Another facet of the diversification experience on campuses is education. While it seems self evident that education alone will not diversify a campus, diversification may also be necessary but insufficient. Resistance to education related to diversity has been manifested in both students and faculty, even in culturally sensitive social work programs [10]. Within programs, students may struggle with a firm definition of diversity, the importance of increased awareness, and knowledge of diverse populations while faculty members struggle with limited knowledge of diverse populations and unprepared class agendas focused on the work related to diverse populations [10].

Consequently, it is clear that both institutions and individual educators bear responsibility for achieving the benefits associated with the understanding of difference among people. While the university's task is diversification of the student body, the educator's challenge is to create an environment of cultural sensitivity and cultural competence to confront and overcome tension and resistance. Utilizing the concept of critical pedagogy, Redmond (2010) [5] developed structured classroom discussions as 'safe space' for articulation of taboo or emotional topics. Modification of the classroom setting became necessary when the avoidance of perceived taboo topics resulted in tension within the classroom. The study identifies the instructor as a mediator to address issues in the classroom regardless of personal discomfort [5].

Instructor characteristics and those of the educational environment conducive to learning and skill building include diversified classrooms as the forum for developing sensitivity and skill building. Faculty members who are comfortable with addressing tension-filled student issues have been found to be instrumental to student development. On the other hand, faculty discomfort in addressing issues of diversity may strain the classroom setting by avoiding a teachable moment. Faculty must work introspectively to identify their own identity issues along with knowledge of the populations they serve in their classrooms to create a safe learning environment where it is possible to confront and discuss tensions. While faculty members may identify that practices of open discussion and forums for learning are present, underlying biases may discourage the faculty member from engaging in discussions focused on diversity. Garcia & Van Soest (1997) [11] identified faculty members' awareness of personal comfort and recognition of their own diversity is important to avoid issues of counter-transference. Students may be influenced in a negative manner on the subject of diversity if a faculty member presents a strong point of view that is in contrast or attempting to correct student discussion [11]. Encouraging students to be open and verbalize both strengths and barriers is important to course planning. Allowing students to develop coursework may encourage independent learning and articulation of educational needs and barriers. Clear, strengths based objectives for class room structure in necessary along with grading focused on learning and quality of work, not political correctness [10]. Simply identifying tensions and resistance are typical when covering issues related to diversity and may inhibit questions by students. Open discussions regarding why diversity is important and student rationale for engaging in coursework may identify tensions that can be addressed and overcome. Creation of a supportive and proactive learning environment focused on recognition of student's efforts to engage in discussions is critical to developing self- recognition and normalization of the learning process [12-16].

In an attempt to create awareness to barriers surrounding the development of culturally competent skills, Messing (2004) [17] details specific tasks assigned to the classroom to identify bias and pejorative language. In a classroom structured activity, undergraduate students in a multicultural social work course were encouraged to de-

velop an understanding of culturally competent practices through class discussion. Messing (2004) [17] developed a method to encourage peer feedback and discussion regarding the use of appropriate, disrespectful, or negative language. To develop culturally competent, non-biased language, students were asked to "choose a characteristic or a population with more than one characteristic" and respond to several reflective questions. The questions elicited responses based on the student's beliefs, current knowledge, and issues or level of discomfort. The student submissions were integrated into a document of statements pulled from each paper with modifications made to each statement to protect the confidentially of each student as the statements are read aloud in class. The class is encouraged to rate each statement (as appropriate, disrespectful, or offensive) then process the statement. The peer discussion encourages students to be aware of biases and respond to pejorative statements in a safe environment. Messing's activity elicited positive responses from students, stating the activity encouraged awareness to personal biases and the importance of professional, culturally competent skill.

Awareness of personal bias is only the beginning of understanding diversity and developing cultural competence. Mills and Ballentyne (2010) [18] caution that expectations of change in student attitudes and functioning should not be too high: a single experience or even a short course is not likely to carry the students through a process of change. They suggest that the process moves from "self awareness / self-reflectiveness" to "openness" and finally to a "commitment to social justice". Likewise, in a study of 200 undergraduates, Gasker and Vafeas (2003) [19] found that a course on poverty which aimed to move students toward a structural explanation for poverty (*i.e.* away from blaming the victims of poverty) was valuable, but that "curriculum-wide effort to provide this material to students may be beneficial".

2.3. Literature Review Summary

It appears that the diversification of campuses is beneficial to all concerned, particularly Caucasian students. Simply increasing numbers of underrepresented groups does in fact appear to facilitate the understanding of difference and the development of skills necessary for improving interpersonal interaction. On the other hand, simply increasing numbers does not seem to be sufficient for developing the comfort level required by social work education to lay the ground-work for developing cultural competency. Effective teaching and learning seems to take place over time in situations where educators and students feel safe enough to risk vulnerability. Identifying the factors associated with creating this atmosphere of safety is a subject worthy of study.

3. Methods

Undergraduate students in three sections of a foundation level social work course and one section of a senior seminar course were offered the opportunity to participants in focus groups. Using a convenience sample, participants were chosen from "major only" courses that had a diversity assignment component. That is, all participants had been required to complete an assignment based on a diverse population. The assignment developed in relation to Council of Social Work Education standards, met submission criteria for *The Social Work Prize: Celebrating Diversity*.

One week prior to the focus groups, a graduate social work student (chosen as interviewer to reduce interview bias) engaged the classes with a brief discussion of the purpose of the groups. Confidentiality and informed consent were reviewed as necessary components of the focus groups. The focus groups, conducted during scheduled class time and time-limited to 30 minutes, would not impact the students' class participation grade.

During the initial classroom visit, potential participants were encouraged to ask questions or provide feedback to the interviewer regarding the purpose of the focus groups or the research project. On the day the focus groups were to be conducted, the interviewer re-entered all sections of undergraduate classes to restate the purpose and location of focus groups. Prior to the instructors' entrance, the interviewer disclosed the location of the focus group and exited the classroom. As the students entered the focus group room, the interviewer provided each participant with a brief, written description of the study. The interviewer encouraged any questions prior to the participants signing informed consent and completing the demographic questionnaire. The interviewer assured confidentiality and requested permission of all participants to audio record.

All data were recorded and transcribed prior to analysis. Atlas. ti provided a means for analysis, which was conducted through grounded theory's open coding methods [20]. Reliability was checked via independent coding and differences were resolved via discussion. Member checking was conducted with the focus groups in informal discussion following analysis.

4. Findings

Of the four focus groups, nineteen students (seventeen females) participated. Three females identified as racial minorities — one Black and two Hispanic — while one male independently identified himself as gay, which became an important part of that group's discussion.

Qualitative analysis of focus group feedback identified

four possible barriers to participation in *The Social Work Prize: Celebrating Diversity*. Student emotional reaction to a perception of white privilege, and limited self reflection of personal areas of diversity were identified. Other identified barriers could be described as limited knowledge of diversity and a perceived or real inability to appropriately articulate issues related to diversity. Logistic issues of understanding of the submission, review, and awarding of the prize were also identified as potential barriers.

4.1. Emotional Reactions to White Privilege

"White privilege" is a category that was not named by students but emerged from the analysis of data. Primarily, the feeling was manifest in a pervasive discomfort related to various types of diversity, particularly those with which the students had no personal experience. Analysis revealed that students completed their class diversity assignments with a focus on populations familiar to the student. For unfamiliar areas of diversity, discomfort was expressed consistently in the focus groups. Participants seemed to feel that a barrier to submitting a diversity prize for public scrutiny was something like benefiting from the adversity of others. This seemed to be the case despite the scholarship's title "Celebrating Diversity" and its charge, to "explain some way you can celebrate diversity in your life." One student felt that asking a person of a different race or culture to discuss their experience would feel like "gawking" or staring at someone's "misfortune." Another student felt if there were an event to present submissions to the prize, people would look at her as if she "did not belong there" due to her (Caucasian) race.

4.2. Self Reflection

The ability to apply classroom knowledge related to diversity to their own situations emerged as the second potential barrier to participation in the prize. Students who did not apply for the prize in all groups stated that they felt they had "no diversity." Primarily, focus group participants discussed not feeling "diverse" based on racial identification. To them, Caucasian did not "count" as diverse. Students struggled to identify areas in personal diversity and stated initial ideas for submission to the prize would not be "diverse enough" for the prize. Somehow, although the prize instructions did not ask them to focus on their own aspects of diversity, they seemed to view "being diverse" as an entrance qualification. One student stated multiple times during the focus group that she did not feel "diverse" simply because she was Caucasian.

4.3. Limited Knowledge of Diversity

In addition to limited comfort or ability to self-identify as an individual with different characteristics, students also identified feeling uncomfortable with defining, identifying, or articulating diversity in a classroom or public setting. Students feared being regarded as ineffective or inappropriate is they could not identify their own diversity and avoided interaction with cultures dissimilar from their own. The focus group participants primarily viewed diversity as an emphasis on race, neither cultural or ethnic identification nor any other characteristic. One student articulated the understanding that diversity is not only associated with race, but her class project on diversity did not embrace the conceptualization.

One student related an experience in which she attempted to make an entry to the prize competition, but, per the student's report, her proposed diversity project was identified as "not diverse" by a faculty member. The student stated no other efforts were made to participate in the diversity prize after the interaction. The student verbalized feeling embarrassed and worried she might not belong in a helping profession if she could not identify diversity to faculty members.

4.4. Logistic Knowledge of the Application Process

When asked specifically to identify factors associated with participation or nonparticipation in the Prize, students identified communication of the availability of the prize as a possible barrier. While this may be a coping mechanism to avoid more serious issues, it was discussed fully in the groups and was assumed to be as valid as any other response in analysis. The focus group participants suggested that they were unaware that they could submit their class assignments as entries for the Prize. The focus groups discussed miscommunications regarding how projects were submitted, which faculty members were involved in judging the prize, and the benefits of participating.

All students inquired about the amount of money the prize generated for the student. The amount of money was a pivotal point for some students. Without knowing the dollar amount, the students reported that they were unsure if developing a submission would be worth their time and effort. Students were unaware of how the winner of the prize was honored. Discussions regarding fears of presenting the submissions in front of multiple faculty members or a large community of people were identified as barriers for students who struggled to feel comfortable in defining and articulating diversity.

4.5. Student Suggestions

Following the open-ended interview questions, students were asked specifically how the prize might be improved. Student suggestions to make the prize more accessible

included creating a clearly designed brochure with attractive coloring. Students wanted to know the cash amount and which faculty members were involved in the project selection process. Clear articulation of what the entries were to include and clear definition of diversity provided with the application were identified as additional student suggestions. One focus group suggested a website with frequently asked questions regarding the competition. The group stated that limited understanding of the purpose of the prize may be a barrier to participation. Students felt the program should more clearly present purpose of the prize to encourage and motivate people to participate. Opening the prize to the entire university was identified as a method to generate more participation and engagement in the project.

5. Limitations

Limitations include the limited student participation in focus groups. More student feedback may have generated more diverse focus groups, more potential barriers and support for peer identified issues. The focus groups were conducted with a single researcher and audio recorded. After the focus groups were conducted, it was identified the tape or recorder had malfunctioned throughout the focus groups. Although extensive notes were taken, at times during the focus groups audio was lost.

Replication of the study would benefit from multiple focus groups with a larger amount of students matched to the institution's level of diversification. More than one group facilitator would benefit the project and provide additional observation in focus groups as well as note-taking support. Ensuring the adequacy of audio equipment will benefit the transcription of the data.

6. Discussion

Student voices clearly revealed a complex set of circumstances that come together to provide a barrier to their participation in this learning exercise. The diversification of college campuses has created a myriad of opportunities as well as emotional discomfort. For the focus group participants, these pressures ironically co-exist with uncomfortable feelings related to their own status as members of the majority "privileged" group. In addition, participants revealed a limited ability to self-reflect on their own elements of diversity and seemed to lack a cogent definition of the concept itself. These factors together contributed to the lack of participation in the project.

Other barriers were identified explicitly by the students themselves. These include a focus on the aesthetic value of the brochure advertising the prize along with the need for clear, directive language, submission expectations and disclosure of the cash prize amount as potential barriers to participation in the prize. Creating a brochure that demands the attention of a student and clearly states expectations of each submission as well as a clear definition of diversity was identified as a method to generate more participation. Students also expressed an interest in the level of cash prize as something that would dictate their participation. It is interesting to note, however, that this same cohort of students also produced a well-reasoned, well-attended protest of a campus event identified as "racist" (for no remuneration). It appears that emotional barriers are at least as powerful to students as logistic ones. Consequently, the development of a similar "diversity prize" may serve as an effective bellwether of student experiences with difference.

Perhaps most importantly, it appears from the literature and was suggested by at least one focus group that faculty need to recognize their own learning needs. Self-reflection around one's own diverse characteristics is necessary to develop the comfort level needed to seize teaching opportunities as they occur. Resistance in the classroom can be identified by feelings of guilt from perceived white privilege, limited self awareness, and competency issues of articulating diversity in a professional and unbiased manner. The literature indicates support for the focus group findings. A faculty effort to manage personal judgment of student responses encourages the engagement of students in the learning process [14].

Encouraging the learning process through class participation and activities across the curriculum can reduce anxiety regarding diversity and develop a forum of open discussion, but this requires faculty who are aware of personal and professional views. Through the utilization of critical theory and throughout the literature, faculty members are called on, then, encouraged to engage in introspective activities related to personal views and barriers regarding diversity. Finally, a program-wide, standardized definition of diversity may also be helpful to achieve uniformity and comfort with the concept. Indeed, the creation of a "program approved" definition may facilitate faculty professional growth. To achieve cultural competency, programs, faculty and students all need to be open to vulnerability and change.

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Creative Education, 2010, 2, 75-80
doi:10.4236/ce.2010.12012 Published Online September 2010 (http://www.SciRP.org/journal/ce)

Contemplating Design: Listening to Children's Preferences about Classroom Design

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Received June 29th, 2010; July 22nd, 2010; July 30th, 2010.

ABSTRACT

This paper focuses on children's responses about the design of two images of interior classroom environments. Children reported that key elements were circles, spheres, and windows in the low visual stimulation environment. In the high visual stimulation environment they identified activity materials and the decor as preferred elements in the space. Results from this study can be used by designers of child development centers to guide the design of the space to reflect one that incorporates children's preferences for design.

***Keywords*:** *Classroom Environments, Design Principles and Elements*

1. Introduction

Young children understand and appreciate the aesthetics of their near environment in both a complex and visceral manner. As they work on projects, create new experiences, eat lunch and rest, their eyes are scanning and focusing on the designed classroom environment. Visual stimuli within a space can vary widely from high visual stimulation which may appear to the young child as cluttered and overwhelming to low visual stimulation which may appear boring and static. Interior design principles and elements in the classroom range from bright and subdued colors of materials and manipulative to rich and varied textures on the furnishings, walls, floor, ceiling, and cabinetry. The aesthetics are enhanced with myriad shapes, forms, and light throughout that add to the richness, complexity, and depth of the space. Ideally, the synthesis of functional and aesthetic components in the classroom creates a harmonious setting for young children. Researchers have extensively studied visual perceptual knowledge of children [1]. The area that has not been investigated is the impact of aesthetic form and finishes on children's preferences.

Numerous decisions about the application of the elements and principles of design in the classroom are determined primarily by the teachers in the setting. Possible questions teachers may ask themselves when designing the classroom include the following: 1) Does my classroom design reflect a welcoming learning environment? 2) Does my classroom design represent the curriculum or theoretical perspective of the center? 3) How do the children in my class perceive the designed classroom? and 4) What type of design characteristics do children in the environment prefer and why? The focus of this study was concerned with the last two questions regarding children's perceptions and preferences in the classroom environment. Specifically, the researcher was investigating children's preferences for an environment with design elements and principles illustrating a space with low visual stimulation versus a high visual stimulation environment. The overall objective of the research project was to have a better understanding of what principles and elements of design are considered to be aesthetically pleasing to young children.

2. Background

Enclosed space provides a backdrop for combining complex and meaningful design elements and design principles. "*In the large literature on environmental quality, relatively few works attempt to understand how people feel about space and place, to take into account the different modes of experience* (*sensorimotor*, *tactile*, *visual*, *conceptual*), *and to interpret space and place as images of complex - often ambivalent – feelings*" - Yi-Fu Tuan. [2].

Tuan highlights the idea that space is somewhat minimized and underappreciated as a salient concept. Young children report detailed knowledge of the various shapes, forms, and colors in the near environment; however, the

meaning of these elements of design to children is unclear. Malnar and Vodvarka [3] propose that sensation is mediated by culture and experience to form an individual's reaction to space. This proposition places sensory experiences as the central concept that impacts a person's response to their environments.

Principles and elements are usually represented in the use and manipulation of materials. The interaction of the elements of line, shape, form, pattern, texture, scale, light, and color with the principles of proportion, balance, rhythm, contrast, emphasis, and harmony creates the overall aesthetic effect of the space.

The direction of a line can be horizontal, vertical, diagonal, or curvilinear. Horizontal lines are usually thought to evoke feelings of calm, rest and stability within a space. Lines in the early childhood classroom can often be seen in the division of a wall with one horizontal line separating the upper and lower walls with paint and a chair rail. This design is useful when the ceiling in a space is high. A visually lowered ceiling is scaled to and reflective of a child's height. Vertical lines show strength with resistance to gravity [4,5].

Images of vertical lines are created with tall windows, paint, columns, and wall variations with the application of different materials to emphasize height. Diagonal lines suggest a dynamic motion or tension within a space creating a sense of movement. They are best used in areas where children's play is highly active. Curvilinear lines also create visual motion; however, they have a softer effect that has a flow or rhythm as compared to diagonal lines. In a recent study, Dazkir [6] found that people reported curvilinear lines in furniture to be more pleasing than furniture with rectilinear lines. It may be that children would prefer curvilinear lines to rectilinear lines as pleasing design elements in a space.

The elements associated with shapes such as square, circle, rectangle and triangle have similar associations to line. The circle is considered to be a more inviting, calming shape while the square and rectangle are more rigid with their rectilinear shapes and sharp corners. The triangle is dynamic with its diagonal lines but also rigid and uninviting with its sharp corners. Cubes are stable while spheres evoke feelings of movement while a pyramid form shows stability with dynamic diagonal edges. Organic shapes, based on the natural environment, are amorphous without clearly defined shapes. Organic designs denote movement with their curvilinear, asymmetrical line and form. They can be quite effectively in a space to show variation from symmetrical geometric shapes and forms.

The additional elements of color, light, texture, pattern, and scale complete the design of the space. Variety of texture and pattern can create a high visual stimulation environment or a low visual stimulation environment depending on the materials used to create the texture or pattern. For more information on children's color preferences, please see Read and Upington [7].

The natural light in a space is critical to children's proper physical development [8]. Windows add visual interest with transparency, reflection, views, and spatial variation [9] while providing views to the outside helping children with understanding of climate patterns, natural cycles, and different times of the year.

If the center can provide views to green space, children will benefit from the opportunity to gaze at the natural environment [10]. Ideally, a center will have windows on opposite sides of the room to balance the glare and reflection within the space. Clearly the principles and elements of design create an environment that can be dynamic or serene depending on how they are implemented in the design of the space.

3. Evaluations of Children's Environments

The designed classroom is seldom the central focus of observational research with children. For example, Boehm and Weinberg [11] detailed methods for observing children within the classroom environment, however, the descriptions of the classroom focused solely on the furniture layout and lighting in the space.

Interior design elements and principles were not incorporated in the observation guidelines. The ECERS-R scale [12] is used extensively to evaluate classrooms, however, the designed environment is, again, only considered in the context of the furniture layout and materials within the space.

The aesthetics of the physical environment is a significant consideration [13] that, for the most part, has been overlooked in the literature on early childhood education environments.

Interior designers and architects of child development centers do not regularly consider the perspective of the children using the classrooms. Children's perspectives on aesthetics are important for thoughtful inquiry because designers of child development centers are typically using design principles and elements that are pleasing to adults. The center's board of directors, administrators, teachers, parents, architects and/or interior designers may be involved in the design process of the center. The children's perspective on the designed classroom is often overlooked in the design-decision making process. This is unfortunate because young children are passionate observers of the environment and, as such, their reports of preferences for interior design principles and elements are important to understanding their perceptions of the classroom environment.

Clark, McQuail, and Moss [14] concluded that studies should include listening to children's views on the indoor and outdoor environment. Therefore, this study focuses on children's reports of preferences for two designed environments.

4. Method

Twenty-two girls and 23 boys participated in this study. Twenty children were 3-years of age, 21 children were 4-years of age, and four children were 5-years of age. Semi-structured interviews and image selection were used as methods to understand children's design preferences. Each child discussed two photographs with the interviewer while seated at a small table. Two digital images of two different classroom environments were used as the visual stimuli. **Figure 1** shows a classroom with low visual stimulation with subdued colors, low shelving, windows, and area for movement. **Figure 2** depicts a classroom with high visual stimulation in the space. A variety of display materials are seen with bright colors and assorted shapes along with densely placed chairs and tables. The children were asked to identify which room they would like to visit most. The interviews were designed in an open-ended format so that children would express their preferences without a structured plan from the questionnaire. The interviews were recorded with field notes and audiotapes which were then transcribed and analyzed using coding techniques to draw out themes from the interviews [15].

5. Results

The themes that emerged from the children's responses to **Figure 1** were Circular and Spherical Design Elements and Windows. Children discussed distinctive design elements when they noted their preferred classroom environment. The classroom in **Figure 1** was described as open with a lot of space. It was "plain", "not messy", and had "lots of space to run". The spherical forms and circular shapes throughout the space drew the participants' attention for discussion. Although the balls were partially seen in the lower right-hand corner of the photograph, several children, both boys and girls, commented on these forms as representing something special in the space. As well, they noted the hat above the window and the map of the world. An additional theme that emerged from the children's responses was the description of the windows. Windows are clearly a dominant design element in the photograph so it is not surprising that they were discussed as a special element in the classroom. In this particular photograph, the windows create an asymmetrical rhythm with seven windows on the left wall and three windows on the right wall along with emphasis on the large scale dominance of the space.

Selected children's responses to Figure 1:

The interviewer question is identified with an *I* and the Respondent is identified with an *R*. For example *R*-6 refers to respondent 6.

I. Would you most like to visit this room (*point at room* 1) *or this one* (*point at room* 2)?

What is special about this room?

Circular and Spherical Design Elements

R*-6** *It has a circle* (pointing to map) *and a baseball* (pointing to orange hat at top of windows). ***Boy

R*-9** *Because it looks better and good and it has a picture of two sides of the earth. Yeah, I can see some stuff in the corner right there, and that red circle there by the windows, which I think is Mars, and... there's a tree* (small plant on desk in farthest corner) *on the table...and it...it doesn't have a clock...and...it's not messy as the other picture.* ***Boy

R*-32** Points to orange hat on wall, points to colored balls in corner. Points to the map on the wall. ***Girl

R*-13** *Because this has a circle thing that you can ride on. Maps. The chairs. I think all of the stuff is special.* ***Boy

Windows

R*-7** *It has lots of windows.* (Points to balls in corner. Points to flowers on desk.) *The floor's so big, windows.* ***Girl

R*-39** *Windows*, (points to more windows), *more windows.* Points to balls in right lower corner. ***Boy

R*-41** *It's plain. Windows.* ***Boy

In **Figure 2**, the high visual stimulation environment, children preferred the wall decorations, particularly the banner of the children, the musical notes, and the poster of the red dog. The space was described as "fancy", "pretty", "more decorated", and "fun". They also noted the puzzles, blocks, and kitchen play area as special elements in the space. The two themes that emerged from **Figure 2** were Décor and Activity Materials.

Selected children's responses to Figure 2:

I. Would you most like to visit this room (*point at room* 1) *or this one* (*point at room* 2)?

What is special about this room?

Décor

R*-20** *Because...I really like it, it's not very messy. Well it has these pretty things here. Like chairs, tables, people on the walls and those...*(pointing to musical notes on the wall). ***Boy.

R*-21** *Well, because there's lots of fancy stuff in it. A lot of fancy stuff in here - this room kind of has more, a lot of, more stuff in it so it looks more fancy.* ***Girl

R*-35** *Because it's more decorated. I like this banner. I like those* (pointing to music notes) *and these stickers on the wall.* ***Girl.

Figure 1. Classroom with low visual stimulation.

Figure 2. Classroom with high visual stimulation.

R*-37** *This room, because it's pretty. Well it has some pink stuff in it...I really like... this around it* (pointing to paper bells around window frame in center) *cause it's pink around...I really like this because it's pink around* (pointing to puzzles on table). *It's really kind of pink...being in this room...I could go to here...this round place.* ***Girl

Activity Materials

R*-5** Points to table and chairs set. Points to puzzle on the table. *I like the beautiful thing up on the wall* (pointing to children's banner). *The clock.* ***Boy

R*-12** *Because there's more toys. Puzzle, Chairs.* ***Girl

R*-15** *Because it's fun. Because it has a whole bunch of toys. And a whole bunch of stuff with color in it.* ***Boy

R*-36** Points to the refrigerator. *The window.* Points to the music notes on wall. ***Girl.

An additional finding when comparing preference and gender was that there was a significant correlation between gender and preference for **Figure 2**, the high visual stimulation environment. Girls preferred the high visual stimulation environment over the low visual stimulation environment ($r = 0.34$, *p-value* $= 0.05$). More boys reported preference for **Figure 1** over **Figure 2**, however, the difference was not significant.

6. Discussion

The intent of this exploratory study was to document children's preferences for visual stimulation via the application of design principles and elements in the classroom environment. The finding that children selected circular shapes and spherical forms as special elements is of note. Circles and spheres provide variety in spaces where most elements are made up of rectilinear lines and forms. Bachelard stated " And in this rounded landscape, everything seems to be in repose" [16].

The spherical forms had special meaning to the children which they clearly stated in their responses. Possibly children felt more relaxed when viewing the spherical forms and shapes in the environment. The large-scale windows with their rectilinear shapes created dramatic rhythm within the low-stimulation environment. Children responded positively to these design elements and principles. Also of significance is the finding that girls preferred the environment with high stimulation over the low visual stimulation environment. Their descriptions of the space focused on decorative elements that created texture and rhythm in the space. Designers and teachers may wish to consider designing the environments for young children with more variety of circular shapes and spherical forms. Interest can be created simply by varying the shape in an environment to show emphasis on a form or shape through use of textures and materials. Girls may be more interested in a display area if it reflects a high stimulation view of materials. The classroom can be balanced for open areas with less visual stimulation and more enclosed areas with more visual stimulation.

Interviewing very young children always presents certain challenges to the interviewer. At times children were not interested in completing the interview. They were occasionally bored or tired of talking with the interviewer. Most of the children, however, appeared to enjoy giving their opinions about the photographs presented to them. Their responses to the interviewer were often thoughtful and complex.

Future directions for research would be to focus on investigating a greater variety of design principles and elements within a setting such as combinations of different lines and volumes. An increased understanding of children's preferences for design in the early childhood education classroom is clearly important for designers and teachers to consider when designing a space.

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Creative Education, 2010, 2, 81-92
doi:10.4236/ce.2010.12013 Published Online September 2010 (http://www.SciRP.org/journal/ce)

Communication Practices and the Construction of Meaning: Science Activities in the Kindergarten

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Received June 25th, 2010; July 28th, 2010; August 10th, 2010.

ABSTRACT

The paper presents a comparative analysis of communication practices used in two kindergarten classes in Greece during science activities related to magnets and magnetic attraction. Communication practices are classified as interactive / dialogic, interactive / authoritative, non-interactive / dialogic, or non-interactive / authoritative. Moreover, the role of different communication practices in the construction of meaning is analyzed, at the ideational, interpersonal and textual level. The analysis of characteristic episodes of the two activities reveals that different communication practices produce significant discrepancies in the meanings constructed in each classroom.

Keywords: *Communication practices*, *Construction of meaning*, *Dialogicity*, *Preschool education*, *Science teaching*

1. Introduction

The transition from teacher-centered to pupil-centered models of teaching has resulted in the formulation of preschool curricula based on children's experiences and active participation in exploratory learning processes. This approach is supported by the view that an environment rich in motivations can effortlessly ensure a child's development. However, this "natural development" stance has been questioned. According to Vygotsky [1] knowledge is socially acquired through communication and the teachers' role is crucial in this respect. Considering social interaction as vital in learning, the social organization of teaching activities becomes a key factor in the achievement of the teaching objectives.

Consistent with this view, Bakthin [2] identifies two factors determining the effectiveness of communication. On the one hand the speaker forms an utterance taking into account the previous experiences of the public s/he is addressing. On the other, understanding, that is effective communication, has been accomplished only when the addressee of the message takes up an active role in communication. Consequently "the speaker himself is oriented precisely toward such an actively responsive understanding. He does not expect passive understanding that, so to speak, only duplicates his own idea in someone else's mind" [2:69]. Therefore, in every case participation in communication means differentiation [3]. Differentiation first and foremost originates from the social and cultural environment effecting different experiences on individuals as well as different ways of processing them. Especially in education, dialogue provides pupils the opportunity to process their reserve of experiences, while at the same time it engages children in a process of cognitive challenge [4]. More particularly, in science teaching this process is realized by means of the formulation of hypotheses, explanations, conclusions, or the formation of taxonomies. Cognitive challenge is therefore promoted by the establishment of learning environments which aim at and support the pupils' active involvement and within which learning is a cognitive and a social process at the same time [5].

In this context the effectiveness of an instructional procedure can be assessed in terms of analyzing communicative practices. Relevant research has suggested that classroom communication is mostly developed in the form of triadic dialogue [6,7]. However, the effectiveness of this communicative practice is currently questioned, since it is based on closed questions that do not encourage exploration, but ask for a unique correct answer [8]. Besides, triadic dialogue excludes some pupils from participating in the instructional process and clearly does not support children's interaction and cooperation [9].

Teaching requires from the teacher to develop appropriate communicative practices corresponding to each cognitive objective. Research outcomes [10] have confirmed the positive contribution of dialogicity in the con-

text of reflective teaching, establishing the importance of reflection and dialogicity in understanding and solving problems as well as in reducing asymmetries between the roles of teachers and pupils. Nevertheless, studies [11,12] focusing on communication strategies employed in science teaching reveal that these are in majority developed on non-dialogic models. Other studies suggest that in science teaching a combination of dialogic and authoritative models of communication is essential [8,13].

Research focusing on preschool education indicates that communication between teacher and pupils is primarily based on children's play and cooperation [14]. However, especially when teaching science, teachers seem reluctant in organizing relevant activities [15], feeling unprepared to teach complicated scientific concepts, let alone encourage interactivity and dialogue. Indeed, structured science activities tend to favor directed learning and quantity of information [16], thus reducing the opportunities for children to actively participate in and contribute to the development of the activities. Likewise, the evaluation of science activities mainly focuses on children's ability to memorize and quote technical terminology and expressions previously presented [17]. Nevertheless, it is currently acknowledged that the attribution of meaning to experiences [18] is closely related with language development in children that is with the process of ontogenesis.

The present study aims at extending the discussion on the role of communication practices used in science activities in preschool education. Science teaching is considered as a social activity based on a process of logogenesis, which initiates the exploration of scientific topics while at the same time determines the roles of the participants in the process of knowledge acquisition. The study focuses on the comparison of two science activities to exemplify the role of different communication practices in the evolution of each activity.

2. Method

2.1. Research Setting

The study concentrates on two activities about magnets and magnetic attraction implemented with two groups of children in different kindergartens in Nea Ionia of Magnesia, Greece, in May 2005. The groups consisted of seven and five pupils of 4.6 to 6 years of age. The children had similar socio-economic backgrounds. Also, the teachers who implemented the two activities had similar qualifications and no significant difference in professional experience.

The topic of magnets and magnetic attraction was selected because it is commonly negotiated in the Greek kindergarten. Furthermore, the topic was voluntarily selected for negotiation by the two teachers, without any kind of communication or cooperation between them. Each teacher had full responsibility of the organization and implementation of the activity in her classroom. Both activities concentrated on magnets and their properties and the children participated in hands-on explorations using a variety of materials and magnets of different shapes. The first author was present during the implementation of the activities as a non-participant observer. The activities were video-taped and subsequently transcribed in the form of a digital file.

2.2. The Framework of Data Analysis

For the purposes of the comparison of the two activities, the analysis of characteristic episodes of each activity involves two axes: a) The classes of communication practices employed in the activities and b) The role of communication practices in the construction of meaning. These axes, along with their constituent dimensions will be presented in the following paragraphs.

A) Classes of communication practices

In regards to the first axis of the analysis the model proposed by Scott, Mortimer & Aguiar [13] was used, according to which communication is determined by two dimensions.

The first dimension concerns the way in which the participants are involved in communication and is based on the concept of dialogicity as described by Bakthin [19]. In this respect communication can be either dialogic or authoritative. This dimension reflects the teacher's attitude towards classroom communication and the way it determines the participation –active or not- of pupils in teaching and learning activities [20]. More particularly, a teacher applying dialogic discourse takes into account a range of different perspectives and attends equally to the pupils' (different) points of view and to the school science view. On the other hand, authoritative discourse reflects the teacher's intention to concentrate exclusively to the one and only acceptable viewpoint, that of school science [13].

The second dimension concerns the organization of the activity, that is the participation or non-participation in communication, which is recorded as dialogue or monologue and corresponds to interactive and non-interactive communication practices respectively [13]. In science activities addressing young children, communication is mostly interactive. Monologic, non-interactive communication is rather fragmentarily and sporadically used in instructional activities, when it is considered as essential by the teacher. However, one should not confuse dialogue (that is interactive communication) with dialogic discourse. As will become apparent below, interactive communication (dialogue) can be authoritative (non-

dialogic) when promoting a single point of view, excluding any alternative judgment expressed by an interlocutor.

The combination of the different values of the two dimensions described above, results in four basic classes of communication practices (see **Table 1**). Therefore, dialogue that is used to support the active, responsive understanding and is based on the expression of children's thoughts, observations and speculations, corresponds to an interactive / dialogic communication practice. Interactive / authoritative communication employs dialogue to support a single viewpoint and in classroom settings is mainly implemented by means of triadic dialogue [13,21], that is a three-part pattern with utterances from the teacher who initiates a discussion (*e.g*. by posing a question), the students (responding to the teacher's utterance) and again the teacher (who evaluates the students' response). Furthermore, non-interactive / dialogic practice corresponds to parts of classroom discourse that aim at combining and recapitulating different ideas to come to a conclusion, which often corresponds to the scientifically accurate view. This practice is used when the teacher introduces a functional definition, or summarizes the outcomes of an activity, on condition that the children's observations and comments are taken into account. Last, non-interactive / authoritative communication, involving a single interlocutor (monologue) and reflecting a single viewpoint, is typically adopted in lectures and does not normally occur in the lower levels of education, and especially preschool.

B) *The contribution of communication practices in the construction of meaning*

The second axis of the analysis framework allows a more comprehensive account of the way in which classroom communication contributes to the construction of meaning. For this purpose the systemic theory proposed by Halliday [22] will be adopted, according to which each text and each human interaction form many different meanings. Therefore, the analysis of different episodes of the teaching activities will illustrate the different meanings which the communicative practices are expected to support, namely the negotiation of experience, the roles of the participants and the textual organization of the activity corresponding to Halliday's ideational, interpersonal and textual meanings respectfully [22].

These dimensions enable the comparative discussion of the role of communicative practices in the constitution and effectiveness of teaching activities. **Table 2** presents the aforementioned three levels of meaning [22] along with their functions and the relevant teaching purposes.

More particularly, the negotiation of experience (ideational meaning) relates to the elaboration and development of the topic. The ideational meaning of an activity reflects on the use of technical vocabulary by the teacher -subsequently adopted by the children-, as well as on the occurrence of incidents such as formulation of functional definitions and conclusions, or the presentation of results, typical in science activities.

The second dimension referring to the roles of the participants (interpersonal meaning) relates to the way in which communication practices promoted by the teacher determine the role of the participants in communication and their involvement in the activities.

The third dimension is related to the textual organization of the activity and reflects on information flow. In the context of the present study the activities' expansion is examined at the macro-level of textual structure [23]. Therefore, the way in which communicative practices determine the presentation of the news and the unfolding of the activity will be explored. Communicative practices can either reflect a procedure predetermined by the teacher, or shaped by the actions, observations, comments and questions of the children. Moreover, the organization of information flow will be examined in respect to time allocated to the evolution of the activities. The aspect of time was considered as important because in the context of preschool education it plays an important role both in logogenesis and ontogenesis.

Table 1. Communication practices.

		Activity organization	
		Interactive	*Non-interactive*
Participant involvement	*Dialogic*	Interactive / Dialogic	Non-interactive / Dialogic
	Authoritative	Interactive / Authoritative	Non-interactive / authoritative

Table 2. The different meanings supported by classroom communication practices, their functions and relevant teaching purposes.

Meaning	Functions	Teaching purposes
Ideational	• Negotiation of experience • Elaboration and development of the topic	• Initiation of technical vocabulary • Formulation of functional definitions • Presentation of experimental results • Extraction of conclusions
Interpersonal	• Roles of participants	• Teacher and pupils' roles in communication • Teacher and pupils' involvement
Textual	• Textual organization	• Evolution and expansion of the activity • Information flow • Organization of time

C) *The data analysis procedure*

The transcripts of the two video-taped activities were analyzed focusing on the interactions between teachers and children and particularly on the types of communication practices (first axis of the analysis) and on their role in the construction of meaning (second axis of the analysis).

The selection of teaching episodes for analysis was made on the basis of their functionality in the instructive process and their consistency in respect to content. This methodological choice regards teaching performance as basically episodic and especially in nursery activities where regulative interventions or other kind of interruptions are very common. These criteria resulted in the selection of episodes which varied in constitution and structure, ranging from a single question of the teacher to parts of dialogues that may not be successive, yet are directly interrelated since they compose a distinctive and unified conceptual sequence.

As already mentioned, the aim of this study is not to describe the two activities in terms of the communicative practice prevailing in each of them. By analyzing characteristic episodes we rather aim at identifying the function of the alternative communicative options in the development of each activity and in the construction of meaning. The episodes analyzed in the subsequent paragraphs will be referred to as Examples and their numbering will indicate the first or the second activity as well as their sequence. For instance, Example 1.2 refers to the second episode of the first activity.

3. Analysis of Teaching Episodes

3.1. Communication Practices

The two activities develop by means of different communication models, using different communication practices. These two models apparently reflect the two teachers' divergent perceptions of their role as well as the role of pupils in the classroom. Furthermore, a remarkable feature of both activities, particularly apparent in the first one, is that they consistently and unvaryingly follow a single communication model throughout all stages of the instruction.

More particularly, in the first activity communication between the teacher and the pupils is largely composed according to the interactive / dialogic model. Thus, in this activity the pupils' participation is based on their free and spontaneous engagement in hands-on experimentations, which results in a variety of actions evolving simultaneously. This communication model establishes an environment of freedom and independence and this is also reflected on the children's interactions with the teacher. They usually do not respond to the teacher's questions unanimously or as a group. Furthermore, the teacher's questions are generally open and ask for information instead of demanding confirmation of the information provided by her. Consequently the children tend not to give one-word or elliptical sentences, but to formulate complete and varying answers to the teacher's questions.

A typical example of the interactive-dialogic communication dominant in the first activity is the following excerpt from an episode during which the children - encouraged by the teacher - look for objects that are attracted by magnets. Three children, Demetra, Helias and Georgia take on Zisis' suggestion and verify his observation.

Example 1.1

Lines 194-204

Teacher 1: Therefore… Let's see where it [*the magnet*] sticks and where it doesn't. Watch out!

Zisis: It sticks here, on the table. On the table…

Eleni: Yes, it sticks…

Georgia: This sticks very hard!

T1: Where else? Let's see out here [*the children start moving around following the teacher*].

Helias: Madam, I know, I know!

T1: Go on, try. Here, not outside in the yard.

Z: On the radiator?

Demetra: On the radiator, madam…

T1: Let me see…

H: Yes. [*Georgia joins the group to try if her magnet will also be attracted by the radiator*].

In the cases where contradicting views are expressed, these are used as opportunities for open and constructive dialogue. Moreover, cooperative actions often develop in the course of the activity. This suggests that the dialogic model of communication initiated by the teacher is also adopted by the children. The duration of the first activity was 49 minutes.

In striking contrast, during the second activity communication between teacher and pupils is largely implemented by means of the interactive-authoritative model. The children's actions are firmly controlled by the teacher. A single action evolves each time, according to the teacher's instructions. Consequently the teacher's questions usually address the whole class and the pupils answer collectively, as a group. Moreover, the directed actions determine the teacher's interlocutor each time. Most of the teacher's questions simply ask for verification, hence the children are restricted to one-word answers, typically a "yes" or a "no". The authoritative discourse promoted by the teacher – reflecting her intention to control the procedure totally – significantly limits the

interactions between the children. Furthermore, the control wielded by the teacher in the course of the activity and the type of interaction play a decisive role in its duration, which does not exceed 22 minutes.

The following episode exemplifies the type of communication prevailing in this classroom. The teacher not only controls the organization of the activity but even the position of the children, this time, Areti's hands.

Example 2.1
Lines 141-155

Teacher 2: Yes. Let them down for a while. Just let them. Take, take the magnet and magnetize one. Pull one of these objects for me.
Vana: Madam, can I take one, too?
T2: So bring that here. Guys, what is this [*pointing to a paper clip*]?
Dimitris: A hairclip.
T: Is it called hairclip?
Group: No.
T2: How is it called?
George: I told mum to buy me some [*pointing to the paper clip*].
T2: Well, those things that it [*the magnet*] pulls are called paper clips [*with an emphasis*]. They are made of what?
Elli: Of iron.
Areti: Of wire.
T2: Of iron. Let it down for a while [*to Areti*]. It's made of iron [*she takes Areti's hands and puts them under the table*]. You've already done it. All right. Bring those paper clips [*the teacher collects them*]. The paper clips that we've pulled.
V: Me, madam?
T2: Wait.
E: Come, Vana, take it [*the magnet*].

This general image of the different communication practices and their role in the construction of meaning will be analyzed in the following paragraphs substantiated by further episodes from the two activities.

3.2. The Role of Communication Practices in the Construction of Meaning

A) *The organization of the ideational meaning*

The organization of the ideational meaning is determined by a) the way in which the procedures that will enable pupils to understand magnetic attraction are realized through communication and b) on the way this process is achieved through the introduction of technical terms and specifically through definition and nominalization.

1) *Procedures*

Communication determines the way in which the children engage in the elaboration of the theme of an activity. Both of the analyzed activities involve experimentation, which aims at assisting children to identify the properties, characteristics and functions of magnets. However, this objective is implemented by means of different communication practices in the two activities.

Thus, in interactive / dialogic communication systematically promoted by the teacher in the first activity, ideational meaning is constructed by means of open questions and speculations uttered by her, which contribute to the dialogic elaboration of the theme. The following excerpts involve such teacher utterances:

Example 1.2
Line 215

[*After the children have observed that most objects attracted by the two magnetic poles are attached to them, while the central area remains clear, the teacher asks for justification*]
Teacher 1: Why? Why? Let's think about it. Why did most of them go and stick here onto Christo's and didn't go to the middle? What do you say?

Line 308

[*The teacher encourages the children to connect science activities with every day life*]
T1: Now tell me: Where do we use those magnets? Do we really need them?

The episodes presented above are indicative of the teacher's effort to motivate children and engage them in dialogue. This communication practice provides children with an active role in the elaboration of the activity engaging them in incidents such as observation, description, classification and explanation, typical in science lessons. The open questions in the above excerpts serve different purposes, from recollection of experiences (line 308), to explanation of an observed phenomenon (line 215).

However, this practice is not always functional or effective. The following episode involves this teacher's unsuccessful effort to elicit a conclusion after relevant experimentation.

Example 1.3
Lines 288

Teacher 1: Very well. See how he put it correctly. When we have a magnet, Antonis says, and we put near the magnet something else that is not a magnet, like this nail [*the teacher attaches a nail to the magnet*], what does the magnet do? It [*the nail*] gets magnet from this magnet, so it has magnet on it, itself. And so, what can it [*the nail*] do? What is it about to do?

The dialogic / interactive character of this episode is initially revealed by the teacher's allusion to Antonis' inference, but also by the fact that she uses a question to elicit a conclusion. However, the question remains open because the children continue their experimentation and

neither them, nor the teacher conclude to a definitive explanation.

On the other hand, in the second activity experimentation is exclusively coordinated by the teacher who takes full control of all procedures, while in several instances the children are limited to mere observation of her actions, or the actions of a particular child, firmly prescribed by her. The teacher adopts an interactive / authoritative communication practice, which is embedded in the use of closed questions, without giving children the opportunity to express their views and speculations. The following excerpt is an example of the teacher's pervading role in the elaboration of the theme.

Example 2.2

Lines 292-299

Teacher 2: Let's see what will happen with iron [*the teacher tries herself*]. Dimitris, look. Does it [*the magnet*] pick up the wood?

Dimitris: No. Give it to me [*he tries to take the wooden clothes-pin from the teacher and explore the interaction himself*].

T2: Let me do it here. Does it pick up the wood?

Group: No.

T2: These, what are these made of?

Group: Wood.

T2: Toothpicks are also made of wood. Does it pick them up?

Group: No.

The authoritative communication model applied in the second activity affects the pupils' participation significantly. During experimentation, their answers are generally brief or one-word, since the teacher does not give them the opportunity to reflect on their actions and use technical words to describe the observed phenomena. Moreover, as is apparent in the following episode, apart from the topic of the activity, the teacher totally controls and determines the way in which the children participate in the experimental procedure.

Example 2.3

Lines 325-349

Teacher 2: Well, Giorgos will do it. Well, let's see Giorgos. Bring the two reds near [*referring to similar poles of two magnets]*, Giorgos, to see what happens. Bring them near [*the children laugh*].

Areti: I want to see [*Giorgos continues and the children laugh*].

T2: Giorgos, now bring the two greys near. The two greys. The grey poles. Bring them near. With one hand bring it near [*Giorgos executes, the magnets rotate and the children laugh*]. Bring the two grey poles near once more [*laughter*]. Let Elli do it, too.

Elli: From the two greys.

T2: Yes, from the two greys. Do it with the two grays and see what will happen? [*Elli holds a magnet in each hand and slowly brings them near*]. Leave the one still and bring the other near slowly. Leave that still, don't touch it. Leave it still. And move this slowly, slowly. As if the cat comes close to eat the mouse. Slowly. Let's see what will happen. Will it eat the mouse? [*On approaching, one of the magnets rotates, Elli is surprised, and everybody bursts out laughing*].

A: The cat got scared.

T2: What does the other magnet do when the grey one approaches? What does it do?

Vana: It turns.

T2: It turns [*Dimitris tries to take something*].

E: Leave me now!

T2: Leave her, now. Elli is doing it.

D: Look! [*He shows the paper clips and Vana laughs*].

A: Slowly [*Talking to Elli*].

T2: Bring it near slowly.

D: Madam, here!

T2: Yes [*to Dimitris*]. [*They burst out laughing when the magnet rotates*].

A: Madam, can I do it, too?

T2: [*To Elli*] Let's see what will happen if you bring the red near the grey. Bring the red near the grey.

D: Madam, look! [*Showing the objects he is exploring*].

T2: Dimitris, you too look here to see what will happen now. Look at what Elli is doing. She is slowly brining the red near the grey. The grey pole. The red pole to the grey pole [*the children laugh with the attraction between the* poles]. What happened?

E: They got stuck [laughing].

The teacher's authoritative role is apparent in this episode. She does not enhance, but quite the opposite restricts the children's range of experiences. Had she promoted free experimentation in the context of dialogic communication, she would have facilitated the children to actively discover the properties of the magnetic poles. For example, if the children had the opportunity to hold two magnets -one in each hand, as Elli attempted to do- they would have sensed the repulsion between similar poles as a complement to visual observation. This experience would have resulted in a more evident and concrete perception of repulsion compared. However, the teacher's coordination of their actions deprives them of this opportunity.

2) *Technical language*

An important issue in science lessons is the use of technical language. The transition from everyday talk to scientific discourse is achieved by the use of technical terms through definition and nominalization [18]. During the second activity a functional definition is composed following an experimental procedure, by means of a dialogic / non-interactive communication.

Example 2.4

Lines 135-141

Teacher 2: So these little…

Elli: Little magnets.

T2: How did we call them?
E: Magnets.
T2: They have a job. They can do something. Sit down [*to Dimitris*]. They can pull some objects [*with an emphasis*]. This is called 'magnetism'. They pull them, they can pull them, and this is called 'magnetism'. But they cannot pull them all.

In this case the teacher recurs to the children's observations to introduce the concept of magnetism. Nevertheless, when attempting to introduce the concept of magnetic poles and their properties, she abandons the dialogic stance and selects an authoritative / interactive mode of communication by giving a definition herself, without pursuing the children's engagement in any kind of experimental procedure, or taking into account their utterances.

In contrast, the dialogic / interactive practice is adopted in the first activity even during the introduction of technical language.

Example 1.4
Line 255-259
Teacher 1: Well done, we put this one here, too. Very well, Eleni. Let's give a name now. Helias. Let's give a name to the two edges of the magnet. How can we call them here and there? The edges, we shouldn't call them 'edges' [*with an expression of discontent*]. How else should we call them?
Dimitris: Angles.
Antonis: Superma…
T1: Superma... what?
Helias: Super magnets, because they are powerful.

The teacher invites children to participate in the activity trough brainstorming, a procedure that activates imagination and creativity. She is not concerned about unexpected thoughts and responses of the pupils. Thus, finding a name for the poles becomes a playful procedure and also an opportunity for reflection. The children select a 'phrasal' name ("super magnets") that signifies the poles' quality. This practice is more likely to promote the pupils' skills of formulating functional definitions, than the authoritative stance of inviting them to adopt and replicate ready-made terms.

B) *The organization of the interpersonal meaning*

The interactive / dialogic mode of communication characterizing the first activity is evident in the teacher's constant reference to the children's actions, her avoidance of evaluative comments and her encouragement of the expression of their ideas. More importantly, the dialogic interactivity promoted by the teacher in the first activity establishes the appropriate conditions for dialogic interactions among the children. In this context the model of interaction between teacher and pupils supports and at the same time is supported by spontaneous investigations, cooperative action, and exchange of ideas between the children, as illustrated in the following example.

Example 1.5
Lines 112-119
Zisis: Hey, guys, this much, what is it?
Teacher 1: Which one?
Z: A magnet? What is it? [*Antonis explores the interaction between the unspecified object with a small magnet*].
Antonis: It sticks.
Helias: A big headphone? Ice cream?
T1: Does it look like ice cream?
A: It attaches here easily.

In the previous episode, as well as in the episode presented in Example 1.1, the children are encouraged by the teacher to move and act freely. They are given the opportunity to observe and the responsibility to reflect upon the phenomena they choose to explore. In other words, this context provides the necessary motivation for the pupils' active engagement in the activity, thus establishing interaction and dialogicity. The example presented above displays the dialogue between the children, the spontaneous organization of common actions and the adoption of suggestions. Therefore, dialogue and interaction support the co-construction of meaning by the members of the group.

The interactive-authoritative communication model characterizing the second activity imposes the teacher's total control on the interpersonal relations developed within the group. In this context the children execute instructions and are expected to adapt their answers in order to correspond to the predetermined objectives set by the teacher. This stance is particularly obvious when children spontaneously express their thoughts. Pupils' unexpected statements are either ignored, or commented upon in a way which discourages their spontaneous expression, as will be apparent in the following example.

Example 2.5
Lines 204-213
Teacher 2: What happened, Giorgos?
Giorgos: It doesn't pull.
T2: It doesn't pull. Why on earth, Giorgos, since this is a key and that is a key, also [*pointing*]? Why doesn't it pull this key while it pulls the other one?
Elli: Because this is made of crystal.
T2: What is this made of?
E: Of crystal.
T2: What is this crystal?
E: I don't know. I only know a word [*meanwhile Giorgos explores the*

interaction of the magnet with other objects].

T2: Ah, Giorgos, give me your magnet for a while. Or you rather come here, come here. Magnetize this key [*Giorgos tries and pulls the key from its ring*]. Is it magnetized?

This example reveals the non-dialogic –albeit interactive- character of the interaction. The teacher determines who will participate and what their actions will be. During this episode the children try to explain why some objects are not attracted by the magnet. Elli –trying to justify why some materials are not attracted by the magnet- identifies them as "crystal". However, the teacher questions the appropriateness of Ellis' idea. Elli perceives the critical tone in her teacher's question "What is this crystal?" and adopts an apologetic attitude confessing her ignorance "I only know a word".

Another significant effect of the non-dialogic communication on the interpersonal meaning in the second activity is related to the discouragement of interaction between the children and their actions, or ideas. The teacher, by addressing one child at a time, mainly directing him/her towards specific operations, eliminates every possibility of cooperation and estimation of different viewpoints expressed by the children.

C) *The organization of the textual meaning*

The third stage for analyzing the meaning of the activity concerns the managing of information flow. Therefore the interactional context defines the way children's actions and thoughts contribute to the presentation of the activities' news. The analysis of textual structure will focus on information flow comprising two aspects, namely the activities' textual expansion and temporal organization.

1) *The expansion of the activity*

The evolution of the first activity is mainly organized by means of the teacher's comments on the pupils' actions. Those comments encourage the participation of all children in similar actions and subsequently support their attempts to explain what they have observed during their experimentations. This practice creates cohesion between the children's experimentations and the unfolding of the activity.

Example 1.6

Lines 209-213

Teacher 1: Ah! Look what Helias has done. Ah! Very very good!

Antonis: Look!

T1: Eh, Helias, why haven't they been attached here, in the middle? But look at the sides of this magnet. Everyone, look at Helias for a moment. Look for a moment. Where have most of them gone and stuck? Here, at the middle, or on the sides, on the edges?

Group: On the sides.

T1: Most of them are stuck on the edges, huh? There! And the one that Georgia has, raise it up, Georgia, for us to see. See where they mostly got stuck? Here, in the middle, or here on the edge [*pointing*]?

G: On the edge.

T1: Why? Why? Come on, think about it. Why most of them went and got stuck here on Christos' [*magnet*] and didn't go to the middle? What do you say now?

In the episode presented in Example 1.6 the teacher initiates another stage of the activity by directing the children to the observation of the magnetic poles by identifying Helias' action. Two children immediately correspond to her incitement. Therefore, the dialogic / interactive practice here contributes to the expansion of the activity, by stimulating the children's interest and ensuring their involvement in a common action. This action is aimed at advancing the activity, allowing for the prospective explanation of the observed phenomenon. Conversely, every action and every stage in the course of the second activity is determined by the teacher's statements and is not related to what has preceded.

Example 2.6

Lines 74-77

Teacher 2: Elli, put the rubber band down here. You too, leave the clothes-pin, Dimitris. And now… Giorgos take the magnet. Take it in your hands. And now Elli will approach the magnet to these objects that we have up here. Let's see, what happens? Will there be any magic? [*Elli experiments until an object is attracted and the children start laughing*]. What happens?

Group: It sticks.

The episode presented above reflects the communication's non-dialogic character. The teacher has full responsibility of the organization and flow of the activity. The pupils' actions are supposed to execute her instructions in a definite time without self-acting, or expressing personal views and queries. This only leaves a single possibility for the evolution of the activity, namely the one prescribed by the teacher.

On the other hand, the most extensive non-interactive parts of the teacher's discourse in the first activity involve in majority instructions for the coordination of the children's actions. Similarly, the teacher's utterances loudly describing the pupils' actions, or announcing a personal teacher-pupil dialogue aiming at facilitating the evolution of the activity, can also be classified in the same context. Therefore, even when this teacher introduces non-interactive communication, this remains dialogic, since its frame of reference is children's actions and viewpoints.

Example 1.7

Lines 181

Teacher 1: Everybody, look. It got stuck. Vagelitsa stuck it there. Eh… It remained up there. This, Dimitra said before, some have iron. But it does not stick onto Dimitra's bracelet. Look. On the bracelet, says Dimitra, it doesn't stick onto her bracelet. Where else can it stick? Go on, try somewhere.

Example 1.7 documents the teacher's attempt to convey individual children's experiences and thoughts to the whole group. This contributes to the extension of the activity, putting forward new problems. The teacher's statements establish a dialogic process aiming at informing the group, and at broadening the field of individual observations.

2) *The temporal organization of the activity*

A particular component of the first activity, significantly enhancing its interactive-dialogic character, concerns the managing of time. The interaction between teacher and pupils is not restricted temporally. This attribute supports the dialogic nature of the activity in two ways. First, the teacher does not rush to close the discussion, but instead avoids providing answers to the pupils' questions directly, inviting the children to further explore them.

Example 1.8

Lines 445-449

Teacher 1: But do you know why? Why these two hands do not hug each other? There! There! There! Look at Zisis' little hand. He is trying. Why don't they hug and push each other like this? Huh? Do you know why? Why… Why… Yours goes like this, too [*to Vaggelitsa*]? Mine also turns around. Look. Do you know, Vaggelitsa?

Vaggelitsa: I know! Because from the other side it doesn't have any magnetism, while from this it does.

T1: Look here, for a moment. Vaggelitsa says that these little magnets… look here for a moment. Vaggelitsa says that these little magnets push one another; they don't want to hug because, she says, one of them does not have magnetism. Anything else you might think about this? Dimitra?

The second way in which the loose organization of time supports dialogic communication in the first activity involves the repetition of stages. Therefore, the activity does not evolve serially, but the group is allowed to refer to previous unresolved issues requiring further exploration or a more elaborated explanation.

The loose organization of time in the first activity is also evident in the teacher's reactions at instances where the pupils refer back to an unresolved issue. In the following episode Dimitra participates in the exploration of a question and initially confronts Zisis' view. The time provided by the teacher for investigation gives Dimitra the opportunity to develop her explanation about the phenomenon under consideration and to demonstrate her point of view through the experimental procedure. Dimitra returns to the issue that troubles her and this offers the teacher the opportunity to repeat the experiment inviting all the children to observe and participate in the discussion. Episodes like the one presented below support the position that meanings flow, as dialogue expands. In addition they reveal that children's ideas, explorations and pace contribute to the construction of meaning.

Example 1.9

Lines 215-224

Teacher 1: Why? Why? Let's think about it. Why did most of them go and stick here onto Christo's and didn't go to the middle? What do you say?

Zisis: Because it had no magnet.

T1: Why?

Z: It had no magnet.

T1: It had no magnet here, at the middle?

Dimitra: There's magnet all over it.

T1: There's magnet all over it, she says.

Helias: But it sticks [*moving an object towards the magnet*].

T1: Yes, but why did most of them go to the edges?

D: There's magnet all over it. Because if we put it like this… can you put it?

[…]

[Meanwhile Dimitra confirms through her experimentations that there is magnetic attraction all over the magnet. Trying to explain why objects are mainly attached to the poles she proposes her teacher to leave the magnet on the table instead of holding it vertically].

Lines 243-247

Dimitra: You know something, madam? There's magnet all over it. If we lie it down!

Teacher 1: You say if we lie it down it won't go? Look, Dimitra. Everyone, look at something! Let's see what Dimitra says. Everyone, come over here! Oops! Oh, they went away. Never mind. Leave them there. Never mind, never mind, never mind. Let's see what Dimitra says. Let's see what Dimitra says [*She moves the magnet on the table*]. As it moves on, its edges pull them, see?

D: Yes, its edges.

T1: So, could it be that its edges have more power?

D: No.

[…]

Lines 271-272

Dimitra: You know something, madam? As it's lying down, if we put a small nail here, it catches it.

Teacher 1: It catches it. But it only catches a small nail, while here it catches a lot.

The dialogic aspect of the interaction is more explicitly revealed at the final part of the episode (lines 271-272), where the teacher takes advantage of Dimitra's

observation to refine the account of the observed phenomenon. The improvement of Dimitra's reasoning consists in shifting the focus from mere observation of the phenomenon to the exploration of properties which determine it, providing the discussion with the conditions necessary to shift from description to explanation (at the level of discourse) and from perception to comprehension (at the level of conceptual representation).

This mode of time management – both at the macrolevel of the activity and the microlevel of distinct episodes - gives pupils the possibility to organize their reasoning and their discourse. At the same time it gives the teacher the opportunity to follow the children's line of thinking, reflect on their actions, advance the discussion, and take the activity forward.

In the case of the second activity the teacher has the total responsibility of time management without taking into account pupil's views and speculations (see, for instance, Example 2.1). This total control significantly affects the evolution and duration of the instruction.

It should be noted that under no circumstances the discussion readdressed the same issue at different points during the second activity. Furthermore, many actions are implemented by the teacher herself, which grants her with a particularly tight organization of time and contributes to the prompt textual unfolding of the activity.

4. Discussion

The preceding analysis indicates that the divergent communication practices adopted in the course of the two activities establish different conditions in the respective classes. Dialogicity turns out to be an effective communicational practice that determines the construction of meaning by means of the children's actions. On the other hand, authoritative discourse facilitates the presentation of the scientific aspect.

Each of the dialogic and authoritative communication practices establishes a particular climate in the classroom, which is determined by the way children participate and the actions by means of which the activity is implemented.

The first activity is apparently organized according to a child-centered pedagogical philosophy, while at the same time it adopts a socio-cultural view of learning based on communication [1,2]. These two principles grant the teacher the sensitivity to respect the children's views and the flexibility to avoid a predetermined course. The teacher provides the children with the time necessary for their spontaneous experimentation and takes advantage of their observations. By encouraging dialogue she enables the children to process their experiences and engage in cognitive challenge [4], putting emphasis on the cognitive and the social aspects of learning [5] at the same time. Furthermore, by surpassing the linear temporal evolution of the stages of the activity, she revisits previous stages. This non-linear organization of the activity is either used to extend a problem (Examples 1.12 & 1.13), or to explore ideas and speculations put forward by the children (Example 1.9 lines 243-247 & 271-272).

Therefore, the interactive / dialogic model promoted by the first activity realizes the teacher's intention to facilitate the children's actions and the development of ideas. The teacher grants the children with an active role, to which they correspond; they actively engage in experimentations, contributing to the evolution of the activity. They participate in the activity -at times individually, at others through collaboration in small groups (Example 1.5). They focus not only on their points of concern and interest, but also contribute with their ideas to their peers' effort (Example 1.9). They announce their observations and share the pleasure of discovery with their group (Example 1.1). They engage in cognitive conflict (Examples 1.8 & 1.9). This communication model realizes the fundamental principle of communication, relating understanding with active participation [2,24,25]. Dialogicity, a dominant attribute of this activity, supports reflective teaching [10], overcoming significant weaknesses in the thematic organization of the activity. At the same time, as the analysis in the previous section indicates, the social interactions enacted by dialogicity constitute a valuable strategy for kindergarten supporting children's understanding and cognitive progress and enabling 'the possible to be transformed to feasible' [25. 1006].

However, while dialogicity supports the active participation of pupils, its consistent and undifferentiated use by the teacher in the first activity reveals significant limitations. The evolution of the activity illustrates that this teacher has probably no particular plan, or lacks a theoretical background related to the specificities of science teaching. Therefore, her supportive and facilitative role sometimes remains unfulfilled. In such cases the adherence to the dialogic / interactive communication proves ineffective and underlines the need for systematic planning in science activities and for the use of alternative communicative practices at different stages and for different purposes [13]. Therefore, as every methodological choice, a child-centered stance, realized through dialogic / interactive communication should take into consideration specific teaching objectives and the evolution of the activity.

In contrast, the teacher in the second activity consistently undertakes the role of the expert. She focuses on the quantity of information that can be delivered – mainly by her- in the course of the activity [16], directs children's learning and restricts them to the repetition of

technical terminology and expressions [17]. This is particularly evident when she introduces a definition (Example 2.4 line 141). Such episodes constitute functional and essential parts of science activities. However, the authoritative / interactive communication practice pervasively used during the second activity deprives the children from the possibility to participate in the production of classroom discourse that would have brought out indications of their understanding and of the effectiveness of communication [2].

Moreover, the authoritative interaction promoted during the second activity places the teacher in a strikingly privileged position in relation to the pupils, and allows her to determine the organization and evolution of the activity, as well as the children's role in the whole process. This model of one-way communication, which builds on triadic dialogue [6,7], restrains the development of scientific reasoning based on the exploration of assumptions. Therefore, in the course of the second activity the children are not given the opportunity to express their thoughts and in the few instances where this occurs spontaneously (Example 2.5 line 207) the teacher fails to correspond and exploit the children's ideas relating them to the experimental procedure. Even when she introduces teaching strategies (such as the cat and mouse analogy in Example 2.3 line 330), these do not serve her teaching purposes [24] but are merely used to attract the children's interest and attention, and therefore do not contribute to understanding. Thus, this teacher only seeks passive understanding and discards the opportunity for effective communication [2]. Had this teacher included dialogicity at certain points of her instruction, her pupils would have had the opportunity to elaborate the outcomes of their experiments, draw conclusions from their actions and come up with functional definitions. Such skills of scientific thinking are not encouraged by the communication practice she adopts.

5. Conclusions

The present study employed a framework of analysis for comparing communication practices and their role in the construction of meaning in two kindergarten activities about magnets and magnetic attraction. The analysis presented in the previous sections illustrates critical discrepancies in the discourses produced in the two classes. These different discourses directly result from the communicative practices adopted by the two teachers. Moreover, these discourses produce clearly differentiated meanings at the ideational, interpersonal, and textual level.

More particularly, the differences in ideational meaning result from the differences in the negotiation of practical experiences, the introduction and use of technical language, as well as the formulation of functional definitions, explanations, or conclusions.

The differences in interpersonal meaning between the two activities are exemplified by the different roles adopted by the two teachers (facilitator or expert) and granted to their pupils (equivalent, active participants in the learning process, or passive executors of instructions).

Last, the differences in textual meaning reflect discrepancies in terms of the activities' expansion, that is the degree to which this textual organization is influenced by the children's actions, or is entirely predetermined by the teacher. Differences in textual meaning also reflect discrepancies in terms of time managing. Therefore different levels of dialogicity impose variations in regards to the rhythm and duration on each activity, as well as in regards to its degree of temporal linearity.

The preceding analysis underlines the necessity for preschool teachers to systematically design their science activities taking into account the social dimension of learning [1] and select accordingly the communicative practices most appropriate for each topic, stage, and teaching objective. It also illustrates the relative advantages and disadvantages of dialogic and authoritative interaction in the kindergarten, as well as the need for complementary use of the two communication practices [8,13] to fulfill different purposes related to young children's initiation into science.

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Creative Education, 2010, 2, 93-100
doi:10.4236/ce.2010.12014 Published Online September 2010 (http://www.SciRP.org/journal/ce)

Increasing Positive Perceptions of Diversity for Religious Conservative Students

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Received January 30th, 2010; July 19th, 2010; July 25th, 2010.

ABSTRACT

Evidence suggests that positive perceptions toward diversity enhance the potential group and organizational benefits resulting from diversity. Given the make-up of today's organizations, encountering diversity has become the norm rather than the exception. As such, it is becoming increasingly important to address diversity issues, and take steps to increase positive perceptions of diversity within the business classroom in order to carry that advantage into the workplace. Religious conservative students present a unique challenge to diversity education in that they likely hold value-laden attitudes that lack alignment with diversity principles. This study prescribes a scaffolding approach to increase positive perceptions of diversity within a classroom comprised predominantly of religious conservative students.

***Keywords*:** *Teaching Diversity*, *Positive Benefits of Diversity*, *Teaching Methods*, *Religious Conservative Students*

1. Introduction

Diversity is an important and complex issue for organizations today, presenting both opportunities and challenges [1]. Though current research has asserted a number of potential benefits organizations may gain as a result of diversity [2-5], limitations exist that may inhibit organizations from reaching that potential [6-8]. Recent scholarship suggests that positive perceptions of diversity may enhance the likelihood that diversity benefits will be achieved by the organization [6-8].

Specifically, both organization- and group-level benefits have been suggested as a result of individuals' positive perceptions of diversity [6-8]. Konrad and her colleagues (2009) [7] argue that organizational benefits gained differ depending on your perception of diversity. If diversity practices are viewed as fulfilling an ethical and moral obligation only, then the potential benefits will not be realized. However, if diversity is viewed as a strategic advantage to the firm, as a value-add for the organization, the realization of potential benefits is probable. The argument is that value congruence is essential to diversity success. If individuals perceive diversity as a positive attribute to the firm, then value congruence is more likely to occur. This correlates with Schneider and Northcraft's (1999) [8] assertion that by addressing the dilemmas of individual and managerial participation toward diversity, organizational benefits may be more immediately realized. Through greater positive perceptions of diversity and understanding of potential benefits, value congruence will likely be enhanced, and the individual and managerial dilemmas will be reduced. At the group level, Ely and Thomas (2001) [6] found that groups with an integration-and-learning perspective, a perspective where diversity is positively perceived as a valuable resource, were more highly functioning than the other studied groups. All groups were diverse in make-up; the differences existed in the perceptions held by members of the groups toward diversity. Positive perceptions resulted in greater productivity.

Given the potential benefit for organizations when their employees hold positive perceptions about diversity, and the inevitability of encountering diversity in the workplace; it is essential that business classes not only address diversity, but work to increase positive perceptions toward it. Research shows that although overt prejudicial acts toward others may have decreased, discrimination perseveres in society today [9,10]. It is suggested that some people, even though they support egalitarian principles and believe themselves to not be prejudiced, hold negative feelings about others [9]. Further, many only view diversity as a legal or ethical issue [11], yet given the organizational benefits possible, it is important that the business classroom works to shift the view of diversity to be positively perceived as a valuable re-

source rather than simply a legal, ethical, or discriminatory issue.

Our study makes an important contribution by offering guidelines for increasing positive perceptions of diversity within a classroom of predominantly religious conservative students. Diversity education may be especially challenging with religious conservative students because the political positions of the religious right are typically less supportive of the principles of diversity. Scholars suggest it is difficult to make any real progress when the students are committed to their beliefs and disagree in principle with the ideals of diversity education [12,13]. Previous research has recognized the association of religious denominations and beliefs with conservative attitudes particularly those regarding gender [14] and sexual orientation [15]. For example, Fundamentalist Protestants support traditional gender role attitudes using biblical passages portraying men as leaders and women as followers [16-18] and use the bible to argue that homosexuality is a sin.

The United States is a religious country with 83% of the population reporting they are Christians and only 13% reporting no religion (ABC News, 2007). Defining religious conservatives is complicated both because of the large number of denominations in the U.S., almost 1200 by one estimate [19], and because many denominations include a wide range of beliefs. But it is generally accepted that Protestant Fundamentalists who believe in a literal interpretation of the Bible are at the most conservative end of the spectrum [18,20]. While white Evangelicals, Baptists and Mormons are less conservative than Protestant Fundamentalists, they are more conservative than mainline Protestants [21,22], and can still be considered religious conservatives. Also, frequent church attendees tend to have more conservative gender attitudes even after controlling for denomination (Mason & Lu, 1988) [14]. Moore and Vanneman's (2003) [18] study showed that the "Bible Belt" area of the U.S. — including the south and parts of the Midwest, in addition to Utah — were the areas with the highest proportions of religious conservatives, while most other areas of the U.S. have modest to significant numbers of religious conservatives. Given the potential benefits of diversity for organizations and the large number of students that have religious conservative backgrounds, it is important that diversity education be structured in a way to influence the greatest number of students.

The college years may be the ideal time to expose religious conservative students to diverse perspectives and help them move toward broader perspectives-taking and increased understanding of differences. This period is frequently a time that significant social and moral development takes place as students become more aware of the social world in general and their place in it (Rest, 1986) [23]. Similarly, studies of faith development show that the college years are a common time of transition into a less literal belief system [24]. The impact of college education on moral, social and faith development suggests that these changes may also benefit diversity education. We may be able to draw on the large body of research over the last 40 years of studies on moral development and moral education for guidance in how to teach diversity. "Kohlberg's theory of moral development suggests that rather than attempt to indoctrinate or socialize students, moral education should seek to stimulate the natural process of development toward more mature moral reasoning" [25]. There is evidence to suggest that making moral issues an integral part of the subject matter by integrating dilemmas and role-taking experiences into the classroom are beneficial, as is being exposed to exemplars [26].

Education programs designed to stimulate moral judgment produce modest significant gains, particularly those programs that emphasize peer discussion of controversial dilemmas [23]. Diversity education is likely to parallel these findings. Moral development research suggests that the college classroom may be the ideal time to educate students about diversity using peer discussion that encourages broader perspective taking. The challenge may be to find a way to present material about diversity that allows these students to remain open to alternative perspectives. More specifically we examine the research question — If religious conservative students can be taught about diversity in a way that does not trigger strong or defensive reactions based on religious beliefs, will they show positive change in their attitudes toward diversity over the course of a semester? It may be that by finding a way to present material on diversity that allows engagement without defensiveness, the prospect of attitudinal change will be enhanced.

2. Methods

2.1. Study Participants

Participants in the study were 120 students enrolled at a public university in a college town in Utah. Two organizational behavior courses with 78 students served as the treatment group and one human resources course with 42 students served as the control group. As illustrated in the descriptives table (refer to **Table 1**), the student body is composed largely of highly religious and politically conservative individuals. Utah is notably conservative as is continually illustrated by political elections, and it has a prevailing dominant conservative religion. The average age in both the treatment and control groups was approximately 23, and males represented a slightly larger

proportion (56%) of the overall sample.

2.2. Procedure

The two organizational behavior courses were taught by the same instructor, and the human resources course was taught by a different instructor. Both instructors were female and in their 30 s. Other than knowing her class was serving as a control group for an experiment, the human resources instructor was not given any other information. Students in all classes were informed that the purpose of the study was to gain insight into their attitudes toward diversity. Included components were the pre-test questionnaire / exercise at the beginning of the 16-week semester and the post-test questionnaire / exercise at the end. IRB approval was acquired for all aspects of the study and student consent forms were collected. To lessen the potential of a social desirability bias occurring, all questionnaires were numbered and anonymous to the instructors. During the pre- and post-tests, students were asked to complete a "reaction-to-diversity" exercise. Within the diversity exercise, students were asked to circle all words that they associate with diversity. The number of words selected varied by student, and no "appropriate" number was suggested by the instructor. Additionally, religiosity and political conservatism were assessed by numerous survey items. To account for potential selection bias between the control and treatment groups, an independent samples t-test was conducted with the pretest scores. The results confirmed that no significant differences existed between the groups at the onset of the study.

The instructor of the two organizational behavior classes purposefully structured the course for this experiment using scaffolding strategies. With higher percentages of religious conservative students, resistance to diversity is likely to increase. Specifically, some students may feel their beliefs are being threatened, and when individuals feel threatened, they are less likely to be open to diversity [27]. As such, certain strategies for approaching the subject may be helpful. In the year prior to the study, the organizational behavior course instructor collected journal entries from her students at the mid-term and conclusion of the class that detailed effective strategies that were used to aid in their understanding and acceptance of diversity. These strategies, in turn, were incorporated into the planned structure for the examined classes.

The challenge in teaching diversity to religious conservative students is to present material that does not trigger a defensive reaction, but connects on a level that they can find personal relevance and to engage them in higher effort cognitions where they will more likely be influenced. For example, in one of her first years, the instructor introduced a diversity case at the beginning of the course that included issues of race, gender, and sexual orientation. This case triggered strong defensive reactions from a large number of students. This may have occurred because the topics of gender and sexual orientation are diversity issues with conflicting religious conservative beliefs [15,18]. The following year that particular case was not introduced until late in the semester and the diversity case introduced at the beginning of the class discussed a person's weight and the potential biases that person may encounter. Weight, though it still may be a sensitive topic, is not as emotionally charged, and is something that students may see as being relevant to them at some point in their life or relevant to someone they currently know. Therefore, starting slowly with material that is personally relevant and does not contain issues that are strongly counter-attitudinal may help build a level of trust within the classroom; and in diversity education, a climate of trust is essential. The material is sensitive and students need to feel safe in expressing their perspective and questioning others' perspectives.

Scaffolding, though primarily used in K-12 education, is fitting for diversity education in that its purpose is to promote student inquiry, assist conceptual learning, address misconceptions, and encourage reflective thinking [28]. It is an approach taken by the instructor or peer that offers support, as needed, to help the students participate meaningfully [29]. Instructors must continually assess what support is needed to achieve the desired result and provide the appropriate amount at the right time. Scaffolding techniques in the examined classes were to provide students with the conceptual framework, guide the cognitive processes when needed, and provide strategic guidance in how to effectively approach the issues [28-30]. This technique was used in order to shift the ownership of learning and discovery to the students. Given the religiosity and political conservatism of the students examined and the probability of unfavorable diversity attitudes being present within the group, these techniques served to aid in student learning.

First, providing a conceptual framework was a necessary scaffolding technique in order to help the students know what to consider and what to evaluate. The goals for integrating this material into the course were clear; the instructor wanted to increase student awareness and expand student understanding of diversity. Through previous journal entries, several students noted the importance of having both the explicit knowledge provided by the discussion and the tacit knowledge provided by the applied activities. Thus, the class was structured to incorporate both theory and application. The theoretical frameworks were supported with current research findings and implications, and the applications were used to aug-

ment the discussions and took the forms of case studies, simulations, exercises, and group work.

To increase the effectiveness of scaffolds, students should readily understand how the material relates to them [29]. Therefore, the second step was to illustrate why they should care about diversity and to provide them with concrete ideas as to why it is important. This step occurred within the first week of class. Research was introduced that supports the business case for diversity and the value-in-diversity perspective. A rationale was provided to the students as to why this is an important topic that warrants further investigation and study. The third step connecting this topic to the students was the discussion of the multi-dimensionality of diversity which occurred the following week. Specifically, surface and deep-level diversity were discussed. Surface-level diversity is the easily identified differences such as gender and race; and deep-level diversity is the less identifiable differences such as values and personality. This discussion is especially important with a group of students that may not hold favorable attitudes toward diversity. By illustrating the broad scope of diversity, a greater sense of inclusion is created. This broad discussion early in the semester was introduced to lower the defensiveness of the students and increase the likelihood that they would engage in the discussions.

The fourth step focused on guiding the students' cognitive processes and encouraging the students to become active participants. After the discussion of the multi-dimensionality of diversity, a case based on weight (a non-threatening case) was introduced. With the case introduction, students become engaged in the learning process and the emphasis shifts to encouraging class members to share their perspectives. This sharing of perspectives offers an effective scaffold for class learning. And as affirmed through previous students' journal entries, hearing others' views and thoughts helped in their awareness and understanding of diversity. This step was intensified as the semester progressed. Case studies, simulations, and other applied activities became more targeted toward issues of gender, race, and sexual orientation throughout the semester. As the level of trust increased and the climate of acceptance grew, student sharing and disclosure became greater.

The last primary component of the class structure was inter-group contact. Strategic support and motivational encouragement were the scaffolds provided by the instructor if needed, but the primary learning was occurring within the groups and their interaction. Although the classes were quite homogeneous, group interactions facilitated student awareness of their own identity and that of the other group members. This step was the most reported component by the students for helping them in the awareness and understanding of diversity. Teams were formed at the onset of the class and students were required to complete an overall course project and presentation as well as numerous team activities throughout the semester. This constant group interaction created a comfort level within the teams that enabled all students to voice their perspectives within the small group discussions. Often students are not comfortable discussing some of their views with the entire class, but will share their perspectives within their team. The primary components used to teach diversity in a management class may not vary greatly between a class with and a class without a strong religious conservative contingent; however, teaching diversity to religious conservative students requires increased attention to subtle details for success because of the higher risks of triggering negative defensive reactions.

2.3. Measures

Items on the "reaction-to-diversity" exercise were drawn from De Meuse and Hostager's (2001) [31] instruments to measure attitudes toward diversity. Given our purpose was to examine shifts in positive reactions toward diversity, we focused on the 35 positive words within the diversity exercise. The words were randomly placed with the 35 words representing five different variables of positive reactions. The five positive constructs measured were emotional reactions, judgments, behavioral reactions, personal consequences, and organizational outcomes. Each of the constructs is composed of seven terms. Specifically, the terms compassionate, enthusiastic, excited, grateful, happy, hopeful, and proud compose the variable emotional reactions. The terms composing judgments are ethical, fair, good, justified, proper, sensible, and useful. Behavioral reactions consists of collaborate, cooperate, friendly, listen, participate, support, and understand. The personal consequences construct includes advancement, discovery, enrichment, merit, opportunity, rewarding, and wisdom. And asset, harmony, innovation, profitable, progress, team-building, and unity compose positive organizational outcomes. Scores were computed for the participants by counting the number of words chosen within each category. The measures were scored on a scale from zero to seven. For example, if they did not select any of the words within the given construct, they were awarded a zero for that measure. If they selected all seven of the words within the given construct, they were awarded a seven. The positive attitudes toward diversity index were created by summing the diversity dimensions described above and dividing the score by five to remain on a 0-7 scale. We created this index in order to provide a comprehensive picture of the students' overall attitude toward diversity. The coefficient alpha for the pre-test

index is 0.85 and for the post-test index is 0.89.

Age was entered in all analyses as the actual age, and gender was coded as 1 for females and 0 for males. We used three items from Sullivan (2001) [32] which was based upon the religiosity measure developed by Rohrbaugh and Jessor (1975) [33] for our religiosity measure. Representative items are "Religious beliefs are not at all important in my everyday life" and "I am definitely a religious person" (1 = strongly disagree, 7 = strongly agree). Items were aligned so the higher number reported represents greater religiosity. To create the religiosity variable, the items were summed and then divided by three to remain on a 1-7 scale. Coefficient alphas are 0.95 for the pre-test and 0.88 for the post-test. Political conservatism was measured with 9 items that were based on Wilson and Patterson's (1968) [34] scale of conservatism. Specific items were updated using Collins and Hays (1993) [35] and Henningham (1996) [36]. Representative items are "I believe in legalized abortion" and "Religions should allow women clergy" (1 = strongly disagree, 7 = strongly agree). Items representing conservative and liberal positions were alternated in the scale and items were aligned so the higher number reported represents greater political conservatism. To create the political conservatism variable, the items were summed and then divided by 9 to remain on a 1-7 scale. Coefficient alphas are .86 for the pre-test and post-test.

3. Results

Descriptive statistics and t-test results for the treatment group and the control group are presented in **Table 1**. T-tests were performed to examine differences between the pre- and post-test positive attitudes of diversity index score and also to examine differences between the subscale scores of the diversity dimensions composing the index. Findings indicate that there were indeed significant increases in positive perceptions of diversity occurring within the treatment group while no significant changes were realized in the control group.

Our research question asked if it was possible to increase positive perceptions of diversity for religious conservative students. This was tested by conducting a repeated measures general linear model which compared students' positive attitudes toward diversity scores by pre-test versus post-test and by treatment group versus control group. Results indicate that significant positive changes in students' attitudes toward diversity occurred in the treatment group but not in the control group (refer to **Table 1**). Specifically, the overall positive attitudes toward diversity index showed a significant mean change ($p < 0.01$) from the pre- to post-test of 3.26 to 3.58 for the treatment group, but the mean change for the control group was non-significant. Findings, though, do suggest a decreasing trend of positive attitudes toward diversity for the control group with means reported as 3.34 for the pre-test and 3.09 for the post-test.

T-test analyses of the individual dimensions affirmed the findings. The treatment groups' mean changes significantly increased for all dimensions except positive judgments (a n.s. positive increase) while the control groups' mean changes remained non-significant (refer to **Table 1**). Specifically, the dimension of emotional reaction showed a significant mean change ($p = 0.03$) from the pre- to post-test of 1.92 to 2.31, the dimension of personal consequences showed a significant mean change ($p = 0.01$) from the pre- to post-test of 3.63 to 4.08, the dimension of organizational outcomes showed a significant mean change ($p = 0.09$) from the pre- to post-test of 3.71 to 4.03, and the dimension of behavioral reactions showed a significant mean change ($p = 0.07$) from the pre- to post-test of 3.49 to 3.81. These results suggest that there was a significantly positive shift in overall attitudes toward diversity for the treatment group.

4. Discussion

This study makes a contribution by demonstrating that religious conservative students can be positively influenced by diversity education. Although these students present a unique challenge to diversity education, the college classroom has the potential to help students generate their own perspectives through engaging more deeply with others' views. This study also makes a contribution by developing theoretical explanations for why these improved attitudes develop. We draw on the literatures on moral, social and faith development to show that college years are a time when students are likely to experience increases in perspective taking ability [23,24,37]. Because of the increases in perspective taking that often occur in college, we suggest that this period may be an ideal time to introduce diversity to religious conservative students who may not have had much previous exposure to either diverse people or ideas.

Table 1. Descriptives and Results.

	Treatment Group						**Control Group**					
	Pre-test		Post-test		Hypotheses Tests		Pre-test		Post-test		Hypotheses Tests	
Variable	Mean	s.d.	Mean	s.d.	T statistic	P =	Mean	s.d.	Mean	s.d.	T statistic	P =
1) Age	23.38	3.52	23.38	3.52	--	--	23	2.23	23	2.23	--	--
2) Gender	0.46	0.50	0.46	0.50	--	--	0.40	0.50	0.40	0.50	--	--

3) Religiosity	5.86	1.87	5.89	1.71	--	--	6.11	1.70	6.00	1.69	--	--
4) Political Conservatism	5.12	1.12	5.00	1.16	--	--	5.21	1.02	5.19	0.98	--	--
5) Positive Attitude toward Diversity Index	3.26	1.65	3.58***	1.74	– 2.76	0.01***	3.34	1.45	3.09	1.56	1.58	n.s.
5a) Positive emotional reaction to diversity	1.92	2.10	2.31**	2.16	– 2.20	0.03**	1.71	1.83	1.39	1.70	1.46	n.s.
5b) Positive judgments to diversity	3.55	1.98	3.69	2.10	– 0.73	n.s.	3.49	1.94	3.51	1.94	-0.08	n.s.
5c) Positive behavioral reactions to diversity	3.49	2.15	3.81*	2.15	– 1.83	0.07*	3.66	2.18	3.37	2.00	1.25	n.s.
5d) Positive personal consequences to diversity	3.63	2.00	4.08**	2.05	– 2.54	0.01**	3.73	1.91	3.56	2.40	0.67	n.s.
5e) Positive organizational outcomes to diversity	3.71	1.96	4.03*	1.98	– 1.70	0.09*	4.10	1.70	3.63	1.88	1.62	n.s.

Age as actual age; females coded as 1; 1-7 scale for religiosity and political conservatism; 0-7 scale for the diversity scale index and all other positive diversity variables. Treatment Group N = 78, Control Group N = 42. *p < 0.10 **p < 0.05 ***p < 0.01

Group work had the most positive impact on our religious conservative students' attitudes toward diversity which fits well with the moral development findings that peer discussions have shown a positive impact on increases in perspective taking.

We put forth the following scaffolding strategies that appear to positively influence students when teaching diversity.

1) A climate of trust must be established. This was accomplished by encouraging all student input, and being supportive of them through their thought processes. All students were encouraged to be respectful of others during class and team discussions. Starting gradually with the introduction of less threatening material, students were more open to the idea of sharing their perspectives. When they perceived the class climate to be supportive of them, greater sharing occurred. The climate of trust facilitated the student inquiry aspect of scaffolding.
2) An objective overview of diversity was offered at the onset of the class. The students were given a business framework for why diversity is important. At this stage, no specific types of diversity were mentioned, but a business case for diversity was illustrated. This was a balanced overview offering both positive and negative ramifications for businesses which helped keep defensive reactions to a minimum, and helped students to understand the relevance of this topic to them.
3) The multi-dimensionality of diversity was discussed. It was advantageous to start with a broad definition so that all members of the class felt like they, too, had a place within the discussion. Specifically, in addition to discussing the internal diversity dimensions, external dimensions such as religion, socioeconomic status, education, among others were also discussed. Providing this broad conceptual framework helped students to begin making relevant connections to themselves.
4) A non-threatening exercise or case was introduced shortly after the multi-dimensionality of diversity discussion to promote student sharing. How the interactions are received and encouraged by both the instructor and fellow students will directly impact the climate of trust. The greater sense of trust the students perceived, the more willing they were to share their perspectives. And, as the semester progressed, the activities selected gradually started representing more sensitive areas of diversity.
5) Team work was an integral part of the class. Student sharing was typically greater in smaller forums, and the students in the group were more attuned to other members' perspectives in the small setting than they were to the class as a whole. Additionally, the process of team work was a learning instrument in itself. The constant team interaction required within this course was the greatest single factor that helped the students in their awareness and understanding of diversity, representing the scaffolding techniques of strategic guidance and motivational encouragement. The slight shift from instructor to team orientation enabled students to reach the next level in their learning.

A limitation of this study is that it was conducted at one university. Although the university is located in a substantiated "religious conservative" area [18]; it may be beneficial for future researchers to conduct this study at other universities. Our assertion is that religious conservative students hold similar attitudes toward diversity irrespective of their particular faith; however, it is possible that the results may vary depending on the dominant religion for that region.

Additionally, we envision three other areas of future research that will extend and build upon the current analysis. First, conducting a longitudinal study could provide insight into the longevity of the positive attitudes toward diversity over time, and a behavioral measure of diversity acceptance could be developed to assess the

effectiveness of transferring the positive attitudes acquired to positive behaviors. Second, research is needed to determine effective methods for managing extreme polar positions within classroom discussions and activities of diversity. And last, it would be beneficial for future research to differentiate between students who are new to the concepts of diversity and students with preexisting biases toward diversity. This study's population primarily encompassed those students new to diversity. Most are from homogeneous environments without much exposure to diversity and often do not realize what their biases may be. Other students from heterogeneous environments may enter class with established diversity biases. Both sets of students present challenges, but they may respond differently to diversity efforts. As such, more research is necessary to understand the backgrounds of our students, and how to effectively integrate those backgrounds into the methodology for teaching diversity. The research suggested would complement the current study by providing a more comprehensive understanding of diversity teaching methods and potential outcomes for the students.

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Discovering Oneself and Discovering Ourselves with the Help of Literature: Educational Possibilities of Narrative

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Received May 12th, 2010; June 2nd, 2010; June 10th, 2010.

ABSTRACT

Undoubtedly narrative in education has frequently been studied. Nonetheless, in this paper we want to explore the different educational possibilities offered by narrative in order to discover identity through tradition. MacIntyre's thought offers the categories of practice, tradition and narrative, in order to penetrate the central questions of personal identity and communicability that we consider the most suggestive. Some authors understand narrative as a very accurate means to access tradition and self-knowledge as well as to show the unity of human life and to vindicate the unity of tradition that we can face and those elements that constitute our moral habitat.

***Keywords*:** *education*, *narrative*, *identity*, *tradition*, *moral*

1. Introduction

We can add to the well-known expression of Gadamer "a comprehensible being is language" [1] another not less famous from Spaeman "the wealth of reality only becomes unveiled through the language that links us to others" [2]. Both judgments introduce the idea of what else we could try from the educational perspective in order to contribute to the solution of some relevant problems. Both theoreticians of education and educators – those who apply their energies to practice – think about the following paradoxical and peculiar stages of Postmodernity. People use efficient elements of information; nonetheless, they lose interest and motivation in understanding reality. People have access to communication technology that facilitates establishing contacts over the limits of space, and somehow over time; nonetheless, isolation and anomie are the lived experience of many people. It is paradoxical that our culture praises the value of liberty, creativity and subjectivity, ignoring that the number of problematic subjects, uprooted and lost among novelties, which is proportionally increasing with that idea.

These three situations hold an existential relationship and have repercussions on educational stances. On the one hand, it is easy to prove that people afflicted by these negative conditions can not educate and are hardly educable. It is possible from the educational intervention to help people to a better self-knowledge as well as to help them to know others. In this way they could push forward their interpersonal communication and through it their social life, as well as their interest in reality. The consideration of narrative by educational theorists illustrates the orientation that we should give to educational practice in order to face the goals described above. In this vein, we have to underline the ideas of a thinker, MacIntyre; through his categories of practice, tradition and narrative, we can access central questions of personal identity and communicability [3].

In order to demonstrate all these points we will follow these steps: a) understand tradition as a basic dimension of identity; b) consider narrative as very efficient means of accessing tradition and understanding who we are; c) consider that traditions can only have influence on educational models through agents integrated into them in a very committed way; d) narrativity in education is also necessary in order to show people in an understandable way the unity of human live as well as to vindicate as a society the unity of traditions that we contact, and those elements that constitute our nutritional moral habitat.

2. Identity and Tradition

Clearly the question of identity is one of the many aspects that underlie reading and narrative [4-6]. Above all there is one idea of identity behind those aspects that

supports each different prospective. Frequently we call identity that which the person chooses for herself with hardly any conditional references where others can be included. This notion of identity underlies liberty as an absolute and produces isolation in individuals. Identity can also be thought of as the result of rational construction through the generalization of values. In this matter each individual is what she simply considers her inscriptional group by age, beliefs, economical status, culture, *etc*. Nonetheless, there is another possible interpretation of identity, that one is related to origin.

We consider that identity has a reference to origin. It is not established as something definitely given, as an unchangeable *fatum* at the personal life that has as a result a terrible and unavoidable design. Identity as a start means a "departure point". For its essential character of coexistence and openness is the initial step of the personal life and of the flourishing of a culture. On the other hand the "Modern Identity" — using the expression of Ch. Taylor — implies the consolidation of the close individualism and fatally brings us to solipsism. Both A. MacIntyre and Ch. Taylor, not participating in this correct notion of identity as origin, have considered and censured the effects of Modern Identity in the mentioned way. For Taylor [7] the derived influences of that idea have produced an erosion of the traditional and common links. Ch Taylor demands a reaffirmation of the proper values of ordinary life, especially those directly related to family life and work. This is the necessary path in order to recover and to renew the true human spirit. Taylor [7] also insists on the formational properties of art and literature.

In another light, MacIntyre [8] recognizes *tradition* as an essential dimension of personal identity that is conceived as something received and developed at the heart of a community, and which sustains the continuity of subjects' life as a "unity of search" [9]. In this conception, tradition is not a dead weight; a heavy burden that we can hardly bear, and that undermines and cuts the wings of any innovation. Tradition is something given and for this reason is a source for the possible changes carried out by subjects within a community, made by responsibility and solidarity. It is not a matter of reviving the dead tradition but of updating dialogue with a living tradition which is "the requirement of a real scientific progress: progress that only occurs in a learning community" [10].

In order to keep speaking about identity it is necessary to become closer to better clarify the meaning of community that which joins me to others and helps me discover who I am and what I am [11].

3. Narrative as Mean for Accessing into Tradition

There are numerous thinkers that underline from different stances the dimension of narrative in human life [12]. Let us highlight some of the main contributions in order to understand their educational relevance. In *After Virtue* MacIntyre remarks a relevant aspect for self-knowledge; he posits "human action as a narrative in action" [13]. Also in relation to that idea Barbara Hardy wrote "we dream in narrative, we daydream in narrative, remember, anticipate, we hope, despair, believe, doubt, plan, review, criticize, build, learn hate and love by narrative" [14]. Using narrative through told stories supposes a way of practically experiencing human actions [15].

Narrative as non-arbitrary model of knowledge has been exposed, among others, by Mink. According to Mink [16] there are in a general sense three ways of comprehension.

a) The theoretical way (or hypothetical-deductive) that goes from the universal to the particular through which we can learn concrete things by way of example.
b) The categorical way which explains reality through the use of general and abstract notions (categories) extracted from the observation of reality.
c) The configuring way in which the central category is narrative. The configuring way is that which composes a series of objects in a unique complex of relationships.

The tool used for this configuring operation is the "narrative of the plot" (the Aristotelian *mythos*). Speaking about comprehension, the plot is able to make "a synthesis of the heterogenic", since it allows the union in intelligible unity of different elements, such as the actions with agents, the aims, means, initiatives, the non undesired circumstances, *etc* [17]. The narrative mode is presented as the best way of describing human action, as the most suitable to describe human action with the components that integrate it, its conceptual network [18]. Told stories make reference to a tradition. When narrative is reached by means of those stories we have experience of human action. Exactly what connects tradition with action is narrative.

Narrative is what, in the end, gives us the "who" of the action that is to say, what reveals the identity. In effect, as H. Arendt [19] remembers, whenever we tried to define who man is we are tangled in a series of descriptions that retract the answer because they say to us, in fact, what man is. Man, continues Arendt [20] – see also MacIntyre [13]-, reveals himself by his actions and speech, but since the speech in action is narrative, the last word on human identity, the understanding of himself and others in relation to oneself, has a narrative form. Indeed, as Den Heder and Fidyk affirm "Hannah Arendt suggested that a life that is ''specifically human'' shares a story with others" [21]. These considerations introduce the

category of narrative identity that together with theory of narrative has been applied to educational practice [22,23].

It is not strange that, for many theoreticians, narrative has become a suitable category to describe those human sciences in which the speech and temporality are implied in some form. It is through the help of narrative that we can access understanding of ourselves, that we can give ethical value to actions in the framework of a narrated life [13]. That History [24,25] can be understood with its educational [26] implications, or even, as all critical [27] speech must be understood at the end.

4. In search of Educational Tradition

In this context it can be argued that we live in a world characterized by the diversity and rivalry of traditions and some programs even try to do without any tradition. Undoubtedly it is and was always in such a way. This rivalry entails different educational models that compose diverse visions of the educational process and the task of the teacher. And this can provoke a certain disappointment insofar as we are not able to establish the real requirement in a learning community: dialogue [28,29]. This situation transcends the social scope. Traditions can only have influence on educational models through agents who integrate themselves into them in a more or less committed way. This requires that tradition be embodied in all practice.

In this light MacIntyre [13] suggests the convenience of integrating the different practices as a means of reaching a full human development as well as abandoning the perplexity that is trapping us. These practices entail four characteristics.

- *Coherency:* there must be activities with consistent rational and foundational structures.
- *Complexity:* enough to give certain enrichment to the participants.
- *Sistematicity:* that is to say, it is not sufficient to have sporadic activities. Some structure and interdependency must have been reached.
- *Cooperation*: There must be activities with enough participant cooperation.

Every practice thought in this way entails internal goods that MacIntyre calls models of excellence that suppose an ideal of future. Every practice has proper goods, entails learning and is also rooted in the past. These internal goods have the possibility, within the practice, to manage the conduct of those who are participating in it, being specified in a concrete order and in internal rules.

Thus, what is a luminous signal of a good practice is that those goods, internal and specific to this activity, which are only well understood insofar as they are practical, grow systematically, becoming deeper and more attainable. Increasingly they bond among participants and extend to others as well as to different practices. This is the measure of the good state of a practice. It is not enough to have a practice but it is also necessary to have a moral order, thus for MacIntyre "moral order is the indicative of a good practice (…) the practice would flourish in societies with very different codes, not so in societies where virtues are unvalued. Nonetheless, other practices would flourish in institutions and with technical skills valid for unified purposes" [13]. Practices are related to every type of social collaboration; therefore, they also include the relation of collaboration that is produced in education. It is well known that MacIntyre has been critiqued for his idea when he speaks of teaching as a practice [30].

Why do we insist on this integration of diverse practices? For MacIntyre [8] the integration of diverse practices entails a fruitful collaboration between educators and the educated at the heart of the practice itself, the right place where the distinction can be learnt between the following:

a) The distinction about what is really good and what seems good for the student.
b) The distinction between what is good for me, in my particular learning level, and what is always good.

These practices should be maintained throughout life regardless of the degree of maturity of students at the scope of the practices. But a key element for those practices to be effective in the educational process requires authority. It is a rational teaching authority, and authority worth trusting that comes from a self-rational knowledge [31]. Departing from this authority, we should accept that intellectual and moral habits are necessary to be a good and autonomous educated citizen [8]. Authority that is reflected in the virtues that belong to tradition is represented by the teacher. It is not really recognized by the student till the educator has not internally incorporated them at least in a partial way.

The recognition of authority is especially relevant in two moments of the educational process.

a) When it happens before comprehension. It is through trust in authority that one can be introduced to tradition.
b) In the process of understanding we follow a teacher that helps us to move on to higher degrees of intelligibility, thus "we can never do this in our mortal life without the authorized testimony of someone that consists of leading us further from where we were" [8].

The necessity of authority is fundamental during the learning process. Authority is also a permanent condition as far as learning is necessary during the whole life [32].

The importance of educational practices drives us to give value to tradition and authority. In doing so, the educational value of community takes a relevant dimension as a political scope that could bring a tradition, with enough extension to place the different practices in a concrete human group. MacIntyre is speaking about different social habits, where not only intrinsic criteria can be learnt in a practice but also how to conjugate different practices in a more complex social scope. There is in human beings a tendency for history, for narrating, for sharing stories that represent the individual experiences, in this way are made interpretations that reflect moral commitments established by a society or by that which wants to be a society. This is one of the most powerful ways to produce social unity as well as to look for the unity of every individual.

In this light, Grisez and Shaw [33] point out "when we determine ourselves through commitments we shape our lives, our way of looking at things, we determine the significance of the experience that we will have. In such a way, we really create situations in a moral way, since we give to events that happen in our lives and in the world the only meaning they have for us".

The ideal community is, for MacIntyre, the one that carries out a coherent tradition and that in addition is able to make its position rationally explicit, as much in its interior to those who share the project of the community, as towards the outside, to the rival traditions from which it is distinguished. This happens without excluding or discriminating from the beginning the incorporated achievements of those different traditions from such community. In this sense the tradition to which MacIntyre is referring is that where a healthy realism in education is possible: "Tradition of virtues".

5. Narrativity in Education

The previously indicated thing to obtain this element is developed by MacIntyre in his work *After Virtue*, when affirming the importance of narrative in human life and in the development of people. Both elements are closely tied in the scope of education.

MacIntyre states in his own experiences as a child the importance of narrative in education. For him "telling stories is a key issue for educating in virtues" [13]. In fact, he attributes a decisive role in formation to stories in general and particularly to the Gaelic sagas as transmitters of a distinctive tradition, in many ways in opposition to the dominant tradition of modern societies, shedding light "these narratives supply, adequately or not, the historical memory of societies where finally they were fixed in writing. More than that, they give the moral ground of the contemporary debate in classic societies, the vision of a moral order partially or completely transcended, whose beliefs and concepts were still partially influential, and gives also an illuminating contrast to the present time" [13].

MacIntyre emphasizes the importance and the necessity of narrative and the communication of proper stories of a concrete tradition during the first stages of education. In some way MacIntyre goes to his personal experience. The stories that we heard when we were children allow us to learn what a parent and a child are, and what kind of society we live in, etc. If we deprive children of these narratives, they could not distinguish nor wander a world presented as unknown for us [13].

Narrativity in education is seen as a necessary tool to show the unity of human life in an intelligible way, but also to claim the unity of traditions through which we make contact, or those which constitute our nutritional moral habitat.

Then education is taken as a promise of a novelty and the new beginnings with each person keeping the possibilities of the world that is coming from the past. This also requires from every educator to learn how to organize teaching time. Think about the rhythm of learning as well as the maturity of the students. Make students, when they are able to do so, think about their rhythm of learning. For each student, reaching that goal means learning how to organize their lives, which entails making an election of priorities.

Thus, helping students reflect on goals supposes understanding who we are, when, and where we are going. Then narrative is manifested as an efficient help for the proper goal of education: to be happy [34], insofar as it allows us to discover who and how we are. From the old times human beings have used told stories as an efficient means for moral education; therefore, we consider that this method is still very useful today [35,36].

In a different way Geneviève Patte [37], discloses an slogan that succeeded even among teachers "let them read!", proposing leading students with respect but taking into account that "the child has to be conscious that she is living a decisive time where every book has to be "too good to miss"; books and stories that could play an essential role in the development of her personality, of her affective and intellectual life".

Nonetheless it is true that for students, being only part of one tradition, there is a time when she faces other cultures that, in many cases, would be differing versions of her own tradition [38,39]. This is the moment for dialectic and rational discussion, where narrative has its imitation in drama. The importance of dramatic narratives is crucial as an example of attitudes that must be adopted in the situation of conflict among cultures that is brought throughout the dialectic among traditions. For a good solution of this possible conflict, MacIntyre [40] takes

into account the necessity and fecundity of this phase, foreseeing and nourishing through the help of narrative models of historical character.

With the passage of time narrative has to be applied to one's own life and to autobiography. It happens to be a necessary genre to give unity to one's own life project and to make it intelligible to the eyes of those who surround us, sharing or not the tradition in which we live. To reach this goal we need a narrative of the context in which we located ourselves, otherwise the autobiographical story could not be possible either.

In the end, the ideal story which MacIntyre advocates, as we indicated in the beginning, is the one of a search: that in which each person is committed to the truth. The search for human life is obtained as a whole. Indeed that search becomes total and intelligible because it is able, albeit always in a limited way, to give a coherent explanation of truth as well as of the good that we pursue. As MacIntyre exposes by means of narrative we can discover and give an answer to the great questions that are posed by human beings: who am I and what am I?

Discovering oneself and discovering ourselves. The answer to this question that we considered at the beginning is expressed in a very clear way by MacIntyre [41,42] "people at certain moments of their lives often discover -and the crucial word is discover- that their lives have taken a narrative form independently of anything they wanted. And this discovery that in their lives has a narrative form, looking back can rather be understood as a movement in one direction rather than in another. Is not the discovery that the rest of their life is predetermined, but a discovery that there are objective limitations coming from the past in the options that what one can do, and in the meaning of those options. The problem with social constructivism is that it does not recognize the necessary objectivity of social orders".

6. Conclusions

According to McIntyre tradition is an essential dimension of personal identity. One way of growing in self-understanding is by expressing in narrative form those contradictions, experiences, states of mind, and moods that connect me to others and help me to discover who and what I am. In this vein, a task of the first importance in the intellectual life is the narrative articulation of one's autobiography, whether of one's past life or of one's most intimate aspirations for the future, in the context of a community of learning. This is the way one becomes effectively the author of one's own life, discovering what connects me to others and discovering who I am.

What we understand about ourselves is the result of a narrative articulation of the events that we have lived. But we only grasp the true meaning of lived events when we compare what we were with what we could have been. This last idea, the possible, we can know, even if we have not lived it, through fictional stories. With the connection between the historical and the fictional, our personal identity – which is, in the end, a narrative – is finally built up.

Therefore it is no surprise that for many theoreticians, narrative has become a category well-suited to describe those human sciences which involve, in one way or another, discourse and temporality. It is through narrative that one attains an understanding of oneself, gives value to those actions framed by a narrated life, grasps the meaning of history, and discovers one's personal identity.

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Creative Education, 2010, 2, 107-114
doi:10.4236/ce.2010.12016 Published Online September 2010 (http://www.SciRP.org/journal/ce)

The Effect of Speech Rate on Listening Comprehension of EFL learners

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Received August 2nd, 2010; August 21st, 2010; August 27th, 2010.

ABSTRACT

The present research examined the effect of speech rate on listening comprehension of Iranian EFL learners. Initially, a sample of 108 *sophomore EFL learners majoring in English translation was selected based on systematic random sampling from Abadan Islamic Azad University. Then, based on an ECCE proficiency test*, 62 *participants were chosen and divided into two homogeneous groups of* 31. *One group had exposure to natural speech rate and the other to slow speech rate of listening materials. After thirteen academic sessions, the results o the paired t-test regarding the pre-tests and post-tests of the two group means showed that both differences* (*group one*: – 2.83 *and group two*: – 1.22) *were significant at* 0.05 *levels* ($P < 0.05$). *These findings suggest that each speech rate, whether natural or slow, could improve EFL learners listening comprehension*; *however*, *natural speech rate could demonstrate greater improvements than slow speech rate in EFL learners' listening comprehension.*

Keywords: *listening comprehension*, *speech rate*, *EFL*

1. Preliminaries

Numerous scholars (Griffiths, 1990, 1991, 1992; Jensen & Vinther, 2003; Zhao, 1997), [1-5] have stated that one of the major aspects of listening comprehension and speaking fluency is speech rate which has also been the focus of recent English as a Foreign / Second Language research. Some researchers (Chiang & Dunkel, 1992; Goh, 1997, 2000; Wu, 2005) [6-9] contend that listening comprehension is affected by many factors like unfamiliar lexis, speech rate, and background knowledge. Learners have been observed to demonstrate a listening problem mainly because of speech rate. Zhao (1997, pp. 62) [5] states that the conflicting findings of the previous studies suggest that the issue with speech rate is far from settled and needs more productive investigation.

Basically, speech rate, as one of the main factors, has caused one of the major difficulties in evaluating listening comprehension. This controversy over what level of speech rate best serves the learners has not yet been resolved. Some methodologists (Chastain, 1988, pp. 200, Rivers, 1981, pp. 173) [10,11] believe that speech rate should go up as the students make progress. Their assumption is that listening comprehension and speech rate are inter-related and as speech rate goes up listening comprehension goes down. Others (Griffiths, 1990, 1991, 1992; Harmer, 2001; Richards, 1983) [1-3,15,18] contend that students should be exposed to listening materials with normal speech rate right from the start.

Slow rate of speech is generally believed to be usually easier to comprehend than natural speech rate; this gives the students enough time to process the stream of information at a slower rate of delivery. But does it count for listening comprehension in the long run? In other words, because comprehension is increased in slow speech rate, students should be exposed to slow rate. However; the question that remains to be answered is how students will perform in listening comprehension if exposed to moderate speech rate. Note that there are many factors such as length of passage, syntactic complexity, vocabulary, discourse structure, noise level, accent, register, propositional density, amount of redundancy, socio-cultural knowledge, pragmalinguistic knowledge, contextual knowledge, world knowledge, background knowledge, cognitive and affective factors that affect listening comprehension [4,14]. At the same time, speech rate varies from speaker to speaker, age to age, dialect to dialect, context to context, and occasion to occasion. Although speech rate can cover only a small proportion among the above-mentioned variables, it seems to play one of the major controlling roles in listening comprehension that has

formed the main initiative for the development of this research.

1.1. Statement of the Problem

One of the major problems most Iranian EFL listeners complain about is speech rate that seems to have exerted an influential effect on their listening comprehension. Speech rate as one of the main variables and factors in listening comprehension has been the main subject of research lately [5,14-16]. For Iranian EFL learners, approaching L2 listening based on spoken, non- reduced input can be overwhelming. Not only must they cope with linguistic input beyond their actual level of proficiency, the time available is also often too short to pay attention to input form [4]. Limitations in L2 learners' working memory and time do not always permit them to process natural listening input (normal speech rate). In non-interactional listening where EFL listeners have no control over the stream of speech rate they are exposed to, it has been observed that listeners are encountered with some listening comprehension problems mostly related to speech rate (Chiang & Dunkel, 1992; Goh, 2000; Wu, 2005) [6,8,9]. But how students will be trained to deal with speech rate in listening comprehension is still a controversial issue that needs more investigation [5].

Most studies conducted on speech rate in foreign contexts deal with appropriate tendencies of speech rate or Word per Minute (WPM) for certain levels, but rarely has any one touched on the issue of how to practice improving our listening comprehension by speech rate. There is also a lack of research on this issue in our context Iran. Therefore, the main objective that has prompted the development of this research is the question of how to overcome the problem of speech rate in listening comprehension by being exposed to natural or slow speech rate.

1.2. Research Questions

The main questions to be perused in this study are as follows:

1) If sophomore EFL learners are exposed to natural speech rate for a certain period of time, how well will they perform in listening comprehension?
2) If sophomore EFL learners are exposed to slow (VOA special English) speech rate for a certain period of time, how well will they perform in listening comprehension?

1.3. Research Hypotheses

H01: Listening to natural speech rate has no significant effect on sophomore EFL students' listening comprehension.

H02: Listening to slow speech rate has no significant effect on sophomore EFL students' listening comprehension.

2. Review of Literature

Zhao (1997) [5] found some valuable results about speech rates. He pointed out that speech rate is something controlled individually rather than by groups. What is new about his study is that past research looked at speech holistically while Zhao viewed it individually. He designed an experiment with four conditions in which participants have control over speech rate in conditions two and three while no control in conditions one and four. Note that not every subject listens to the same passage in conditions 2, 3, and 4. This was controlled by a computer program. In condition one, the participants listen to 20 sentences while in the other three conditions they listen to passages. Sentences in the first condition were presented at a speed of 180 wpm. Conditions 2 and 3 differed in the way that once participants in condition 2 choose their ideal speed rate they cannot change it during listening but in condition 3, the participants had the chance to choose their desired speed rate while listening. In condition 4, the passage is delivered at the speed of 194 wpm and the participants have no control over the speed of the speech. In each condition subjects are asked to complete multiple-choice questions after listening. The participants in Zhao's study were 15 non-native speakers of English from China, Colombia, Venezuela, Turkey, Taiwan, and Korea. His results show that the participants comprehended better when they had control of speech rate. At the end, he concludes that by giving the control of speech rate to the students and by attending to individuals instead of groups, a) when given control, students' listening comprehension improved and b) improved listening comprehension was achieved by slowing down the speech rate.

Cauldwell (1996) [15] introduced some specific software to remedy the problem of comprehending fast speech rate. He states that the capability of his audio-stack software - access, editing, and zooming – made it possible to be more optimistic about the possibility of teaching and learning "fast speech rules" in the classroom or language laboratory. His software, as he points out, can present fast speech in such a way that learners can have direct encounters with the phenomena of normal speech and thus be in a better position to learn both to perceive and comprehend fast speech in the classroom.

Griffiths (1990) [1] studied the effect of speech rate on comprehension of a semi-scientific text that was read aloud at three different speech rate levels and found that moderately fast (200 wpm) speech rates reduced comprehension, but a slow rate of delivery did not increase comprehension significantly as compared to speech de-

livered at a normal rate. In another descriptive study, Griffiths (1991) [2] stated that language learners are likely to meet a far greater speed of rates than the rates investigated in the earlier study. In a similar study but with different materials (stories rather than semi-scientific texts), Griffiths (1992) [3] conducted an experiment on 24 Omani elementary school teachers for a five-week course. He provided three story passages with three different speech rates: slow speech rates (127 wpm), average speech rates (188), and fast speech rates. Based on the participants' scores in listening comprehension, he concluded that a slower rate of delivery resulted in better comprehension scores than fast and average rates (although average rates did not lead to better results than fast rates).

Most researchers agree that speech rate has created a problem in listening comprehension and may be a key and controlling factor too. The above studies largely deal with or are generalized around: whether fast speech rate increases or decreases comprehension, if slow speech increases or decreases comprehension, or what speech rate is the ideal one [1-3,17], how to control speech rate, giving control of speech rate to the learners or controlling speech rate by devices [5,15], the effect of native speakers or nonnative speakers' speech rate on listening comprehension [18], or whether speeding up or slowing down of the speech rate correlate with the ease or difficulty level of listening items / tasks [14]. They mostly deal with how learners performed on fast speech rate or slow speech rate and conclusions are mostly contradictory from one researcher to the other (Blau, 1990; Brindley & Slatyer 2002; Jensen & Vinther, 2003; Zhao, 1997) [4,5,14,17].

2.1. The Rationale for the Present Study

The present study has viewed speech rate from another perspective to provide some novelty. While most researchers test the effect of fast or slow speech rate on listening comprehension, this research tries to give speech rate another perspective and examines learners' performance on two types of natural speech and slow speech rate. In the above research slow speech was mechanically modified by inserting long pauses (Blau, 1990) [17] or prolonging the time to make it slow.

Blau (1999) [17] felt that reduced velocity and inserted pauses, although usually yielding slightly higher comprehension scores, are not a significant aid. However our sample of VOA special English (slow speech rate) did not have these characteristics and slowness did not remove so much of its naturality. There were not long pauses or prolonged sentences but rather the slow speech was presented just as natural as possible word by word. This slow speech rate is not mechanically slowed down by devices, but rather the newscaster reads the news in a slow way word by word or chunk by chunk while the phonetic features and intonation patterns of the speech are preserved and are not broken down. None of the above studies tested the learners' performance on another type of speech rate after exposure to one type of speech (exposure). It means how learners would react to moderate speech rate if they had only exposure to natural speech rate. Or what is the learners' reaction to moderate speech rate after having exposure to slow speech rate after almost three month.

Most of the above literature fails to have an obvious definition of slow or fast speech rate and most researchers do not agree on one definition. One of the main problems they encountered in their research was in operationalizing the speech rate variable. In this context, research has identified the difficulties involved in defining speech rate and especially in deciding what constitutes a 'fast' as opposed to a 'slow' rate [4,5,14]. These difficulties are further compounded by the fact that speech rates may vary throughout a text. An average wpm count will not reflect these differences and therefore cannot provide any information that will help the researcher to understand the effect of speech rate at the level of the individual item. The moderate version that is used for pretest and posttest is neither slow nor a fast speech rate. But rather a version of speech rate designed for testing listening comprehension for pedagogical purpose. Therefore, it is not a natural speech rate as defined earlier. Because of the difficulty existing in defining fast, moderate, or slow speech rate in the field of speech rate and listening comprehension research, moderate speech rate has been labeled by the researcher's to be neither slow as VOA nor natural speech rate, but something in between them depicting his own perception.

3. Methodology

3.1. Participants

In the present research, the participants were chosen from BA students of Islamic Azad University of Abadan. They were studying English translation in their fourth semester. The population was 108 male and female students. The 62 homogeneous participants drawn from this sample were randomly divided into two experimental groups of 31. There were 27 females and 4 males in group one who had exposure to natural speech rate; and there were 26 females and 5 males in group two who had exposure to slow speech rate. In group one, the average age was 25.29 ranging from 19 to 46. There were 17 bilinguals with Arabic-Persian backgrounds, 1 Turkish-Persian bilingual, 3 Kurdish-Persian bilingual, and the

rest were Persian monolinguals. In Group two, the average age was 24.61 ranging from 19 to 39. There were 12 bilinguals with Arabic-Persian backgrounds, 1 Kurdish-Persian bilingual, and the rest were Persian monolinguals. Note that learners' bilingualism, age, and gender were not considered as variables and are presented here only to describe the participants.

3.2. Instrumentation

A proficiency *Michigan Examination for the Certificate of Competency in English* (ECCE) [19], multiple-choice test of 60 items was first administered to 10 fourth semester EFL subjects from Islamic Azad University of Abadan and after an interval of two weeks the same test was administered to the same 10 subjects and the reliability of the test and the retest was calculated as r = 0.83. When the reliability was assured, this test was administered to 108 EFL populations in order to select the homogeneous subjects. The other instrument was a 20-item multiple-choice listening comprehension Examination for the Certificate of Competency in English (ECCE) test that served as pre-test and post-test for both experimental groups. The reliability of the test before administration of the pretest was calculated by the correlation between the means of test and retest by two weeks interval between the test and retest. The reliability coefficients was calculated based on correlation coefficient and it was met as r = 0.87.

It is worth noting that group one was exposed to natural speech rate such as audio and video news, interviews, political speeches, and lectures; and group two was exposed to slow speech rate materials such as VOA special English news, interviews, political speeches, and lectures. Assignments given to both groups also included out of class activities alongside class activities. Participants were permitted to work in groups to check the video or audio scripts.

3.3. Procedures

A 60-item language proficiency test of ECCE Michigan (Mennen, 2005) whose reliability coefficient was met, was prepared and administered to 108 EFL subjects. Then, for the purpose of selecting the homogeneous participants, those who scored one standard deviation below and above the mean were called for the next phase of the study. After that, they were randomly divided into two experimental groups of 31 participants. Their classes were held once a week for 90 minutes for thirteen sessions.

Before any treatment, a different listening test of ECCE was administered to measure the participants' listening comprehension; in fact, this listening test of 20 multiple choice items designed for pre-intermediate to intermediate EFL level functioned as both pre-test and post-test for both groups. It is a listening test. In order to make sure of the reliability of the pre-test, it was administered to 10 fourth semester EFL majoring BA translation students twice within two weeks intervals. The reliability of the pre-test obtained by the coefficient correlation between the test and retest was r = 0.87. After the reliability of the pretest was assured, it was administered to both experimental groups to measure their listening comprehension knowledge.

Based on the video or audio materials, learners sometimes had to listen to a clip of 3-5 minutes listening text to answer some listening comprehension questions. Sometimes they had to transcribe the listening materials. Other activities included video clips with covered subtitle at first and after working out the text, the uncovered subtitle, followed by some listening comprehension questions.

It is important to note that some in-class and out-of-class listening activities were worked out in groups. Sometimes assignments included transcription of an audio or video clip of their own materials. However, in order to avoid taboos in video clips, the socio-cultural appropriateness of materials was checked with the subjects before they were brought into the classroom.

4. Results

The performance of group one (natural speech rate) on pretest and posttest produced a difference between their scores. **Table 1** below shows the participants' performance on the 20 item multiple-choice listening comprehension pre- and posttest.

This was followed by paired *t*-test as depicted in **Table 2**.

The significance value for the t test indicates that there is a significant difference between the pretest and posttest. The difference was also significant even at 0.001 level. Performance of the participants in group two, who had exposure to VOA slow speech rate, on multiple-choice listening comprehension test also revealed that there existed a difference between the means of pretest and posttest (see **Table 3**).

Once the raw scores were obtained, paired *t*-test was calculated. **Table 4** illustrates the comparison of these two means.

Comparison of the pre-test and post-test means indicated a significant improvement over learners' listening comprehension.

A comparison between means and t-observed of the two groups showed that the mean difference between

Table 1. Descriptive statistics of group one's pretest and posttest.

	N	Mean	Std. Deviation
Group 1 pre-test	31	10.74194	3.306234
Group 1 post-test	31	13.58065	2.486955

Table 2. Group 1 paired t-test.

	Paired differences					t	df	Sig (2-tailed)
	mean	Std. Deviation	Std. error mean	95% confidence interval of the difference				
				Lower	upper			
pair 1 pre-post test	– 2.838710	2.517893	0.452227	– 3.762280	– 1.915139	– 6.277	30	0.000

Level of significance = 0.05 Sig = 0.000 *t* observed = – 6.277 t critical = 2.000

Table 3. Descriptive statistics: pre-test and post-test results of group two.

	N	Mean	Std. Deviation
Group2 pre-test	31	11.35484	2.763432
Group 2 post-test	31	12.58065	2.202638

Table 4. Group 2 paired t-tes.t.

	Paired differences					t	df	Sig (2-tailed)
	mean	Std. Deviation	Std. error mean	95% confidence interval of the difference				
				lower	upper			
Pair 2 pre-post test	– 1.22581	3.007875	0.540230	– 2.32910	– 1.22509	– 2.269	30	0.031

t observed = – 2.269 level of significance = 0.031 at 0.05

Table 5. Paired t-test of G1 & G2 pre-and posttests.

	Paired differences					t	df	Sig (2-tailed)
	mean	Std. Deviation	Std. error mean	95% confidence interval of the difference				
				lower	upper			
Pair 1 pre-post test	– 2.83871	2.517893	0.452227	– 3.76228	– 1.91514	– 6.277	30	0.000
Pair 2 pre-post test	– 1.22581	3.007875	0.540230	– 2.32910	– 1.22509	– 2.269	30	0.031

pretest and posttest of group one was higher compared to that of group two. Statistically, differences found in group one are simply more significant than those of group two (See **Table 5**).

As indicated in **Table 5**, there is enough significant difference in t-observed and t-critical as well as level of significance of group one to reject H01 not only at 0.05 level but also at 0.001 level. It is worth mentioning that the level of significance for rejecting the null hypothesis was set at the 0.05 level of significance for both hypotheses (H01 and H02).

5. Discussion

In the following, research questions are respectively discussed and answered.

1) *If sophomore EFL learners are exposed to natural speech rate for a certain period of time, how well will they perform in listening comprehension*?

Table 5 shows that participants' performance on pretest is much different from their performance on posttest. Results suggest that participants' exposure to natural speech rate had a significant effect on the improvement of their listening comprehension. The results related to the first hypothesis are in agreement with Rivers (1981) [11], Chastain (1988) [10], and Brindley and Slayer's (2002) [14] ideas on natural speech. In the same line, Rivers (1981) [11] believes that learners should be exposed to natural speech and when speech is mechanically slowed it is not desirable; and learners can understand natural speech even in the early stages of language learning.

2) *If sophomore EFL learners are exposed to slow*

(*VOA special English*) *speech rate for a certain period of time, how well will they perform in listening comprehension*?

A comparison between the means of pretest (11.35) and posttest (12.58) of group two showed a difference. Group two performances on listening comprehension posttest showed that although they had only exposure to slow speech rate, their performance had an improvement which was not comparable to that of group one. However, the difference (0.031) was large enough at 0.05 level of significance to reject the null hypothesis. It implies that listening comprehension is affected by fast or slow speech but exposure to slow speech rate is constructive and formative as well. Although the degree of its formativeness and construction is not obviously so clear, it demonstrated a degree of improvement.

There are a lot of intervening factors that might change the results of research or the results one gains might not be because of the treatment. Speech rate in listening comprehension cannot be easily studied if other factors are not taken into account. Speech rate whether slow or fast is strongly affected by other factors such as formality and informality of the speech, the situation type, the relationship between speaker and listener, level of technicality of that speech or its jargon, learners background and world knowledge and many other factors (Brindley & Slatyer, 2002) [14]. However, this research could somehow imply that participants' exposure to natural speech rate made a better improvement over those exposed to slow speech rate. What is important to note is that this research can partially imply that in designing any listening material, fastness or slowness of speech rate do make a difference but what makes the biggest difference is the *naturalness* of both material and speech rate. Slow speech rate or fast speech rate are only a short path practice for comprehending natural speech rate. Therefore, mechanical slowing down and speeding up the speech rate is not a long term objective in teaching and learning listening comprehension.

Now compare slow speech rate with slow motion video. Slow motion in video can give a clearer picture of what eyes may skip or miss in natural motions. Although slow audio may not be well compared with video motion, it can be noticed that video slow motions are usually used only for special purposes by detectives, scientists, sports professionals, *etc*; on the other hand, slow audio might be used for the same purpose but in EFL / ESL listening comprehension in general and speech rate in particular that may suggest a different sense. As slow motion videos can give a better visual picture, slow audio or slow speech rate can give not only a good phonological fracture of speech rate but also a good practice to listening comprehension.

Researchers have to guard against the idea that comprehending slow speech rate is not an end but rather a short path practice to comprehend natural speech. The reason might be that when speech rate is mechanically slowed down some critical features of naturalness are potentially removed from the speech. EFL / ESL listeners do not usually go around asking their interlocutors to slow down their speech, rather slowing down in speech may happen rarely when the global features of communication are broken down. It means, in real life experience in L1 as well as L2, naturalness is more marked or prominent than unnaturalness. It might also be true about EFL / ESL speech rate in listening comprehension. Students had better practice to deal with natural speech rate, although they might have started with slow speech rate.

Sometimes learners' capability and flexibility in EFL / ESL listening comprehension research is underestimated. As Chastain (1988) [10] has indicated, first language learners can comprehend speech rate even over 400 words per minute and learners' ears can be attuned or accustomed to different speech rates. What is more, the reason we raised the issue of cognition and metacognition in review of literature was that to support the idea that speech rate in listening comprehension is a process happening in the mind of learners and we have no control over that. That means, what is slow to one student might be fast to the other. So these are the students who decide on fastness and slowness of speech rate in listening comprehension and it is a phenomenon controlled individually. Therefore, metacognition is more manifested than cognition or we can observe and, to some extent, have a control over students' metacognitive learning strategy than cognition (Wenden, 1987). The results of Goh's (1997, 1998, 2000, 2002) [7,8,21,22] and Vandergrift's (2003, 2005, 2006) [23-25] research on cognition and metacognition in EFL / ESL listening comprehension when accompanied by Zhao's (1997) [5] research on speech rate as an individual factor are somehow the manifestation of the relationship between speech rate and cognition and metacognition in listening comprehension.

Comprehending natural speech is the optimal objective in EFL / ESL listening comprehension; however, problems or obstacles that make this input overwhelming to learners might be related to the limitation of working memory. Jensen and Vinther (2003) [4] state that an utterance should linger in the listener's working memory long enough to be processed, not only for meaning, but also, subsequently, for form. The time constraint on working memory is an obstacle to this process of natural speech rate. They state that natural speech does not give learners enough time to pay attention to the form and meaning of speech, and as a result, *noticing hypothesis*

(Jensen & Vinther, 2003) [4] is not observed. According to the noticing hypothesis, it is crucial for the development of learners' interlanguage (IL) to have plenty of opportunity to pay attention to the formal features of the input they receive. Their solution for this shortcoming was to use exact repetition and reduced speech rate. This solution may provide good grounds to advocate slow speech rate in listening comprehension. Some researchers also used some similar approaches to make up for this shortcoming (Blau, 1990; Brindley & Slatyer, 2002; Derwing & Munro 2001; Griffiths 1990, 1991, 1992) [1-3,14,17,18] and mostly used speech rate reduction. Others (Zhao, 1997; Cauldwell, 1996) [5,15] used devices to slow down speech rate and gave the control of speech rate to the listeners. These alternatives might partially have some potentialities for controlling fast speech rate but the controversy of fast (natural) or slow speech rate is not settled down yet and needs more comprehensive research.

6. Conclusions and Implications

The results of the two experiments presented in this research focused on the effect of natural and slow speech rate on Iranian EFL learners' listening comprehension. The assumption to use natural speech rate was motivated by the fact that natural spoken language constitutes a large input in listening comprehension, and on the other hand, there are limitations for learners to comprehend this natural input in EFL / ESL context; therefore, slow speech rate (VOA) has been another compensation for the learners' limitations to be investigated. The results of the two experiments conducted in the present study provided positive answers to our hypotheses and research questions. That is, listening or exposure to natural speech rate made a significant improvement in learners' listening comprehension. This improvement was manifested in their post test compared to their pretest. On the other hand, learners' exposure to slow (VOA) speech rate also demonstrated an improvement. However, the significance of the improvement in exposure to natural speech rate was greater than exposure to slow speech rate. What is clear in this research is that natural and slow speech rates both have some features that can be beneficial to the listeners. That is, it is difficult to include one to the exclusion of the other. But the degree of benefit learners gained in natural speech rate drove us to the point to indicate for now that naturalness counts better for listening comprehension, although slow speech rate suggested an improvement in listeners' comprehension. Although others (Griffiths, 1990, 1991, 1992; Blau, 1990) [1-3,17] might have come to different conclusions on the issue of slow or fast speech rate in listening comprehension, the naturalness of speech counted better in this research.

In teaching and learning listening comprehension, speech rate cannot be overlooked. But the decision to use what materials is vital to the whole concept of teaching and learning listening comprehension. Although the results of this research implied that natural speech rate made improvement in listening comprehension, it does not mean slow speech rate should be excluded. Teachers and learners should take into account features of slow and natural speech rate and know that both have some advantages and disadvantages. But if comprehending natural speech rate is the optimal objective, therefore, the attention and focus should be given to natural speech rate rather than to slow speech rate. Slow speech rate may be used as a short path practice for comprehending natural speech rate.

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Creative Education, 2010, 2, 115-120
doi:10.4236/ce.2010.12017 Published Online September 2010 (http://www.SciRP.org/journal/ce)

Using an Interactive Computer System to Support the Task of Building the Notions of Ratio and Proportion

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Received February 27th, 2010; July 18th, 2010; July 25th, 2010.

ABSTRACT

This article describes the design and general outcome of applying a computer system that includes interactive activities to the topics of ratio and proportion. The work was undertaken with Mexican students attending primary school grade six (11 *year olds*)*. In designing the activities, our work was based on the studies of researchers who have focused on such topics, as well as on the work of researchers in the field of computer sciences and education technology. Support of the activities designed is found in psycho-pedagogy, in knowledge of mathematics and in the fields of computer sciences and education technology.*

***Keywords*:** *ratio*, *proportion*, *interactive activities*

1. Introduction

There is little doubt of just how important it is th at students attending basic education classes develop cognitive structures in the area of mathematics, structures that provide them with the basis nee ded to successfully meet the academic de mands of the next school s ystem level. Hence development of so ftware for basi c educat ion i n mathematics b ecomes just as significa nt in the c urrent Mexican c ontext because i ncursion of c omputers i nto that ed ucational lev el raises th e need t o an alyze which pedagogical st rategies rec ommended by M exican researchers to teach t he c oncepts of ratio a nd proportion can be incorporated into an educational software system, and precisely how that should be done.

Consequently the au thors of this article h ave fo cused their attention on supporting the task of bu ilding the notions of ratio and proportion. And in doing so, they have developed a c omputer sy stem t hat uses t echnology t o carry out interactive activities.

In th is article, th e au thors in troduce a teach ing proposal de veloped i n a c omputer system wi th i nteractive activities that make use of tech nology. The design of the proposal activities was based on a prior study undertaken by R uiz, [1] with stud ents who co urse six grade of pr imary scho ol an d th at deals with t he top ics of ratio and proportion. These topics were selected in view of the fact that their instruction is begun in primary school and th at they serve as t he basis for subsequent conc epts, s uch as those of direct proportional variation or linear function.

2. Portrayal of the Problem

To ide ntify whethe r the ra tio and proportion teachi ng activities designed through a computer system enable the 11 year-old student to build notions or ratio and proportion, developing said stud ent's qualitative p roportional thought and aiding him / her t o recover the sense of his qualitative proportional thought.

Qualitative pro portional thou ght is supp orted b y lin guistic rec ognition, c reating comparison ca tegories s uch as large or small. Qualitative thought also includes things intuitive th at are based on ex perience and th at are em pirical, an d th ings perceptual th at a re su pported by th e senses.

Qualitative proportional t hought refers to activ ities that enable st udents to c ount measure and employ quantities in procedures.

3. Theoretical Basis

3.1. On Ratio and Proportion

According to Piaget [2] one can see in 11 and 12 year old subjects th e presen ce of t he notion of proportion in different ar eas, notions su ch as : sp atial proportions (lik e

figures), the relation between the weights and length of arms on a scale, probabilities, *etc*. [3], also states, based on his experiments, that *children acquire their qualitative identity before their quantitative conservation*, and further distinguishes between qualitative comparisons and true quantification.

In fact for Piaget the notion of proportion always begins qualitatively and logically prior to being structured from a quantitative standpoint. He stresses that in order for a student to develop his / her qualitative proportional thought that student must necessarily begin with the *notions of enlargement and reduction, following the idea of a photocopier or scale drawing,* assuming that at a very early age the student is able to recognize what is proportional.

According to Piaget and Inhelder [3] after the student develops his / her perceptual ability, an ordering takes place by way of comparisons, which can be seen when students use phrases the likes of "larger than…" and "smaller than…" and which are known as *verbal categories*. In this sense Piaget says that during the transition from things qualitative to things quantitative, the idea of order appears without a quantity having yet emerged, an event that Piaget calls *intensive quantifications*.

Subsequently when students use measurements to make *comparisons* they first confront parts of the object and *superimpose one figure on top of another* and afterward *use a measuring instrument*, be that a conventional instrument or not. Freudenthal [4] states that comparisons make it possible to *measure* and measurement is shown by way of two modes: *direct and indirect*. The direct mode of comparing is when an object is superimposed onto another object, while the indirect mode is when there are two objects (A and B) and a third element to compare (C).

With respect to the emphasis that should be placed on early education of ratio and proportion, Streefland [5-7], states that the point of departure should be qualitative levels of ratio and proportion recognition and that use should be made of didactic resources that foster development of perceptual patterns in support of the corresponding quantification processes.

The didactics of mathematics are referred to as an essential activity in teaching ratio and proportion, as is the importance of didactic tools developed by the designer. Freudenthal's Didactic Phenomenology [4] is particularly mentioned, together with other background considered in order to attain a realistic building of mathematics.

Freudenthal indicates that comprehension of ratio can be guided and deepened by way of visualizations. He moreover states that such visualizations can be illustrated by way of detailed constructions in which the drawings are differentiated and in which the drawings depict which points of the original and image actually coincide. An example of the foregoing is in two contiguous figures one of which is an enlargement or reduction of the other, and in which the same linear ratio can be established in each segment of the figure. Freudenthal suggests that when working with the ratio of longitudes, flat figures is used as a means of representation because of their global expressiveness, in the sense that a student's qualitative and quantitative comprehension is facilitated by visual perception.

Ruiz and Valdemoros [8] found that the students she worked with presented different difficulties, specified as: a) The students' qualitative thought dealing with proportionality has not been exploited to the utmost, which was observed when they demonstrated that they were centered on one of the dimensions of the figures they had been asked to reduce or expand; b) In some students, things qualitative are barely raised as an introduction to things quantitative, given that in the linguistic categories detected among them, one found the following: "it is larger than…", "it is smaller than…", which reflects a certain understanding of proportion; yet among these same students one did not find other categories through which they showed a greater understanding of the idea of proportion; c) They appeared confused when establishing relations between quantities, which is why is became necessary to emphasize that in order to reach the notion of ratio.

3.2. Technological Elements

Lim [9], states that technology makes it possible for teachers to be more flexible thus enabling them to address the different needs of students with varying levels of capabilities – all of whom may be sharing one single classroom- by using software that can be adapted to the teaching and to the particular conditions of each student or group. Technology makes it possible for teachers to divide their groups of students into teams and to work with each one at their own pace. What is more, technology can make it possible for the students to determine the pace at which they feel comfortable working.

Some research has been undertaken for the purpose of finding out if usage of a Web-based environment benefits learning. The study carried out by Galbraith and Haines [10] shows that students who use a computer in their daily mathematics learning enjoy mathematics. They like the flexibility provided by the computer and spend a great deal of time at the computer to complete a task, and enjoy trying out new ideas. The researchers also concluded that Web-based applications increase levels of confidence, motivation and interaction.

Nguyen and Kulm [11], Combs [12], Gourash [13] and

Engelbrecht and Harding [14, 15], point out that usage of computers in educational terms enables students to find the meaning of what they are doing in that their ability to discover is developed and they are able to delve deeper.

Working with the points mentioned by the researcher in the previous paragraphs, **Table 1** depicts a specification of the indicators that refer to ratio and proportion, as well as to the didactic actions associated to those indicators.

4. Methodology

Under this heading the authors of this article have included the subjects with whom work was undertaken, the elements of the computer system used to carry out didactic activities and the didactic activities themselves.

Subjects

The research was carried out with a sample of 29 students all in the same grade six class of a primary school in Mexico City, to whom the activities designed were applied.

Sequence of activities and their presentation in the computer system

Taken into account in the task of designing the sequence of activities are the didactic actions specified in the theoretical framework, the computer activities, as well as the theoretical elements entailed in the concepts of ratio and proportion.

Activity 1. Choose the reduced or enlarged figure of the figure provided, by way of visualization.

This activity is based on ideas of "*reduction*" *and* "*enlargement*" supported by models of the scale and photocopier drawings-type experiment, using things perceptual and observation.

This was used as the point of departure in view of that indicated by Piaget, [12], Streefland, [5-7] and Ruiz y Valdemoros [8], regarding the point that early instruction on ratio and proportion needs to begin with qualitative levels of that learning, which is why activities that do not require use of quantities for solution of the activities are first used.

Table 1. Objectives, indicators and didactic actions of the concepts of ratio and proportion.

Concepts Objectives	Indicator		Didactic Actions
Ratio: Relation between two magnitudes expressed through a quotient	Intuitively establish ratios	Compare	Superimpose figures Use verbal categories such as "one side fits twice in the other side" or "one side is one third of the other side"
	Explicitly establish ratios	Express the ratio in the form of a fraction	Count the sides of a square (in a grid) Use a table Count the sides of a square and write out the ratio as a fraction.
Proportion: Relation of ratios or the equivalence of two or more ratios	Qualitative proportional thought	-Visualize -Use linguistic expressions	Choose reduced or expanded figures. Enlarge and reduce figures. Use verbal categories, such as "larger than" or "smaller than"
	Transition from qualitative to quantitative proportional thought	-Compare -Measure indirectly	Superimpose figures Count sides in the squares of a grid
	Quantitative proportional thought	-Measure directly -Use the rule of three or of the excluded third	Measure using a conventional instrument Use the table Carry out number operations

Table 2. Contains the relation existing between Table 1 activities and the actions to be undertaken on the computer.

Didactic Actions	Actions on the Computer
Superimpose figures	Drag the mouse
Use verbal categories	Use voice
Count the sides of a square (in a grid)	Use a pencil, like in Paint
Choose reduced or enlarged figures	Click on the option
Expand or reduce figures	Use a pencil, like in Paint
Measure using a conventional instrument	Use ruler
Use the table	Table to the filled in by the student
Carry out number operations	Calculator

Consideration has furthermore been given to Freudenthal's points that deal with guiding and deepening comprehension of ratio through visualizations.

By the same token the figures designed in the computer system relate to the knowledge possessed by 11 year old children, to whom the figures are aimed. Examples of the foregoing could be a boat, a bus, a star, a dog, albeit all drawn in straight line segments.

How the concepts appear in the computer system

Shown are four similar figures, all of which have small differences. One of the four figures is also depicted in a double or triple linear amplification or reduced by half or to a third of the linear size. The user is asked to choose among the four figures and find the figure that is a reduced version of the original. (See **Figure 1**).

Figure 1. Source: Created by the authors.

Figure 2. Source: Created by the authors.

After having chosen one of the figures, the choice is then analyzed and an answer is immediately provided bearing the result of the analysis. The user is asked if he / she wants to try again, the answer is received and, depending on that answer, the exercise is either restarted or work is continued with the next exercise.

Activity 2. Choose the figure that is a reduction of amplification of the figure provided, by way of comparison.

Case 1 Superimpose one figure over another

Superimposition of one figure on top of another enables subjects to recognize relations of similarity among the figures in intuitive terms.

The action of comparing figures is the beginning of measurement, yet without using a conventional instrument since it is achieved by superimposing the figures just as specified by Freudenthal, 1983.

How the activity appears in the computer system?

The student has the option of using his / her mouse to drag any of the four figures in order to place the figure on top of the original and review the result, by way of visualization, to see if the figure is an enlargement or reduction on all sides by the same amount. See **Figure 2**.

Case 2 Use of a grid

The transition from qualitative to quantitative proportional thought is achieved by using the grid [1] Counting is used and the measurement unit is one side of a square in the grid in which the figures are portrayed.

The result of the process of counting the sides of the figures is used in order to establish quotient relations with the results obtained, that is to say ratios. This is also done for the purpose of establishing relations of equivalence between two ratios or proportions.

How the activity appears in the computer system

The student is presented with a figure on a grid, as well as another empty grid in which he / she can draw and use the grid itself as a means of support. The student is asked to draw the figure at double or half or one third, *etc.*, of its original size (See **Figure 2**). The drawing in the first grid is a means of support, used to compare with the drawing done by the student. The student is told whether his / her answer is correct and asked if he / she wants to repeat the exercise, and the student decides if he / she wants to repeat the exercise or go on to the next one.

Activity 3. Use of the table

The table was used as a means of representation in order to determine internal and external ratios Freudenthal [4]. The students work with proportional variation problems and obtainment of the quantities is not only achieved through use of the operator, but also by establishing relations among ratios.

Finally, work was done on equivalence relations as a proportionality relation.

Outcomes of the didactic activities

Activity 1. Choose the figure using visualization

Eleven of 29 students used observation to choose the reduced figure. Whereas the remaining 18 decided to compare the figures by superimposing one figure over the others. They used the mouse to drag the figure to see if it was, from the side or width, double, half or one third of the original. All of this was commented upon during the session; and furthermore coincides with Freudenthal [4]. If the figure in question was a circumference, the students compared the radii or the diameters. Consequently all of the students were able to determine that the answer was the reduced figure, and each student decided for him / herself whether to drag the figure and superimpose it over the other figure in order to compare them. This student reaction is similar to comments made by Combs [12].

Activity 2. Grid

Of the entire group of 29 students, 23 were able to draw correctly on the grid figures that were similar to

those presented to them. The remaining 6 students made two to three attempts before they were successful with the task. The computer system was extremely useful in that it presents the student with the option of working with different figures, thus making for work that is not mechanical. What is more, students are given the opportunity to discover what is taking place.

The work reached the level of recognition of ratios as a comparison by quotient of two quantities. The group worked on notation of ratios in the form of a / b fractions, in which b is a different from 0.

Activity 3. Use of the table

Once again of the entire group of 29, 20 students were able to fill in the table correctly. They accomplished this by deciphering the unit value, in the event that it was not provided, while others established ratios by reading them from the table and writing them down in the form of fractions. All students used the calculator, first determining the operations that had to be undertaken; for instance, in **Figure 3**, reference is made to the case of Luis.

When faced with the activity, this is what Luis did: In the case of Luis, one can see that he establishes relations between two variables, the milk and the chocolate bars. In Freudenthal terms, these are external ratios.

Manuel is another case: What Manual expressed when solving the activity can be seen in **Figure 4**.

Manuel was asked to provide a conclusion, as follows:

> "*The conclusion you're asking me for is that… well like, to get the* [*number of*] *chocolate bars you have to use the* 6 *times table. So, first you need* 6 *bars for* 3 *liters of milk, then* 12 *bars for* 6 *liters of milk, then* 18 *bars for* 9 *liters. So if I compare liters to chocolate bars I can see that it's double the number of liters in chocolate bars.*"

There is indeed food for thought in Manuel's work. Before asking him to provide a conclusion, Manuel had already established relations among the data in one of the columns, the liters of milk column. Freudenthal refers to this as internal ratios.

Usage of the table enabled the students to establish relations between magnitudes of figures, to the point of establishing both internal and external ratios (as per their definition by Freudenthal). Lastly the students were in-

> "*I saw that* 3 *fits* 2 *times into* 6, *so for* 3 *liters of milk you need* 6 *bars of chocolate. In other words, you need double the amount of chocolate bars, so one liter needs two bars, two liters four bars, three liters six bars.*
>
> *I'll just use the calculator to multiply by two to fill in the data I'm asked for*"

Figure 3. Response provided by Luis in the activity of filling in the table.

> "*I saw how the quantities in the chocolate bars column changed, because they gave us more numbers in that column. I saw that it began with* 6, *then there was a blank that I had to fill in, then came the* 18 *and right after that the* 24. *I used the calculator to divide* 18 *by* 6, *and it gave me a result of* 3; *then I divided* 24 *by* 6 *and it gave me* 4. *So I took the* 6 *and multiplied it by* 2 *and got* 12, *and that's the value of the second blank, and the last blank in the column is the result I got from* 6 *times* 5, *which is* 30."

Figure 4. Manuel fills in the table, first filling in the liters of milk column.

deed able to use the different representation registers – drawing, table and things numerical- when they were solving ratio and proportion problems. One is therefore led to point out that work with these interactive activities enabled the students to build the concepts of ratio and proportion, investing them with meaning and sense, rather than just using the algorithm to work on the topics. This is indeed similar to the findings obtained in the studies by Galbraith, P. and Haines, C. [10], Nguyen and Kulm [11], Combs [12] and (Engelbrecht and Harding [15]).

5. Conclusions

According to the findings obtained we are in a position to state that the activities designed to support students in the task of consolidating the concepts of ratio and proportion were adequate given that the students demonstrated a great deal of interest when working with the computer system and worked independently to solve the problems. Their teacher did not have to instruct the students to compare one figure with another in order to determine which one was the reduction, rather the students developed that ability thanks to the activities proposed in the system. The foregoing leads one to infer that the students were able to develop both their qualitative and quantitative proportional thought; they showed a good deal of freedom in dragging the mouse, using the grid and filling in the table, activities for which there was no need for their teacher to give them instructions. Working in this manner moreover enabled the students to develop visually and perceptually, in other words they were able to further develop aspects that constitute their qualitative proportional thought.

Use of the table made it possible for the students to establish relations among figure magnitudes, establishing internal and external ratios (as defined by Freudenthal). Finally the students were able to use the different registers of representation (the drawing, the table and things numerical) when solving ratio and proportion problems, which enables the authors of this article to point out that working with interactive activities made it possible for the students to build the concepts of ratio and proportion, and imbue those concepts with meaning and sense rather than simply using the algorithm to work on the topics. This is quite similar to the findings obtained in the studies undertaken by Galbraith, P. and Haines, C., Nguyen and Kulm, (Combs, and (Engelbrecht and Harding, The computer system made it possible for the students using it to develop skills that were not developed by all of the other students in their group using pencil and paper and the blackboard.

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Creative Education, 2010, 2, 121-127
doi:10.4236/ce.2010.12018 Published Online September 2010 (http://www.SciRP.org/journal/ce)

Investigating Numeric Relationships Using an Interactive Tool: Covering Number Sense Concepts for the Middle Grades

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Received July 1st, 2010; August 24th, 2010; August 30th, 2010.

ABSTRACT

This article investigates intriguing number patterns utilizing an emerging technology called the Square Tool. Middle School math teachers will find the Square Tool useful in making connections and bridging the gap from the concrete to the abstract. Pattern recognition helps students discover mathematical concepts. With the development of puzzles, games, and computer programs, students learn and practice the skills that are created in the mathematics classrooms. By studying patterns that exist within different number arrangements, consistencies are observed among them. Middle School students will investigate various mathematics relationships found in numbered squares including multiples, factors, ratios of comparative numbers, and other mathematical concepts.

Keywords: *Number Sense, Number Patterns and relationships, Puzzles, Games, Computer Programs, Number Arrangements, Multiples, Factors, Ratios of Comparative Numbers, Investigation, Number Squares, Number Games*

1. What is the Square Tool?

The Square Tool (see Appendix) is an emerging JavaScript technology that allows users to discover many numeric relationships. It is based on the idea of arrays of consecutive numbers such that the program can configure any N × N area up to 20 × 20, like the Hundreds Chart. A simple hundreds chart would be a 10 × 10 area listing the numbers 1 to 100.

In **Figure 1**, the interactive Square Tool creates squares of consecutive numbers (Su, Marinas, & Chraibi, 2008) [1] http://mcs-research.barry.edu/squares/squares99 html. In the case of a 9 × 9 square, the sum of either major diagonal is 369. While the Square Tool explores patterns, the tool has the ability to add numbers and interactively change square sizes.

2. Investigating Patterns and Numeric Relationships

Using the Square Tool, teachers will discover many possibilities for its use in which to educate children in investigating patterns and numeric relationships. It can help students improve recognition of similarities promptly and correctly, apply patterns to different subjects and venues, and form the fundamental concept of patterns, such as counting by tens or recognizing sums of numbers. The National Council of Teachers of Mathematics (NCTM) *Standards* (2000) [2] document has made one of its principles for teaching mathematics the use of technology during math instruction. The Square Tool can be used at any grade level and employs technology as students discover intriguing number patterns.

1	2	3	4	5	6	7	8	9
10	11	12	13	14	15	16	17	18
19	20	21	22	23	24	25	26	27
28	29	30	31	32	33	34	35	36
37	38	39	40	41	42	43	44	45
46	47	48	49	50	51	52	53	54
55	56	57	58	59	60	61	62	63
64	65	66	67	68	69	70	71	72
73	74	75	76	77	78	79	80	81

Figure 1. A 9 × 9 Square showing the sum of either major diagonal is 369.

Furner (2005) [3] and Ozel, Yetkiner, and Capraro (2008) [4] discuss the importance of using technology in the classroom and creating connections by bridging the gap from the concrete to the abstract using such promising technologies. The Square Tool helps students explore many fascinating number patterns and concepts. Students can create and extend number models and patterns in a progressively deeper and more meaningful manner. They can create a variety of visually interesting patterns that express fundamental mathematical ideas in today's math curriculum.

At the early grade levels, students should transition from hands-on activities to semi-concrete representations like virtual manipulative, to finally abstract numerical concepts. "It is like magic, I've made a 5 × 5 grid and clicked every other number and the red numbers are all even and the other numbers are all odd," said Jose in the 4th grade. The Square Tool adds distinct numbers and examines patterns to advance higher-level thinking skills. It can also be used to perform operations and show numeric relationships including the basic operations of addition, multiplication, and division. (**Table 1**)

2.1. Properties of Numbers

Since number theory is the study of the properties of numbers, the Square Tool is a practical instrument for discovering prime and composite numbers (**Table 2**), the Sieve of Eratosthenes, multiples, and factors. Mathematicians such as Euler, Gauss, Fermat, Euclid, and Pythagoras were fascinated by number patterns and provided important contributions to number theory. Wall (2010) [5] feels that number theory ideas should be introduced in the elementary grades as a foundation that leads to more abstract reasoning in the middle grades. Overbay and Brod (2007) [6] contend that exploring magic squares and recognizing number patterns with middle school students is motivating and fascinating for this age group. This lays an important foundation for work with number theory concepts at higher levels.

While the Father of Primes and Composites Exploration was claimed to be Gauss, Eratosthenes developed the organized method to find the prime numbers (**Figure 3**). The system is known as the Sieve of Eratosthenes. By using the Square Tool, one can easily find prime numbers using the Sieve of Eratosthenes technique. An example of finding primes less than 100 would look like this:

1) At the Square Tool site, select the 10 × 10 grid.
2) The number 1 is not classified as a prime number, so the smallest prime number is 2. Highlight all the multiples of two, excluding 2 (4,6,8, *etc*.).
3) The next non-highlighted number is a prime number, 3. Highlight all multiples of 3, excluding the number 3 (6,9,12,…99). Some of the numbers are already highlighted as they are also multiples of 2.
4) Highlight all the multiples of next prime, 5 up to 100, excluding the number 5. (10,15,20,…100). Some of the numbers are already highlighted as they are also multiples of 2 and / or 3.
5) Highlight all the multiples of next prime, 7 up to 100, excluding the number 7. Since most of the numbers are already highlighted previously, the only remaining multiples of 7 are 49, 77, and 91.
6) The remaining numbers on the grid are prime (shown in black in **Figure 4**).

3. Classroom Implementation

As we visited the classrooms of our pre-service teachers, a class of 7th graders discovered that they can play integer games using the grid. For example, one team clicks on 2 pairs of numbers and turning them red (they

Table 1. Numeric relationship in addition, multiplication and division.

Operations	Relationship / Activity
Addition	Add two even numbers together. What kind of number is the result? Add two different even numbers. What kind of number is this result? Do this for several more pairs of even numbers. Write a conjecture about the type of number you get when you add two even numbers. Explain why the result of two even numbers always seems to be an even number. Explain why the result of two odd numbers always seems to be an even number. Explain why the result of adding one even and one odd number always seems to be an odd number. Using the Square Tool to look for a pattern when one even and one number are added.
Multiplication	Multiplication is based on repeated adding of groups. Students develop concrete ideas about multiplication by using hands-on grouping activities. The Square Tool guides students to the abstract view of multiplication using numbers. To multiply 5 • 3, make a 5 × 5 square. (**Figure 2**) Each row represents a group of 5 items. So 3 groups of 5 leads to the last number in row 3 or **15**.
Division	Since multiplication and division are inverse operations, the tool will explore this relationship. In **Example 1**, let's use the tool to visually calculate 17 ÷ 5. Make a 5 × 5 square (**Figure 2**), 17 is in the 4th row, 2nd column. There are three complete rows and two additional numbers in the next row written as 3 remainder 2. This leads to 17 = 5 • 3 + 2 and extended to 17 = 5 • □ + □. Students build a foundation for Algebra by filling in the boxes with the numbers that make the equation true. In **Example 2,** the Square Tool can be used to calculate 9 ÷ 5. There is 1 complete row and 4 additional numbers in the next row. The answer is 1 remainder 4, which means 1 whole row and 4 / 5 of another row.

Table 2. Discovering prime and composite numbers using the Square Tool.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Figure 2. Numeric relationship in division.

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

Figure 5. Prime and composite number's game.

Figure 3. Practical usage in Sieve of Eratosthenes.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Figure 4. Using the tool to identify prime numbers.

called the red numbers positive numbers), but the team must leave two un-highlighted (negative) numbers in between (**Figure 5**). The other team must quickly add the first 4 numbers and then subtracts the two negative numbers and state if the sum is prime or composite. Below, Team 1 selects the numbers 3,4,13, and 14, Team 2 adds (3 + 4 + from the teams would be, "the answer is 51 and it is not a 13 + 14) – (– 8) – (– 9) = 51. One acceptable answer prime number because 51 is divisible by 3." The students decided that this game will work with multi-plication of integers. Teams can compete to see who can come up with the easiest way to multiply the highlighted numbers using mental calculation. For example, to find the product of 3 × 4 × 13 × 14, Team A came up with [(13 × 13) + (13)] × 3 × 2 × 2 = 2184; Team B came up with 12 × 13 × 14 = 2184; and Team C came up with 12 × 13 ×(13 + 1) = 2184. Since the students mentally calculated the products, the teachers point out that some expressions could be further broken down. For example, 12 × 13 × 14 could be broken down as 12 (12 + 1) (10 + 4). The students enjoyed and challenged each other with the games that were created by our pre-service teachers.

One teacher used the Square Tool to remediate the use of multiplication tables, mental math, and computation skills. The Tool reinforced character traits such as teamwork, cooperation, respect, and self motivation. "The students worked very well together. There were a few arguments about the final sum, within the groups, but

overall they did well. The students thought the Square Tool was a neat mathematical tool."

3.1. Prime Numbers

While many interactive websites identify prime numbers by using the Sieve of Eratosthenes, the automated process eliminates the understanding of multiples by doing all the hands-on work of removing the multiples. Through observations, we as teachers feel that students should use the Square Tool to help develop and then reinforce their own understanding of "prime numbers" by creating their own Sieve manually.

Students can use colored tiles as concrete examples to explore the concept of multiples. By making differing square sizes, the Square Tool helps the teacher discuss multiples of the square size. The teacher can make paper copies of the 10 × 10 square and allow the students to find multiples by using different colors. For example, all multiples of three can be blue and all multiples of five can be red, then making multiples of fifteen purple. They then can transfer to the Square Tool, make the appropriate grid and click on the numbers to identify the multiples.

In connecting the bridge from the concrete to the semi-concrete, students can first use colored tiles to develop a concrete understanding of the concept of factors. For example, the factors of 12 are 1,2,3,4,6, and 12, students can make the areas or arrays of each. Then they can use the Square Tool to determine which method is more efficient and why. Proper Factors are factors of *n* other than itself. The proper factors of 14 are {1,2,7}. Teachers may enjoy allowing students to learn about abundant, deficient, perfect, and amicable numbers after learning about proper factors as well.

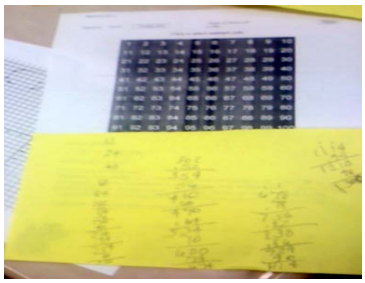
3.2. Factors

This leads to Greatest Common Factors (GCF). Students can then identify the GCF of two or more numbers. The GCF is the largest factor that divides evenly into two or more numbers. For example, the GCF for 15 and 24 is 3, as 3 is the largest number both 15 and 24 can be divided by evenly without a remainder.

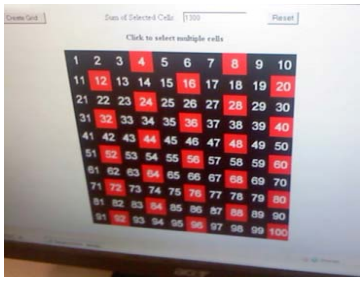
By using the Square Tool, students can play games that reinforce the concepts of proper factors and Greatest Common Factor. In an urban school from southeastern region of the United States, one writer of this article during a class demonstration lesson found that the seventh grade students picked up the GCF concept quickly and had fun doing it to the point that they did not realize that they were learning math (**Table 3**). They were testing each other using the Square Tool by taking turns selecting 2 random numbers on the grid and see who can identify the GCF from the two random numbers within the shortest time frame. This class of regular twenty-one seventh graders in this Title One school, generated their own factor problems and initiated the idea of testing their conjectures with different grids. For example, Using a 7 × 7 grid, Mary, a student in this class, challenged her classmates to identify the number for the proper factors {1,2,4,7,8,14, and 28}. Mary's math

Table 3. Classroom implementation of the Square Tool.

7th graders using the Tool for prime numbers



Student using the tool to investigate patterns



Students highlighted Multiples of 4 in red

Students the Tool to create mathematical games

classmates responded with, "56 is a composite number, it has factors other than 1 and itself, therefore it is not a prime number." Students can see the 8 factors of 56 are 1,2,4,7,8,14,28 and 56. The factor pairs of 56 are 1 × 56, 2 × 28, 4 × 14, and 7 × 8. They went on and said that the number for proper factors {1,2,4,7,8,14, and 28} is 56. They also identified the prime factors of 56, which are 2,2,2, and 7.

3.3. Connections to Magic Squares

The Square Tool can create non-Magic Squares, since the diagonals, horizontals, or verticals are not necessarily equal to one another. Loly and Steeds (2005) [7] says that there are an interesting class of purely pandiagonal, *i.e.* non-magic squares, counting number squares of orders (row / column dimension) that exist and many patterns can be discovered while observing them. Based on reviewing the hundreds square which arranges the first 100 numbers respectively into 10 rows and 10 columns (**Figure 6**), students can look for patterns and draw appropriate conjectures.

One feature of the Square Tool is to add selected numbers. The following number patterns and relationships can be discovered using any size square. In this example of a 7 × 7 square (**Figures 7**, **8**, **9**, and **10**).

1) Numbers in the opposite ends of diagonals add to 50, for example in **Figure 7**:
   1 + 49 = 50 or 7 + 43 = 50
2) In **Figure 8**, the sum of the major diagonals add to 175.
   1 + 9 + 17 + 25 + 33 + 41 + 49 = 175 or,
   7 + 13 + 19 + 25 + 31 + 37 + 43 = 175
3) If you take an "M × M" square within an "N × N" square in **Figures 9** and **10**, the diagonal numbers at the each corner add to the same number. In the 2 × 2 square at the top corner of the 7 × 7 square, 1 + 9 = 10 and 8 + 2 = 10. In **Figure 10**, the 3 × 3 square with vertices 17,19,31, and 33 have diagonal numbers with the same sum 17 + 33 = 50 and 19 + 31 = 50.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Figure 6. The Tool and connection 10 × 10 Square.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	45	46	47	48	49

Figure 7. Sum of corner diagonal numbers are the same.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	45	46	47	48	49

Figure 8. Sum of diagonals are the same.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	45	46	47	48	49

Figure 9. Sum of diagonal numbers are the same.

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	45	46	47	48	49

Figure 10. Sum of diagonal numbers are the same.

4. Square Tool Tutorial

The Square Tool serves two major mathematical concepts: **addition and grouping**.

1) Pick the size of your square from the pull-down menu and then click on **Create Grid** Button.

2) Highlight the numbers (it will change to a red background) that you want to add. The sum of those numbers will be found in the **Sum of Selected Cells** display.
3) If you want to remove just one cell, click on it again and it will be deselected.
4) If you want all the cells cleared, select the **Reset** button.

The size is 6 × 6 grid and click on **Create Grid** Button.

Click on 4, 14, and 29. They will be highlighted with a red background. In the **Sum of Selected Cells** display, sum of the three highlighted numbers is 47 (**Example 1**).

a) The size is 6 × 6 grid and click on **Create Grid** Button.
b) Click on the numbers down a major diagonal from 6 to 31. They will be highlighted with a red background. In the **Sum of Selected Cells** display, sum of the highlighted cells is 111. If you **Reset** the Grid and select the major diagonal from 1 to 36, the sum will again be 111 (**Example 2**).

The sums of the diagonals of a square are equal. 1 + 36 = 6 + 31

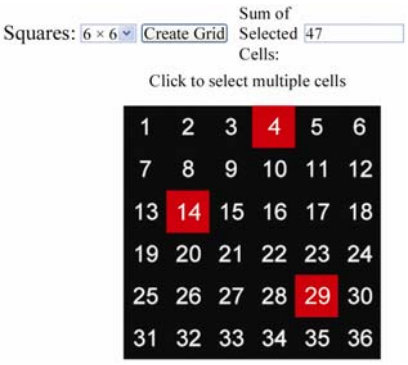
Grouping is helpful with multiplication and division.

1) Pick the size of your square from the pull-down menu and then click on **Create Grid** Button.
2) Highlight the number under consideration.
3) Use the visual aspects of this number in relationship to rows and columns to help with multiplication and division problems (**Example 3**).

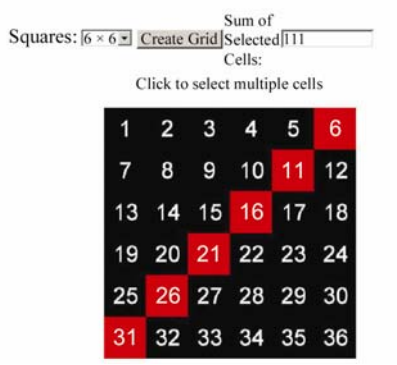
Other Examples

a) The size is 6 × 6 grid and click on **Create Grid** Button.
b) If the number 18 is selected, 18 equals 3*6 because it is found on the 3rd row of 6 numbers.

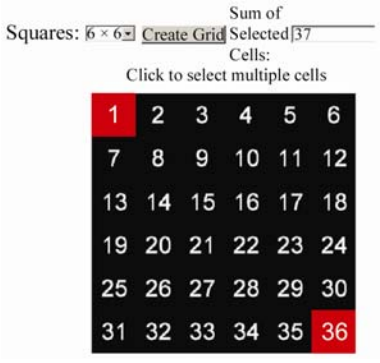
If the number 26 is selected, 26 ÷ 6 = 4 remainder 2 (4 completed rows and 2 additional numbers in the fifth row) (**Example 4**).

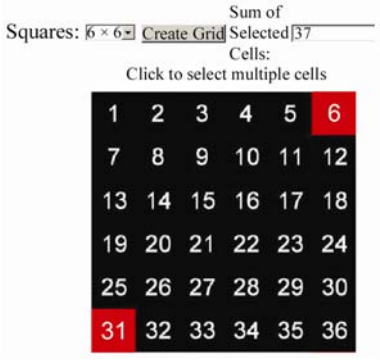


Example 1. In the Sum of Selected Cells display, sum of the three highlighted numbers is 47.



Example 2. In the Sum of Selected Cells display, sum of the highlighted cells is 111.





Example 3. The sums of the diagonals of a square are equal. 1 + 36 = 6 + 31.

Example 4. If the number 18 is selected, 18 equals 3*6 because it is found on the 3rd row of 6 numbers.

5. Summary

As an interactive program, the Square Tool puts the learner in charge of his / her own exploration of number patterns at all mathematics grade levels. Number theory, the study of properties of integers, is taught at the college level but its foundation is developed in the middle grades. To provide this foundation, math teachers can use the Square Tool to investigate numeric relationships ranging from simple operations to primes and multiples and beyond. The Square Tool's main goal is to connect the concrete number ideas using Color Tiles and other manipulatives to students' abstract understanding of number theory, thus serving as a bridge or semi-concrete representation of these mathematical ideas in an interactive fashion. The Square Tool can serve as a semi- concrete bridge connecting the concrete to the abstract for students.

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Creative Education, 2010, 2, 128-129
doi:10.4236/ce.2010.12019 Published Online September 2010 (http://www.SciRP.org/journal/ce)

How Do We Introduce the Arrhenius Pre-Exponential Factor (A) to Graduate Students?

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Received May 21st, 2010; July 2nd, 2010; July 19th, 2010.

ABSTRACT

A simple and easy understanding of Arrhenius pre-exponential factor (*A*) *is described in this article for a graduate class-room lecture.*

Keywords: *Arrhenius factor*, *pre-exponential factor*, *frequency factor*, *collision number*, *collision frequency*

1. Introduction

In chemical kinetics, the pre-exponential factor or A factor is the pre-exponential constant in the Arrhenius equation, an empirical relationship between temperature and rate coefficient. It is usually designated by A when determined from experiment, while Z is usually left for collision frequency. For a first order reaction it has units of s^{-1}, for that reason it is often called frequency factor.

In short, the Arrhenius equation gives "the dependence of the rate constant *k* of chemical reactions on the temperature T (in Kelvin) and activation energy Ea", as shown below:

$$k = Ae^{-Ea / RT}$$

where A is the pre-exponential factor or simply the *pre-factor* and R is the gas constant. The units of the pre-exponential factor are identical to those of the rate constant and will vary depending on the order of the reaction. If the reaction is first order it has the units s^{-1}, and for that reason it is often called the *frequency factor* or *attempt frequency* of the reaction. When the activation energy is given in molecular units, instead of molar units, *e.g.* joules per molecule instead of joules per mole, the Boltzmann constant is used instead of the gas constant. It can be seen that either increasing the temperature or decreasing the activation energy (for example through the use of catalysts) will result in an increase in rate of reaction.

Given the small temperature range in which kinetic studies are carried, it is reasonable to approximate the activation energy as being independent of the temperature. Similarly, under a wide range of practical conditions, the weak temperature dependence of the pre-exponential factor is negligible compared to the temperature dependence of the factor; except in the case of "barrier less" or diffusion-limited reactions, in which case the pre-exponential factor is dominant and is directly observable.

2. The Interpretation of Pre-Exponential Factor in the Arrhenius Equation:

So far we have talked if not exhaustively but enough about the pre-exponential factor for a M. Sc. Class-room. So what is really the pre-exponential factor in the Arrhenius equation? Did anybody think of its value with change in temperature? Or did anybody guess its value at infinite temperature? It can be said as "It is nothing but *k* at infinite temperature or it is *k* of a reaction with zero activation energy (barrier less)". So in either way *k* will be very large, more so it is a rate constant close to diffusion limit (5×10^9 M^{-1} sec^{-1}). This can be seen as in the following by simple mathematics. On right hand side of the Arrhenius equation E_a and T are the only variables whereas A and R are constants. *k* will be equal to A when the exponential factor becomes equal to one.

Therefore $\exp(-E_a / RT) = 1$, which leads to

$$-E_a / RT = 0$$

Hence T should become infinite. Or the other possibility is E_a should be zero or the reaction should be "*barrier less"*.

3. Evaluation of A:

In the first case: To get A it is necessary to evaluate *k* experimentally, in which it is not possible to determine

such a large rate constant at infinite temperature because one cannot maintain or achieve infinite temperature. Instead one can determine the k at different temperatures and get A from the antilogarithm of the intercept of the Arrhenius plot (plot of ln k or log k versus 1 / T).

In the second case: One can use fast reaction kinetic techniques like stopped flow methods, T-jump or P-jump methods, laser flash photolysis, and pulse radiolysis.

In the third case: Proceed to evaluate by calculation [1] assuming the atoms or molecules as Hard-Spheres as pointed out by Max Trautz – 1916 [2] and W. C. McC. Lewis – 1918 [3]. The formulation given by these people was purely based on simple version of the kinetic theory of gases in which the molecules were treated as hard spheres.

The final equation obtained was

$$Z_{AA} = 2d^2 N_A^2 \left(\frac{\pi k_B T}{m} \right)^{\frac{1}{2}}$$

and if the gas contains two types of molecules say A and B and where 'μ' is reduced mass, the equation obtained was

$$Z_{AB} = N_A N_B d^2 \left(\frac{8\pi k_B T}{\mu} \right)^{\frac{1}{2}}$$

Lewis [3] applied this equation to the decomposition of HI.

$$2HI \rightarrow H_2 + I_2$$

He obtained a value of 5.5 X 10^{10} mole^{-1} sec^{-1} for 'A' both by experiment and by calculation. This clearly shows that the theory put forward by Trautz and Lewis assuming the molecules as hard spheres and neglecting the slight variation of 'A' with temperature in good agreement with each other.

In **Table 1**, log A values are given for some gas phase reactions [4]. It is clear that the calculated values are all close to 14 which may be due to the fact that the over simplification of the assumption that the molecules were assumed to be hard-spheres and to have the same molecular diameter. The observed values were smaller than those of the calculated ones. The reason is that the steric factors, which are the ratios of the observed values to those calculated ones, vary from 10^{-1} to 10^{-3}. The low steric factors are attributed to the losses of rotational freedom during the formation of the activated complex.

Table 1. Some gas phase reactions and their observed and calculated logarithmic values of Arrhenius frequency factors (A).

Reaction	Log A, mole-1 sec-1	
	Observed	Calculated by simple collision theory
NO + O3 → NO2 + O2	11.9	13.7
NO2 + F2 → NO2F + F	12.2	13.8
NO2 + CO → NO + CO2	13.1	13.6
2ClO → Cl2 + O2	10.8	13.4
2NOCl → 2NO + Cl2	13.0	13.8
NO + Cl2 → NOCl + Cl	12.6	14.0

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Creative Education, 2010, 2, 130-133
doi:10.4236/ce.2010.12020 Published Online September 2010 (http://www.SciRP.org/journal/ce)

Scientific Research

Determination of the pKa Value of Phenolphthalein by Means of Absorbance Measurements

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Received July 23rd, 2010; August 11th, 2010; August 27th, 2010.

ABSTRACT

We here report a laboratory protocol for the determination of the pKa value of an acid by means of determinations obtained with a spectrophotometer. Students determine the acidity constant (*Ka*) *and the pKa associated with phenolphthalein from the absorbance values obtained from phenolphthalein solutions at different pHs. The present protocol for the determination of the pKa takes a very short time and is useful when teaching in conditions with limited equipment.*

Keywords: *Medical Science teaching*

1. Introduction

Knowing the acidity constant value (Ka) [1] of an acid and its associated pKa value is important for a medical student for different reasons.

One of these reasons is that the pKa of a drug allows obtaining its values of absorption, bioreactivity and tissular accumulation as a function of the pH of the medium [2].

Another reason is that the pKa values of the amino acids of a polypeptide chain are related to the function and structure of the protein [3]. In addition, the pKa values of different chemical species account for their tubular reabsorption if they are eliminated through the urine [4]. They also allow the understanding and management of the internal medium of a living system [4,5], which can be useful in the diagnosis or treatment of diseases.

Despite the importance of Ka and pKa, many students of Biology or Health Sciences learn about them only through lectures or exercises.

Previous studies [6] have shown that students are usually not able to identify examples or topics that arouse their interest. They have a poor qualitative management of the aspects of chemical balance, probably because today's teaching insists on an operational view of the concept [6]. Many students are not able to infer that the constant depends on the temperature and most of them believe that the constant depend on the concentration of the substances [6,7].

We believe that if the student could empirically determine the Ka value and thus the pKa of a substance, he / she could better understand the basis of the acid-base equilibrium and thus have a more open-minded criterion about its application in practical situations.

The pKa of a certain chemical species can be empirically determined using the potentiometric technique by measuring the pH value in a titration until it remains constant [8,9]. However, both the titration and measurement of the pH are difficult because they take a relatively long time, and courses in our University have too many students and the equipment is usually not enough for all the students.

For this reason, we have designed a practical way to determine the pKa, which requires only the use of a spectrophotometer or photocolorimeter. The main advantages of this technique are that it is sensitive, takes a short time, and the equipments are both inexpensive and user-friendly.

While there have been several experimental articles published in education papers applying spectroscopy to determine the pKa of acid-base indicators [10,11], the present article addresses the question of how to give stu-

dents laboratory experience with limited equipment and space.

In the protocol here presented, the student can determine the acidity constant (Ka) of phenolphthalein and its associated pKa from absorbance values obtained from solutions of this substance.

2. Theoretical Basis

The student must first know that the acid-base indicators present different colors according to the pH of the medium. In the case of phenolphthalein, which is a weak acid, its non-disassociated form has no color, whereas its ionized form, or conjugate base, absorbs light at a wavelength of 550 nm.

The theoretical foundation (1) is based on the definition of the acidity constant:

$$Ka = [H^+] \, x \, [A^-] \, / \, [HA] \quad (1)$$

where $[HA]$ represents the concentration of the non-disassociated acid, $[A^-]$ the concentration of its conjugated base, and $[H^+]$ the concentration of protons.

In a strongly basic medium, most of the HA is as an A^- anion because the concentration of non-disassociated acid is much lower:

$$[HA] \, total = [A^-]^{\boldsymbol{b}} \quad (2)$$

The supra-index "***b***" accounts for the alkalinity of the medium.

In conditions in which the non-disassociated acid concentration is not negligible, the acid ([HA] total) will be present in both its dissociated and non-disassociated forms.

Taking Equation (2) into account, we can state that:

$$[A^-]^{\boldsymbol{b}} = [HA] + [A^-] \quad (3)$$

By Lambert-Beer Law, the Absorbance (Abs) of a solution is related to the concentration as follows:

$$Abs = \alpha \, x \, b \, x \, [A^-] \quad (4)$$

where

α = coefficient of molar absorption,

b = the distance traveled by the light beam.

Taking Equation (3) into consideration:

$$[A\text{-}]^{\boldsymbol{b}} - [A^-] = [HA] \quad (5)$$

And then, by replacing (5) in (1), we obtain:

$$Ka = [H^+] \, x \, [A^-] \, / \, [A^-]^{\boldsymbol{b}} - [A^-]$$

Considering Equation (4)

$$Ka = [H^+] \, x \, (Abs \, / \, \alpha \, x \, b) \, / \, (Abs^{\boldsymbol{b}} \, / \, \alpha \, x \, b - Abs \, / \, \alpha \, x \, b) \quad (6)$$

Then, by removing the common factor $\alpha \, x \, b$ and simplifying the equation, we obtain:

$$Ka = [H^+] \, x \, Abs \, / \, (Abs^{\boldsymbol{b}} - Abs) \quad (7)$$

Clearing $[H^+]$, we have:

$$[H^+] = Ka \, x \, (Abs^{\boldsymbol{b}} \, / \, Abs - 1) \quad (8)$$

Finally, by removing the parenthesis:

$$[H^+] = Ka \, x \, Abs^{\boldsymbol{b}} \, / \, Abs - Ka \quad (9)$$

This equation is similar to that of a straight line of the following form:

$$y = a + b \, x$$

where:

$$y = [H^+]$$
$$b = Ka \, x \, Abs^{\boldsymbol{b}}$$
$$x = 1 \, / \, Abs$$
$$a = Ka$$

3. Development

The assays to carry out this protocol require 2 h at the laboratory.

Before performing the dilutions or the absorbance reading, the laboratory instructor should explain the basis of the determination.

Instructor's activity: the laboratory instructor should prepare six solutions of Na_2HPO_4 (Mr = 142) 100 mM with different values of pH. The solutions must be prepared from this mother solution and then add PO_4^{-3} NaOH or HCl, as indicated in **Table 1**.

Each student then receives 10 ml of the solutions 1 to 6.

In addition, the instructor should prepare a phenolphthalein solution 1% in ethanol and dilutes a 200-µl aliquot in 10 ml water. Each student receives 6 ml of this dilution.

Student's activity: each student or group of students mixes 10 ml of each phosphate solution with 1 ml of the diluted phenolphthalein solution. These six new solutions must be denominated as A, B, C, D, E and F. The absorbance of the solutions is read at 550 nm in a spectrophotometer or photocolorimeter. The student will then record the values obtained and the pH value for each solution in a table.

Table 1. Solutions with different pH that the laboratory instructor should prepare.

Solution	Volume of NaOH 1 M every 10 ml of phosphate (µl)	Volume of HC (c) every 10 ml of phosphate (µl)	pH value obtained
1	40	---	9.36
2	10	---	9.23
3	---	---	9.15
4	---	10	8.87
5	---	20	8.73
6	---	30	8.56

4. Results

After measuring the absorbance of the A, B, C, D, E and F solutions, the values of "y" and "x" should also be recorded and calculated. The values of a representative assay we carried out are presented in **Table 2**. **Figure 1** shows a graphic representation of the values of **Table 2**.

After that, "a" (the point at which the line crosses the y axis) is calculated in the two following possible ways:

a) graphically, by drawing the straight line manually in a millimeter paper and making the line as close as possible to all the points. With this procedure, the Ka showed values of 2.75 $^{-10}$ and 3.25 $^{-10}$, which represented values of 9.6 and 9.5 respectively.

b) by adjusting the data with the program Origin® (version 6.0). This procedure yielded a Ka = 4.657 $^{-10}$ (± 1.132 $^{-10}$), which corresponds to a pKa value of 9.3 ± 0.1. It must be pointed out that the pKa accepted for phenolphtalein at 25˚C is 9, 7 [12].

Table 2. Absorbance (Abs) values of the indicator solutions at different pHs.

Representative assay.			
Solution	y = [H$^+$]	Abs	x = 1 / Abs
A	4.36 10 $^{-10}$	0.411	2.433
B	5.89 10 $^{-10}$	0.306	3.268
C	7.08 10 $^{-10}$	0.270	3.704
D	1.35 10 $^{-9}$	0.109	9.174
E	1.86 10 $^{-9}$	0.041	24.390
F	2.75 10 $^{-9}$	0.026	38.462

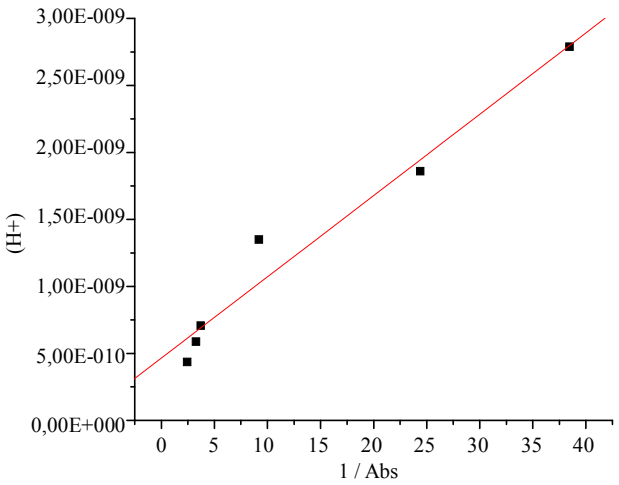

Figure 1. Graphic representation of the absorbance values of the indicator solutions at different pHs. The ordinate indicates the [H$^+$] from which the pKa is calculated according to Equation (9).

5. Conclusions

This protocol allows students to determine the pKa value of phenolphthalein in a short time and without using the potentiometric method. It thus has the advantage that, in a laboratory where a spectrophotometer or photocolorimeter are available, a large number of students can carry out the determination at the same time. As we mentioned in Introduction there are many good procedures but may not be useful for large classes with limited equipment.

This makes it easier to develop the activity, especially because the use of a potentiometric method requires numerous pH-meters, takes a long time and depends on the ability of the students. In addition, the laboratory instructor is able to show the application of the Lambert-Beer Law for acid-base indicators in which the forms have different coloration according to the pH of the medium.

This strategy for the determination of the pKa can also be used to discuss the case of other chemical species in which the non-ionized form has color [13]. In such case, the contribution of the color of the other form of the weak acid should be subtracted from the absorbance measured in **Table 2**.

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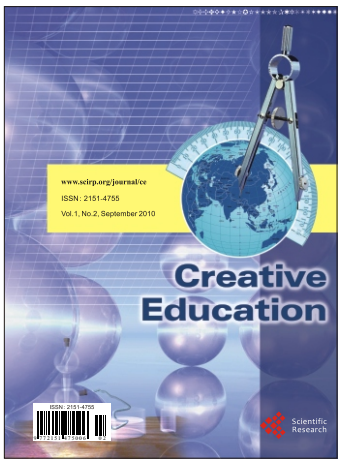

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ISSN Print: 2151-4755 ISSN Online: 2151-4771

http://www.scirp.org/journal/ce

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Creative Education, **2010, 1, 69-133**
Published Online September 2010 in SciRes (http://www.scirp.org/journal/ce)

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