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Araştırma Makalesi ● Research Article

The Mathematics Emporium Model and Psychosocial Factors of Learning in College Algebra*

Matematik Emporium Modeli ve Üniversite Düzeyi Cebir Derslerinde Öğrenmenin Psikososyal Faktörleri

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ÖZ

Bu makalede geleneksel ve matematik Emporium ile yeniden-tasarlanmış üniversite düzeyi cebir derslerinde öğrenmenin psikososyal faktörlerindeki değişimler incelenmiştir. Deney-kontrol grubu öntest-sontest yarı deneysel modeli kullanılan nicel çalışmanın örneklemi 224 öğrenciden oluşmaktadır. Araştırma sonuçları her iki öğretim modelinde de öğrencilerin teknoloji-destekli matematik derslerine karşı tutumlarında, matematikte başarılı olabilmelerine ilişkin inançlarında ve matematiğe karşı genel tutumlarında anlamlı bir değişim olduğunu ortaya koymuştur. Araştırma öğrencilerin matematiğe karşı tutumlarının, matematik öğrenmek için dış motivasyonlarının, matematik derslerindeki öğrenme yaşantılarından kaynaklanan memnuniyetin dönem boyunca sadece yeniden tasarlanan derslerde anlamlı şekilde değiştiğini ortaya çıkarmıştır. Geleneksel yöntemle öğretilen ve yeniden tasarlanmış (Emporium) şekilde öğretilen matematik dersleri karşılaştırıldığında ise her iki eğitim ortamında sadece öğrencilerin matematiğe karşı tutumlarının ve teknoloji destekli matematik eğitimine karşı tutumlarının anlamlı şekilde farklı olduğu belirlenmiştir.

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ABSTRACT

In this manuscript, changes in psychosocial factors of learning were examined in two forms of college algebra: traditionally-taught and redesigned using Math Emporium model. Sample of this quasi experimental quantitative study in which experiment-control group pretest-posttest design is used consists of 224 students. Results of the study revealed that attitudes toward technology-supported mathematics, beliefs about being able to do mathematics, and overall attitudes toward mathematics changed significantly in both educational settings. Attitudes toward mathematics, extrinsic motivation to learn mathematics, and satisfaction from mathematics learning experiences, from technology-supported mathematics, and from mathematics instruction changed significantly in redesigned sessions throughout the semester. Attitudes toward mathematics and attitudes toward technology-supported mathematics were significantly different when traditionally-taught and the redesigned college algebra sessions compared.

1. Introduction

College algebra has been placed at the center of the reform movement in undergraduate mathematics for more than a decade. Small (2006) calls for an urgent transformation for college algebra and similar gateway courses which are not functioning properly. Nationwide, the success rate in college algebra courses is around 40% (Burn, 2012; Haver et al., 2007; Small, 2006; Thompson & McCann, 2010). According to Aichele, Francisco, Utley, and Wescoatt (2011) "…less-than-desirable student success rates; high student drop rates; variability among sections and semesters with respect to grade assigned and content expectations; and controlling cost of course delivery" (p. 13) are some of the underlying problems that need to be resolved in college level introductory mathematics courses for better student learning

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outcomes. Specifically, high failure and withdrawal rates can be triggered by various causal factors in college algebra. For example, Gordon (2008) summarized that not being able to keep up with changing learner demographics, dramatic improvements of instructional technology in mathematics education, and changing needs and expectations of learners are the main reasons for failure in college algebra courses.

Course redesign efforts have shown a continuous and positive impact on college algebra and on similar introductory level mathematics courses which suffered from the aforementioned problems for nearly two decades (see Twigg & NCPPHE, 2005). The NCAT established in 1999 with a support from Pew Charitable Trusts, provides six different course redesign models that share the same goals: improving academic achievement and reducing the cost of instruction (NCAT, 2015; Twigg, 2003). Institutional reports indicate that, among those, the Emporium model yields the best student learning outcomes, and cost savings in the introductory level mathematics courses that include college algebra. Cost saving is not in the scope of this paper; how the Emporium model affects psychosocial factors of learning is the primary concern.

The research institution being studied had two main goals to achieve at the end of the college algebra (Math 110) course redesign: to increase retention by lowering the DFW rate which was approximately 30% over the previous two semesters, and to reduce the cost of instruction (Missouri Statewide Course Redesign Initiative (MSCRI), 2011). The Emporium college algebra was piloted at the research institution in the Spring 2012 semester, and fully-implemented in the Fall 2012 semester after revisions were made based on the lessons learned from the pilot implementation. College algebra traditionally was a three-credit course taught as three 50-minute lectures by graduate teaching assistants (GTAs) or adjunct instructors in a traditional/lecture-based format (MSCRI). This instructional design is fairly typical for college level introductory mathematics courses, and full time faculty involvement is generally limited. For example, selecting textbooks and creating common final exams were two tasks that full-time faculty actively participated in for college algebra instruction at the research institution (MSCRI).

The math Emporium is a theoretical model that proposes radical changes in course design and instructional practices. The Emporium changes the roles of educators, involves instructors who have new responsibilities, and increases the involvement of at least one full-time faculty member in instructional design and the teaching process. Based on the Emporium model, the research institution replaced all 50-minute lectures with two 75-minute interactive learning lab (ILL) sessions and one 50-minute lecture (MSCRI, 2011). The 50-minute class meetings in which key concepts and future tasks were reviewed were taught by a faculty member who was the primary coordinator/instructor of the course (MSCRI). In the ILL sessions, students worked collaboratively through an online classroom management system under the supervision of GTAs or adjunct instructors and undergraduate teaching assistants (UTAs) who provided on-demand help and immediate feedback (MSCRI). Such interactive learning environment supported by extensive instructional and learning technology has shown to provide flexibility and convenience that allows students to learn mathematics by doing.

Instructional and learning technology (ILT) integration is an essential part of the Emporium model. However, attributing better academic achievement solely on ILT integration could possibly be misleading. More attention should be paid to the affective variables of learning such as attitudes toward subject matter, motivation to learn, and satisfaction from the instructional design and practices that directly or indirectly influence academic achievement and retention in this educational context. Not only cognitive variables, but also affective factors influence academic achievement (Tocci & Engelhard, 1991, as cited in Papanastasiou, 2000). The psychosocial factors of learning are most likely to be affected by the course redesign efforts which offer flexibility and convenience, and support interaction and collaboration in college algebra. Thus, the main purpose of this research paper is to investigate whether instructional practices in course redesign and in traditional (lecture-dominated) college algebra influence the psychosocial factors of learning. The following research questions were investigated: (a) Do attitudes toward mathematics, motivation to learn mathematics, and satisfaction from the mathematics learning experiences change significantly during redesigned and traditional college algebra sessions? (b) Is there a statistically significant difference between the psychosocial factors of learning in both forms of college algebra after controlling for pre-existing scores? The following two hypotheses were tested through paired samples t-tests, and multiple regression.

H_{0A}: There is no statistically significant change in students' attitudes toward mathematics, motivation to learn mathematics, and satisfaction from the instructional practices in traditionally-taught college algebra sessions, and in redesigned college algebra sessions.

H_{0B}: There is no statistically significant difference between traditionally-taught and redesigned college algebra sessions regarding students' attitudes toward mathematics, motivation to learn mathematics, and satisfaction from the instructional design after controlling for pre-determined scores.

Why do college level mathematics courses suffer from high failure and withdrawal rates? Perhaps, the question that needs to be asked should be whether the students in these courses want to learn or not. The problem in mathematics education is not that students cannot learn mathematics, it is that they do not want to learn (Csikszentmihalyi & Wong, 2014). Although numerous reasons can be listed by one who does not want to learn mathematics, the majority are affective factors that can be grouped under four general categories: attitudinal approaches; beliefs in learning mathematics; motivational support; and satisfaction from previous mathematics learning experiences. Papanastasiou (2000) summarized that there is a positive relationship between students' attitudes toward mathematics and academic achievement in mathematics, and this relationship is dual-sided which means students who perform better in mathematics tend to have positive attitudes toward mathematics. In a comparative study, Papanastasiou concluded that teaching and reinforcement are two factors having the strongest direct impact on attitudes toward mathematics. The Emporium model supports both of these factors through a student-centered teaching approach and on-demand help with immediate feedback. In an experimental study Wilder and Berry (2016) examined academic achievement and retention of algebra, and they concluded that students enrolled in redesigned college algebra courses yield significantly higher retention of the content knowledge. Likewise, Cousins-Cooper, Staley, Kim, and Luke (2017) found that the emporium has students to be actively involve in learning process and as a result the Emporium model has potential to improve academic achievement in college algebra and trigonometry courses.

House and Telese (2008) examined the Trends in International Mathematics and Science (TIMMS) 2003 results in Japan and in the United States, and concluded that students who indicated positive beliefs in their mathematics ability tended to perform better in mathematics. According to House and Telese, algebra achievement is significantly related to students' mathematics beliefs and classroom instructional practices. Middleton and Spanias (1999) stated that the most important finding across theoretical orientations was that "achievement motivation in mathematics, though stable, can be affected through careful instructional design" (p. 82). Biner, Barone, Welsh, and Dean (1997) reported that overall student satisfaction, learning satisfaction with interaction with instructors, and satisfaction from the technology integration in instructional design were highly associated with academic achievement. In sum, affective factors of learning are influenced by instructional design and teaching practices in various instructional settings that include traditional and online teaching practices at different grade levels, and college algebra is not an exception. Webel, Krupa, and McManus (2015) examined Math Emporium model and concluded that novel technologies have potential to create opportunities for better teaching mathematics, but what is known about teaching and learning should support these endeavors.

Students' attitudes which are not inherited, but learned, can change during the course of the semester (Sundre, Barry, Gynnild, & Ostgard, 2012) because attitudes toward a specific subject matter can be affected by malleable factors such as heavy use of technology, instructional design and teaching practices. Despite Sundre et al., McLeod (1992) emphasizes the stability of beliefs and attitudes in mathematics education, saying beliefs are cognitive in nature, and need a long period of time to develop. Therefore, four months might not be enough to observe significant changes in the affective domain of learners in mathematics education. In mathematics education, students' attitudes and beliefs about learning mathematics is considered as an important factor for their academic achievement (Ernest, 1991 as cited in Parsons, 2004). Pierce, Stacey, and Barkatsas (2007) emphasize that "[a]ttitudes can be affected by recent experience, a series of experiences promoting positive or negative attitude can indeed contribute to the development of more persistent attitudes and even beliefs which are deeply held and strongly influence future behaviour" (p. 286). Haladyna, Shaughnessy, and Shaughnessy (1983) summarized that overall quality of the teaching practices and social-psychological context of the classroom impact learners' attitudes toward mathematics. As an important part of instructional practices in today's classrooms, technology integration and dramatic changes in course structure also have potential to impact learners' attitudes about subject matter at all grade levels. In mathematics education, for example, as instructional practices become more relevant, meaningful, and satisfactory, attitudes toward mathematics change positively, and learners' motivation to learn increases through integration of technology such as computers and calculators (Rochowicz, 1996).

Motivation, which correlates with various learning outcomes such as curiosity, persistence, learning, and performance, is one of the most important psychological concepts in educational contexts (Vallerand, Pelletier, Blais, Briere, Senecal, & Vallieres, 1992). Motivations are defined as reasons that gives energy and direction to behaviors in a given manner and in a given context (Middleton & Spanias, 1999; Waugh, 2002). Middleton and Spanias (1999) reported that "motivations toward mathematics are developed early, are highly stable over time, and are influenced greatly by teacher actions and attitudes" (p. 80). However, Cardetti and McKenna (2011) stated that "it is natural to assume that some of the same motivations carry over from high school to the university setting" (p. 353). In educational contexts, motivational resources are grouped under two general categories: extrinsic and intrinsic. According to Knowles and Kerkman (2007), recognition and rewards are two general criteria for extrinsically motivated learners, whereas intrinsic motivation can be defined as an internal desire to learn a specific concept. Rugutt and Chemosit (2009) examined determinants of motivation to learn at the college level, and concluded that critical thinking skills, student-student and student-faculty interactions are statistically significant predictors of student motivation. Heafner (2004) examined the impact of technology use on learners' motivation to learn in social studies, and concluded that technology integration modifies the nature of given tasks, increases self-efficacy, self-confidence and self-worth; empowers student engagement; and improves students interest and enjoyment. Motivation is not only a dependent variable that is affected by various educational decisions and practices, but also an independent variable that can possibly impact student learning outcomes. For example, Klein, Noe, and Wang (2006) concluded that course outcomes that include learner satisfaction and academic achievement are affected by students' motivation to learn.

Learner satisfaction is one of the main concerns especially in distance education and online learning settings. Although there are various predictors of learner satisfaction in an educational setting regardless of delivery mode, in a mixed-method study with a sample size of 19, Gunawardena, Linder-VanBerschot, LaPointe, and Rao (2010) analyzed online self-efficacy, course design, learner-learner interaction and learner-instructor interaction as predictors of learner satisfaction in online courses. They concluded that these four variables explained 88% of the variance in learner satisfaction, and as a result of qualitative analysis, reported teaching practices, effective course design and delivery, the instructor, organizational support, socio-cultural components, and learning medium were other predictors of learning satisfaction. Comparative studies of learner satisfaction in face-to-face and in online learning yield inconsistent results. For example, Roach and Lemasters (2006) compared learner satisfaction in online learning and in traditional face-to face courses, and reported that students who enrolled in online courses were more satisfied than their peers who took the courses face-to-face. In a meta-analysis, Allen, Bourhis, Burrell, and Marby (2002) compared student satisfaction in distance education and in traditional settings. According to Allen et al., students enrolled in traditional lecture-based courses reported slightly higher level of satisfaction than their peers who enrolled in distance education sessions. In a comparative study, Kearns, Shoaf, and Summey (2004) reported that students enrolled in courses that were taught online were less satisfied than students who enrolled in web-based course, but performed better than their peers who took the courses face-to-face. As a result of comparing student satisfaction, learning effectiveness, and faculty satisfaction in face-to-face, blended and online modes of instruction, Larson and Sung (2009) reported that online and blended modes of instruction are preferred to face-to-face instruction. The Emporium model makes heavy use of information and learning technologies in its course redesign for convenience, flexibility, peer interaction, learner-faculty interaction, and better course design. All those elements of the Emporium model show similarities with the web-based learning practices described above. Thus, it is natural to expect that similar factors will impact student satisfaction when the instructional dynamics of the Emporium model are considered. However, Webel, Krupa, and McManus (2017) reported that students enrolled in redesigned settings reported mixed feelings because of autonomy that the emporium offers.

Attitudes toward mathematics, and motivation to learn mathematics have been studied in K-12 mathematics education, whereas research on satisfaction from the instructional design has been widely conducted in online and distance learning environments. The research on psychosocial factors of learning at the college level is limited, specifically in mathematics classrooms. Only a few institutions that redesigned introductory level courses paid attention to psychosocial factors of learning; these were typically not college level mathematics courses. The University of Massachusetts –Amherst, for example, redesigned the introductory biology courses in the fall 2000 semester, and examined student attitudes toward science. Although positive changes in attitude scores were noted, such a small change was attributed to the timing of the survey deployment and composition of the population (NCAT, 2015a). Likewise, improved attitudes toward subject matter was reported in Developmental English at Glendale Community College, in Physics at North Carolina State University, and in introductory engineering courses at University of Texas. The Tallahassee Community College (NCAT, 2015b) examined learner and instructor motivation in a redesigned College Composition course, and reported that all groups gain motivation to some degree by noting that many students dropped out before completing the post-tests. The North Carolina State University also reported widespread student satisfaction in introductory physics courses (NCAT, 2015c). The University of Central Florida (NCAT, 2015d) reported increased learner satisfaction especially when student-student interaction was facilitated in a redesigned American National Governments course. The University of Alabama (NCAT, 2015e) reported that learner satisfaction in redesigned intermediate algebra courses in 2001-2002 were the highest of the past four years. However, as a result of a follow-up study on the Math Emporium, Webel, Krupa and McManus (2017) reported that students who have high academic achievement in math and who enjoy mathematics take more advantage from the emporium model.

The affective domain, and psychosocial factors of learning have significant importance in learning mathematics at all grade levels. Although extensive research is available in K-12 mathematics education and online education literature, research on psychosocial factors of learning in redesigned college-level introductory mathematics courses is almost non-existent. Accessible research results are limited to course redesign reports submitted by participating institutions, and the results cannot necessarily be generalized to the redesigned mathematics education context. This research paper purposes to fill this gap.

2. Method

Under this section, research design, data collection process and procedures, sampling methodology, instrumentation, data collection procedure and data analysis process have been discussed in detail.

2.1. Research Design

This quasi-experimental research study uses nonrandomized control group pretest/posttest, design that aims to analyze the impact of the Math Emporium Model on psyhosocial factors of learning. Levy and Ellis (2011) defines quasi-experimental research as “the quasi-experiment, also known as ‘field-experiment’ or ‘in-situ experiment’, is a type of experimental design in which the researcher has limited leverage and control over the selection of study participants” (p.155). This research study used a control and treatment groups, which were not randomized, but were consisted of participants who self-selected in which group they enrolled in, so researcher did not have any control over the selection of assignment of participants. Treatment groups consisted of students who were enrolled in redesigned college algebra courses whereas control group consisted of students who were enrolled in traditionally-taught college algebra sessions in a Midwest higher education institution. Pretest and posttest were administered to both treatment and control group at the beginning and at the end of the semester to observe changes in psychological factors of learning. The factors examined were attitudes towards learning mathematics, motivation to learn mathematics and learner satisfactisfaction in redesigned and traditionally taught college algebra courses. According to Leedy and Ormrod (2010), quasi-experimental design provide useful information for improving research. In this regard, noteworthy conclusions which make significant contributions to mathematics education literature were drawn as a result of this quasi-experimenal research study.

2.2. Sampling

Convenience sampling was used, and college level students who were older than 18 years of age, and enrolled in traditional or redesigned college algebra sessions at a Midwestern research university were invited to voluntarily participate in this study. Total number of participants was 687, but the sample size reduced to 229 because of incomplete data, and students who completed the pretest, but not the posttest or vice versa. Briefly, 28 participants were excluded because of incomplete pretests, whereas 272 were excluded because of incomplete posttests. This was not unexpected because dropout rates are often high in college algebra classes. In total, fifty-nine participants were excluded because of respondent control items which were embedded into the survey to check how much attention was paid to the survey items. Ninety-nine cases were excluded because of missing data. Students who enrolled in the college algebra course, completed the questionnaire, but withdrew from the course, and subsequently reenrolled in the course in upcoming semesters were excluded from the study, so only participants who completed both pretest and posttest questionnaire were retained. Respectively, 117 and 112 participants were recruited from traditional college algebra sessions and from redesigned college algebra sessions. As a compensation, 5 points were added to all participants' final exam scores, and students who are not eligible to participate were given a mathematics worksheet, and received 5 extra points upon completion. Student demographics such as age, gender, race etc. were not sought, but intended majors of participants were requested. Fifty-eight different fields were reported ranging from architecture to music education. This, too, was also expected since college algebra is a required course for almost all disciplines, and such requirements inflate enrollment rates in college algebra.

2.3. Data Collection Tools

The psychosocial factors of learning in redesigned introductory mathematics (PFL-RIM) survey developed by the researcher, was used to collect data on students' attitudes toward mathematics, motivation to learn mathematics, and satisfaction from the instructional practices and design. Explanatory and internal replicability factor analyses on the instrument suggested that the PFL-RIM scale is a reliable and valid data collection tool (Demiroz, 2016). The overall reliability coefficient of the 38-item PFL-RIM scale was .84 (Demiroz, 2016). The Cronbach's Alpha reliability coefficient was .87 for the current dataset. The instrument includes one descriptive item, two random response control items, and 35 likert items. The scale consists of three subscales: attitudes toward mathematics (α=.82), motivation to learn mathematics (α = .65) and satisfaction from the instructional design and practices (α=.80). Attitudes toward mathematics, measured through 17 items, consists of three factors: attitudes toward mathematics, attitudes toward technology-supported mathematics, and learner beliefs in learning mathematics; Motivation to learn mathematics, measured through six items, consists of two factors: extrinsic and intrinsic motivation; Satisfaction from the instructional design and practices, measured with 12 items, consists of three factors which are satisfaction from mathematics instruction, satisfaction from technology-supported mathematics instruction and overall satisfaction from the mathematics learning experiences (Demiroz, 2016)

2.4. Data Collecting

The Emporium model course redesign was considered treatment, and students who enrolled in the redesigned sections of college algebra were designated as the treatment group, whereas students enrolled in the traditional college algebra sections were included in the research as the control group. Participants in the treatment group were taught college algebra in the redesigned format. They were required to attend Interactive Learning Lab (ILL), which was fully equipped with instructional and learning technologies, sessions a total of 150 minutes, and a 50-minute in-class session each week. As a part of the treatment, interaction between peers, and between faculty and students was encouraged and participants were exposed to student-centered instruction with immediate feedback and on-demand help. The treatment made heavy use of information and learning technologies such as online textbooks and classroom management systems (MSCRI, 2011). Participants in the control group received college algebra instruction in a traditional (50-minute lecture-based) format three times a week. Instructors only lectured in traditional sessions of college algebra, so participants in the control group were passive listeners during sessions. Participants' assignments into treatment and control groups were not randomized, but self-selective. In other words, students enrolled in redesigned and traditional sections of the college algebra knew both modes of instruction existed, and they enroll in due to time, scheduling, or some other personal factors. The researcher was not able to manipulate the process. The instrument developed by the researcher was administered twice: at the beginning of the semester as a pretest, and at the end of the semester as a posttest in both traditional and redesigned sections of college algebra.

2.5. Data Analysis

After preliminary screening and testing for assumptions, two sets of data analyses were completed to test the hypotheses stated above. Within-group pretest-posttest comparisons were made through paired-samples t-tests, whereas multiple regression analyses were performed for testing the statistical difference between treatment (redesign) and control (traditional) groups. Preliminary analyses indicated that results of Kolmogorov-Smirnov and Shapiro-Wilk tests of normality are statistically significant for some of the variables, but not for all. However, Brown (2011) stated that skewness and kurtosis values between +2 and -2 are desirable to accept that the data are normally distributed. Curran, West, and Finch (1996) recommended that univariate values of skewness and kurtosis indicate a non-normal distribution when they approach 2 and 7 respectively. When histograms, Q-Q plots, skewness (ranging between +1,-1) and kurtosis (ranging between +2,-2) values were considered, data were determined to be normally distributed for further analyses. The first set of between-group comparisons was made by including treatment by covariate interaction to test homogeneity of regression and no treatment-by-covariate interaction assumptions. None of the interaction terms were statistically significant, so these two assumptions were not violated (Warner, 2014). Therefore, multiple regression analyses were repeated without including a treatment-by-covariate interaction term. The posttest scores were normally distributed, the pretest scores were not statistically significantly different for the control (traditional) and treatment (redesigned) groups, and scatterplots indicated a linear relation and no bivariate outliers. No data transformations were applied, but five cases were randomly excluded from the control group to ensure an equal number of cases in both groups for the multiple regression analyses. In total, 224 cases were included in the multiple regression analysis.

3. Findings

Within group comparisons were made through paired samples t-tests to examine if there is any changes in psychosocial variables over the course of the semester. Multiple regression analysis was used for group comparisons by controling pretest scores collected at the beginning of the semester.

3.1. Within Group Comparisons

Possible positive or negative changes in dependent variables were analyzed through paired-samples t-test analyses. The following section reports statistical analyses for one of the research questions: Do dependent variables significantly change within control (traditionally-taught college algebra) and within treatment (redesigned-college algebra) groups during the 4 month treatment? Twenty-two paired-sample comparisons were made for the eight dependent variables, and overall attitudes, motivation, and satisfaction variables. The results of the paired-samples t-test analyses are shown in Table 2 and Table 3.

3.2. Attitudes

A paired-samples t-test was conducted to analyze whether learners' attitudes toward mathematics, attitudes toward technology-supported mathematics, beliefs about being able to do mathematics, and overall attitudes toward mathematics changed throughout the traditionally-taught and redesigned college algebra courses during the 4 month period. The results of the paired-samples t-test indicated that the mean scores of attitudes toward technology-supported mathematics (pretest: M=3.04, SD=.69; posttest: M=2.87, SD=.41), beliefs about being able to do mathematics (pretest: M=3.65, SD=.66; posttest: M=3.51, SD=.75), and overall attitudes toward mathematics (pretest: M=3.17, SD=.41; posttest: M=3.07, SD=.38) changed negatively, and the mean differences were statistically significant at the .05 level of significance in the traditionally-taught college algebra sessions. Also, as one of the factors of the instrument, the mean score of attitudes toward mathematics (pretest: M=2.81, SD=.86; posttest: M=2.82, SD=.47) changed positively, but the mean difference is not statistically significant at .05 level of significance.

The results of the paired-samples t-test for the treatment group showed that the mean scores of attitudes toward mathematics (pretest: M=3.12, SD=.93; posttest: M=2.79, SD=.58), attitudes toward technology-supported mathematics (pretest: M=3.24, SD=.77; posttest: M=2.98, SD=.44), and overall attitudes toward mathematics (pretest: M=3.38, SD=.45; posttest: M=3.17, SD=.41) changed negatively, and the mean differences were statistically significant at the .05 level of significance. In addition, the mean score of beliefs about being able to do mathematics changed negatively, but the mean difference is not statistically significant at .05 level of significance.

3.3. Motivation

A paired-samples t-test was conducted to analyze whether learners' intrinsic motivation to learn mathematics, extrinsic motivation to learn mathematics, and overall motivation to learn mathematics changed throughout the traditionally-taught college algebra and redesigned college algebra courses during the 4 month period. The results of the paired-samples t-tests indicated that the mean scores of intrinsic motivation to learn mathematics (pretest: M=2.88, SD=.70; posttest: M=2.92., SD=.76) changed positively, whereas extrinsic motivation to learn mathematics (pretest: M=3.65, SD=.61; posttest: M=3.59, SD=.64), and overall motivation to learn mathematics (pretest: M=3.26, SD=.54; posttest: M=3.25, SD=.58) changed negatively in the control group - traditionally-taught college algebra. However, none of those mean differences is statistically significant at the .05 level of significance.

The paired-samples t-test for the treatment group indicated similar results to the control group. The mean scores of intrinsic motivation to learn mathematics (pretest: M=2.85, SD=.61; posttest: M=2.87, SD=.67) changed positively whereas extrinsic motivation to learn mathematics (pretest: M=3.79, SD=.56; posttest: M=3.67, SD=.57), and overall motivation to learn mathematics (pretest: M=3.32, SD=.48; posttest: M=3.27, SD=.53) changed negatively in the redesigned college algebra. The mean difference for extrinsic motivation was statistically significant at the .05 level of significance although the mean differences of intrinsic motivation and overall motivation to learn mathematics were not statistically significant at the .05 level of significance.

3.4. Learner Satisfaction

A paired-samples t-test was conducted to analyze whether learners' satisfaction from mathematics instruction, technology-supported mathematics, instructional design, and overall satisfaction from college algebra changed throughout the traditionally-taught and redesigned college algebra sessions during the 4 month period. The results of the paired-samples t-test indicated that the mean scores of learner satisfaction from technology-supported mathematics (M = 3.34, SD = .56; posttest M = 3.26, SD = .77), learner satisfaction from the mathematics learning experiences (pretest: M = 3.19, SD = .68; posttest: M = 3.07, SD = .78), and overall learner satisfaction from college algebra (pretest M = 3.18, SD = .55; posttest M = 3.15, SD = .50) changed negatively, whereas the mean score of learner satisfaction from mathematics instruction changed positively (pretest: M = 3.01, SD = .78; posttest: M = 3.10, SD = .34). None of the mean differences were statistically significant at the .05 level of significance.

Table 1: Paired Samples Statistics

Outcome	Control Group				Treatment Group			
	Meana	*SD*	*Meanb*	*SD*	*Meana*	*SD*	*Meanb*	*SD*
Attitudes toward mathematics	2.81	.86	2.82	.47	3.12	.93	.79	.58
Attitudes toward technology-supported mathematics	3.04	.69	2.87	.41	3.24	.77	2.98	.44
Beliefs about being able to do mathematics	3.65	.65	3.51	.75	3.78	.65	3.75	.85
Intrinsic motivation to learn mathematics	2.88	.70	2.92	.76	2.85	.61	2.87	.67
Extrinsic motivation to learn mathematics	3.65	.62	3.59	.64	3.79	.56	3.67	.57
Satisfaction from mathematics instruction	3.02	.78	3.10	.34	3.13	.80	3.09	.49
Satisfaction from tech-supported math	3.34	.56	3.26	.77	3.62	.66	3.35	.71
Satisfaction from the mathematics learning experiences	3.19	.68	3.07	.78	3.41	.71	3.00	.88
Overall attitudes toward mathematics	3.17	.41	3.07	.38	3.38	.45	3.17	.41
Overall motivation to learn mathematics	3.26	.54	3.25	.58	3.32	.48	3.27	.53
Overall learner satisfaction	3.18	.55	3.15	.50	3.39	.60	3.15	.56

a: Pretest Scores; b: Posttest Scores

The results of the paired-samples t-test for the treatment group indicated that the mean scores of learner satisfaction from mathematics instruction (pretest: M = 3.13, SD = .80; posttest: M = 3.09, SD = .49), learner satisfaction from technology-supported mathematics (pretest: M = 3.62, SD = .66; posttest: M = 3.35, SD = .71), learner satisfaction from the mathematics learning experiences (pretest: M = 3.41, SD = .71; posttest: M = 3.00, SD = .88), and learner satisfaction from college algebra (pretest: M = 3.39, SD = .60; posttest: M = 3.15, SD = .56) changed negatively.

The mean differences of the latter three variables were statistically significant at the .05 level of significance, but the mean difference of learner satisfaction from mathematics instruction was not statistically significant at the .05 level of significance.

3.5. Between Group Comparisons

Multiple regression analyses were performed to assess whether there were statistically significant differences in dependent variables between traditionally-taught college algebra and redesigned college algebra after controlling for pretest scores. The results of the multiple regression analyses are shown in Table 4.

3.6. Attitudes

The results of regression analysis for attitudes toward mathematics and attitudes toward technology-supported mathematics indicated that the overall regression equations were significantly predictive of attitudes toward mathematics (R = .62, R^2 = .38, adjusted R^2 = .37, F (2, 221) = 67.448, p<.001) and attitudes toward technology-supported mathematics (R = .26, R^2 = .07, adjusted R^2 = .06, F (2, 221) = 8.071, p<.001) posttest scores. When controlling for the effect of pretest scores, the magnitude of the group difference in attitudes toward mathematics was -.138 and in attitudes toward technology-supported mathematics was .148. The differences were statistically significant: t (224) = -2.451, p = .015 and t (224) = 2.658, p = .008 respectively. The results of regression analyses for students' beliefs about being able to do mathematics (R = .47, R^2 = .23, adjusted R^2 = .22, F (2, 221) =32.018, p<.001), and overall attitudes toward mathematics (R = .41, R^2 = .17, adjusted R^2 = .16, F (2, 221) = 21.817, p<.001) indicated that the overall regression equations were significantly predictive of learners' beliefs and overall attitude posttest scores.

Table 2: Paired-samples t-test comparisons in control group.

	Control Group (Traditionally-taught college algebra)					
Outcome	*Meana*	*Meanb*	*Δ Mean*	*SD*	*t value*	*Sig.*
Attitudes toward mathematics	2.81	2.82	-.006	.71	-.097	.923
Attitudes toward technology-supported mathematics	3.04	2.87	.17	.89	2.102	.038*
Beliefs about being able to do mathematics	3.65	3.51	.14	.73	2.080	.040*
Intrinsic motivation to learn mathematics	2.88	2.92	-.04	.66	-.654	.514
Extrinsic motivation to learn mathematics	3.65	3.59	.06	.58	1.116	.267
Satisfaction from mathematics instruction	3.02	3.10	.08	.75	-1.183	.239
Satisfaction from tech-supported mathematics	3.34	3.26	.07	.75	1.064	.290
Satisfaction from the mathematics learning experiences	3.19	3.07	.12	.83	1.551	.124
Overall attitudes toward mathematics	3.17	3.07	.10	.43	2.578	.011*
Overall motivation to learn mathematics	3.26	3.25	.01	.47	.230	.818
Overall learner satisfaction	3.18	3.15	.04	.55	.731	.466

* Indicates statistically significant mean differences (p<.05); a: Pretest Scores; b: Posttest Scores

Table 3: Paired-samples t-test comparisons in treatment group.

	Treatment Group (Redesigned college algebra)					
Outcome	*Meana*	*Meanb*	*Δ Mean*	*SD*	*t value*	*Sig.*
Attitudes toward mathematics	3.12	2.79	.33	.69	5.035	.000*
Attitudes toward technology-supported mathematics	3.24	2.98	.26	.95	2.980	.004*
Beliefs about being able to do mathematics	3.78	3.75	.03	.81	.349	.728
Intrinsic motivation to learn mathematics	2.85	2.87	-.02	.59	-.320	.749
Extrinsic motivation to learn mathematics	3.79	3.67	.12	.60	2.037	.044*
Satisfaction from mathematics instruction	3.13	3.09	.04	.84	.494	.622
Satisfaction from tech-supported mathematics	3.62	3.35	.27	.73	3.918	.000*
Satisfaction from the mathematics learning experiences	3.41	3.00	.41	.88	4.979	.000*
Overall attitudes toward mathematics	3.38	3.17	.21	.49	4.513	.000*
Overall motivation to learn mathematics	3.32	3.08	.24	.43	1.212	.228
Overall learner satisfaction	3.39	3.15	.24	.56	4.580	.000*

* Indicates statistically significant mean differences (p<.05); a: Pretest Scores; b: Posttest Scores

The magnitude of the group difference in learner beliefs about being able to do mathematics was .168 and overall attitudes toward mathematics was .042. The differences were not statistically significant: t (224) = 1.742, p =.083 and t (224) = .834, p =.405 respectively. The traditional group had a mean attitude posttest score of 2.82 while the mean score for the redesign group was 2.79. The results suggested that the redesign efforts negatively impacted students' attitudes toward mathematics. On the other hand, the redesign efforts positively impacted students' attitudes toward technology-supported mathematics. Although the differences were not statistically significant, the mean scores of students' beliefs about being able to do mathematics, and overall attitudes toward mathematics were higher in the redesigned college algebra sessions.

3.7. Motivation

The results of regression analyses for intrinsic motivations (R = .58, R^2 = .34, adjusted R^2 = .34, F (2, 221) = 57.637, p<.001), extrinsic motivations (R = .50, R^2 = .25, adjusted R^2 = .25, F (2, 221) = 37.340, p<.001), and overall motivation of students (R = .65, R^2 = .43, adjusted R^2 = .42, F (2, 221) =

82.186, $p<.001$) to learn mathematics indicated that the overall regression equations were significantly predictive of all three. When controlling for the effect of pretest scores, the magnitude of the group difference in intrinsic motivation to learn mathematics was -.037, but the difference was not statistically significant: t (224) = -.474, p = .636. Likewise, the magnitude of the group difference in extrinsic motivation to learn mathematics was .013, and the difference was not statistically significant: t

(224) = .187, p = .852 when controlling for the effect of pretest scores. Finally, the regression analysis results revealed that the magnitude of the group difference in overall motivation to learn mathematics was -.078, and the difference was not statistically significant: t (224) = -1.205, p = .230 when controlling for the effect of pretest scores. Although the group differences were not statistically significant, students enrolled in traditional college algebra sessions had higher intrinsic motivation and overall motivation to learn mathematics mean scores, whereas students enrolled in redesigned college algebra had higher extrinsic motivation to learn mathematics scores. However, it should be noted that students enrolled in redesigned college algebra sessions also had higher pretest scores of extrinsic motivation although the pretest scores did not statistically significantly differ between groups.

Table 4: Multiple regression analyses - group comparisons.

Control vs. Treatment Groups [ab]										
	Mean Statistics			*B Statistics*			*Regression Model Statistics*			
	Meana	*Meanb*	*Δ Mean*	*t value*	*p value*	*B*	*F Value*	*df*	*p*	*Adj. R^2*
Attitudes toward mathematics	2.82	2.79	.03	-2.451	.015*	-.138	67.448	2, 221	.000	.37
Attitudes toward technology-supported mathematics	2.85	2.98	-.13	2.658	.008*	.148	8.071	2, 221	.000	.06
Beliefs about being able to do mathematics	3.50	3.75	-.25	1.742	.083	.168	32.018	2, 221	.000	.22
Intrinsic motivations to learn mathematics	2.91	2.87	.04	-.474	.636	-.037	57.637	2, 221	.000	.34
Extrinsic motivations to learn mathematics	3.58	3.67	-.09	.187	.852	.013	37.340	2, 221	.000	.25
Satisfaction from mathematics instruction	3.11	3.09	.02	-.480	.632	-.026	6.043	2, 221	.003	.04
Satisfaction from tech-supported mathematics	3.27	3.35	-.08	-.523	.601	-.048	23.160	2, 221	.000	.17
Satisfaction from the mathematics learning experiences	3.08	3.00	.08	-1.721	.087	-.177	19.563	2, 221	.000	.14
Overall attitudes toward mathematics	3.06	3.17	-.11	.834	.405	.042	21.817	2, 221	.000	.16
Overall motivation to learn mathematics	3.10	3.08	.02	-1.205	.230	-.078	82.186	2, 221	.000	.42
Overall learner satisfaction	3.15	3.14	.01	-1.489	.138	-.092	36.292	2, 221	.000	.24

a: Posttest mean scores for control group; b: Posttest mean scores for treatment group, * Indicates statistically significant mean differences ($p<.05$).

3.8. Learner Satisfaction

The results of regression analyses for satisfaction from mathematics instruction, satisfaction from technology-supported mathematics instruction, satisfaction from the mathematics learning experiences, and overall learner satisfaction from college algebra learning experiences indicated that the overall regression equations were significantly predictive of satisfaction from mathematics instruction (R = .23, R^2 = .05, adjusted R^2 = .04, F(2, 221)=6.043, $p<.005$), satisfaction from technology-supported mathematics instruction (R = .42, R^2 = .17, adjusted R^2 = .17, F(2, 221) = 23.160, $p<.001$), satisfaction from the mathematics learning experiences (R = .39, R^2 = .150, adjusted R^2 = .14, F(2, 221) = 19.563, $p<.001$), and overall learner satisfaction from college algebra learning experience (R = .50, R^2 = .25, adjusted R^2 = .24, F(2, 221) = 36.292, $p<.001$) posttest scores. When controlling for the effect of pretest scores, the magnitude of the group difference in satisfaction from mathematics instruction was -.026, and the difference was not statistically significant: t

(224) = -.480, *p*=.632. The magnitude of the group difference in satisfaction from technology-supported mathematics instruction was -.048, and the difference was not statistically significant: *t* (224) = -.523, *p*=.601 when controlling for the effect of pretest scores. Likewise, the magnitude of the group difference in satisfaction from the mathematics learning experiences was -.177, and the difference was not statistically significant: *t* (224) = -1.721, *p* = .087 when controlling for the effect of pretest scores. Finally, when controlling for the effect of pretest scores, the magnitude of the group difference in overall learner satisfaction from college algebra learning experience

was -.092, and the difference was not statistically significant: *t* (224) = -1.489, *p* = .138. Although the differences were not statistically significant between traditional and redesigned college algebra sessions, students enrolled in redesigned college algebra sessions reported higher satisfaction from technology-supported mathematics which is not surprising because of the extensive infusion of instructional and learning technologies in mathematics education.

4. Results, Discussions and Suggestions

Technology-infused course redesign efforts supported by the NCAT have impacted thousands of college level students who enroll in courses that suffer from high enrollment, high failure and high dropout rates. According to Thompson and McCann (2010) approximately 40 percent of the students enrolled in college algebra pass the coourse nationwide. Thus, college algebra is one of these courses targeted by course redesign efforts, and institutional reports submitted to the NCAT for program evaluations hold promise for increasing academic achievement by reducing failure and dropout rates in college algebra classrooms. For example, Nayak (2017) reported that students' reflections to redesigned course supported by innovative pedagogical tools and structures were positive; they emphasize confidence in their ability to understand and apply algebraic concepts; and reported an increased enjoyment of mathematics.

Webel, Krupa and McManus (2017) examined perceptions of students enrolled in redesigned intermediate algebra courses for answering some specific questions raised as a result of mathematics emporium. They reported that students, ability to learn mathematics especially for recalling and using formulas for familar problems was affected by math emporium model, but it has limited impact on developing meaning on symbols and solving unfamiliar problems. In addition, they highlighted that structure of the emporium model offers autonomy and students reported mixed feelings about it. However, still many questions need to be answered about why redesign efforts yield better or equivalent student learning outcomes after all teaching practices and dynamics are modified through the extensive use of learning technologies. Thus, the main purpose of this paper was to answer some of those questions, which related to the psychosocial factors of learning mathematics. Changes in students' attitudes toward mathematics, motivation to learn mathematics, and satisfaction from the mathematics learning experiences in both redesigned and traditionally-taught college algebra classrooms were examined. Within-group comparisons were made through paired-samples t-tests, and between-group comparisons were made through multiple regression analyses.

Within-group analyses revealed that attitudes toward technology-supported mathematics, beliefs about being able to do mathematics, and overall attitudes toward learning mathematics changed significantly throughout the semester for students who had completed the questionnaire in traditionally-taught college algebra classrooms, but the magnitude of the change was negative. Therefore, the traditionally-taught college algebra impacts students' attitudes toward technology-supported mathematics, overall attitudes toward mathematics, and beliefs about being able to do mathematics negatively, whereas motivation to learn mathematics, and satisfaction from the overall mathematics learning experiences do not change significantly in traditionally-taught college algebra classrooms during a four-month period.

On the other hand, redesign efforts statistically significantly impacted students' attitudes toward mathematics, students' attitudes toward technology-supported mathematics, learners' extrinsic motivations to learn mathematics, and satisfaction from the mathematics learning experiences in college algebra settings. However, all the statistically significant changes were negative in magnitude. This suggest that the Emporium redesign efforts at the research institution negatively impacted students' attitudes toward mathematics, toward technology-supported mathematics, their extrinsic motivation to learn mathematics, and their satisfaction from the mathematics learning experiences in college algebra sessions. Teaching method can have an impact on students' attitudes although mathematics emporium promotes thinking, asking questions and participating in class activities that are all required for a better class climate (Cousins-Cooper et al., 2017; Hegeman, 2015). Likewise, Alt (2017) reached similar results regarding student dissatisfaction such as confused structure of math emporium and learners' feeling of isolation in mathematics emporium settings. Redesigned efforts in college algebra do not significantly affect learners' beliefs about being able to do mathematics, their intrinsic motivation to learn mathematics, their overall motivation to learn mathematics, and their satisfaction from mathematics instruction although only intrinsic motivation scores changed positively. The reason of such change might be active involvement of learners in redesigned settings. Cousins-Cooper et al. (2017) emphasized that students who are actively engaged in mathematics classrooms are more likely to have higher motivation to learn mathematics.

Regarding the between-group comparisons, only attitudes toward mathematics, and attitudes toward technology-supported mathematics were significantly different between redesigned and traditionally-taught college algebra sessions. Learners enrolled in the traditionally-taught college algebra sessions had a higher attitudes toward mathematics mean score, whereas students enrolled in the redesigned college algebra sessions had a higher mean score for attitudes toward technology-supported mathematics. Students' beliefs about being able to do mathematics, motivation to learn mathematics and satisfaction from the overall mathematics learning experience were not significantly different between the two instruction modes. Although all the analyses revealed useful information, further analyses are needed to examine the relationship between college redesign efforts and student learning outcomes.

Redesign efforts have accelerated last 10 years especially with the support of National Center for Academic Transformation. The results indicate that mathematics emporium model has potential to impact psychosocial factors of learning especially with its extensive use of learning technologies. In this regard, it can be suggested that implementation of learning technologies in college level courses should be well-planned. In other words, superficial adoption of technology might impact psychosocial factors of learning which has potential to impact academic achievement in negative manner. On the onther hand technogy integration should not be considered as a sole factor that manipulates psychosocial factors of learning, on demand help and student centered instructional design also have impact on such changes in students' motivation to learn, attitudes towards learning mathematics, and satisfaction from the instructional design of the Emporium model. As a result, it can be suggested that higher education institutions should adopt the Emporium model for introductory level college courses, but it should be kept in mind that technology integration and student-centered pedagogial approach should be matched accordingly.

4.1. Limitations and Need for Future Research

In this research paper, it was assumed that sampling, attrition rate, location, honesty of participants, and instrumentation did not affect participants' responses. The following limitations might be considered for this research paper: convenience sampling which is vulnerable for generalizations, loss of participants due to high drop-out rates in college algebra sessions, and the difference between the physical settings of traditionally-taught college algebra and redesigned college algebra sessions in which data were collected, and time because a four-month period might not be sufficient to observe significant changes in student affect.

In addition, the delimitations of the study might be summarized as (a) sampling procedure because participation in the study was delimited to the students who enrolled in college algebra courses at a single Midwestern university, and students who enrolled in the college algebra, then either failed or withdrew from the course, and subsequently reenrolled in the course, and students who either completed pretest only or posttest only were excluded from the study; (b) limitations of dependent variables and examination of those variables only in college-level mathematics learning environments; (c) the results of the study were delimited in terms of external validity, and the results of this study only generalizable to the students who enroll in college algebra sessions at a higher education institution which adopts the same NCAT redesign model and uses similar learning technology tools and teaching strategies; and (d) the other important limitation has to do with time. The traditionally-taught college algebra meets three times a week for 50 minute lectures, whereas redesigned college algebra requires only one 50 minute lecture, but two 75 minute interactive learning lab sessions each week.

This manuscript only focused on changes in psychosocial factors of learning in two different formats for college algebra courses, and academic achievement and the relationship between these dependent variables were not in the scope of this research paper. Therefore, more comprehensive and exploratory analyses which involve learners' incoming mathematics knowledge and end-of-semester academic achievement along with psychosocial factors of learning in redesigned college algebra sessions will be highly informative.

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