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Immediate Feedback Using Student Response System

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Abstract:
The current research investigated the effects of providing immediate feedback using a student response system (SRS) to 53 students who had statistically significant similar math skills. The students in the experimental group (n = 25) received continuous, rigorous, and consistent immediate feedback for their responses through SRS, whereas, the students in the control group (n = 28) lacked the same for 18 weeks. An analysis of covariance (ANCOVA) revealed a statistically significant difference in the math achievement of students in the experimental group with a medium effect size (η^2 = .11), when controlling for giftedness, gender, and economic status.

Keywords*: Student response system, immediate feedback.*

1. Introduction

The current generation of students communicate effortlessly using technology at a very fast pace that sometimes renders the traditional methods of education primordial. The students are familiar with faster communication and are used to getting immediate feedback for every response they make in their real life. It thus becomes imperative that the feedback provided for the responses they make in their learning environment should match with their lifestyle.
Student Response Systems (SRS) form a collection of many innovations that are available in educational scenarios to meet the challenge. Educators in modern classrooms can choose from a wide range of SRS hardware and software that enable them to give immediate feedback. The availability of an effective SRS may become expensive, especially if teachers require students to use a common SRS to respond. Hence, it is important for stakeholders of education to make informed decisions about the financial aspect of the use of SRS in classrooms.

1.1. Research Problem

There has been a large volume of sound, theoretically based research conducted to investigate the effects of implementing effective SRS in classrooms(Black & Wiliam, 2009; Clark, 2012; Hattie, 2012; Schunk, 2001; Yorke, 2003; B.J. Zimmerman, 2001). However, despite the potential of SRS to provide effective feedback and engage tech-savvy students, research regarding the efficacy of SRS is inconclusive or controversial. The reported limitations of these studies included period of implementation of SRS(Matus et al., 2011); frequency and rigor in implementing SRS intervention(Penual et al., 2007); and inadequacies of intervention strategies(Abode, 2010; Christopherson, 2011). The researchers recommended further investigations(Dunham, 2011; Matus et al., 2011; Rigdon, 2010); thus, validating additional study of the effects of using SRS as a feedback tool in classrooms.

1.2. Student Response Systems (SRS)

Historically, teachers have used different types of response systems corresponding to their availability. The manual student response systems that include response cards, or using mechanical devices like colored responses, are still used today in many classrooms to elicit student responses. As Randolph (2007)points out, such manual SRS enhances student achievement more effectively than relying upon student expressions. With the advancement of technology, computer-aided SRS improve the ways in which student responses can be collected and analyzed. Clickers with the capability to collect multiple choice responses were a breakthrough when introduced. However, modern SRS, even though generally called clickers themselves, where students can respond in texts, numbers, and sentences, has taken the realm of student responses to a higher level. Technology and its applications, especially those designed for use in classrooms, are improving quickly. The clickers have now become so much more functional that it is improper to call them clickers anymore because they do more than just clicking the right answer. The ways to collect student responses and provide feedback have undergone major refinements. The upgraded technology allows students to respond to teacher prompts using text, numbers, and sentences that involve mathematical symbols. In addition, many Web 2.0 programs, which enable students and teachers to connect through any internet capable device, provide avenues to collect student responses and provide feedback.

2. Literature Review

Many studies(Blood & Neel, 2008; Wieman & Perkins, 2005)pointed out that technology-rich activities increased student engagement and enhanced the learning experiences. According to a statement released from the U.S. Department of Education(U.S.Department of Education [USDOE], 2015), *technology-based learning and assessment system* would improve educational proficiency of our students (p. v). Thus, the use of SRS has a potential to affect the learning process in a significant way. Consequently, SRS and the effects of SRS in educational scenarios have been under constant investigation in the recent decade(Abode, 2010; Christopherson, 2011; Dunham, 2011; Lynch, 2013; Matus et al., 2011; Rigdon, 2010). The potentially huge spending involved in the purchase, installation, training, and maintenance of SRS would naturally stimulate investigations about the effectiveness of the system and the technological devices to prove the worth of the money involved in the process.

2.1. Studies that used SRS

Dunham(2011) researched the statistical significance of clickers, a form of SRS, on the math achievement of seventh grade students. Christopherson(2011), after an investigation on the effects of SRS, came to a conclusion that the use of SRS should be incorporated with the best teaching practices to see the effects of SRS in the desired student achievement. According to Christopherson, the role of teachers in using the technology is very pivotal, since effective implementation of the system plays the key role in the effectiveness of learning achievement.

In addition, developments in technology in recent years have led to significant improvement in the structure and utility of SRS so that the tech-savvy students of our generation can interact with this technology without losing their pace. Educators should incorporate text and numerical responses rather than just multiple-choice questions because it would be difficult to evaluate student responses based only on multiple-choice responses (Becker, 1998). Thus, if properly planned, teachers could use SRS to collect and interpret higher forms of input.

2.2. Theoretical Framework

Well supported by different perspectives, including 'operant theory, phenomenology, information processing theory, social cognitivism, volitional theory, Vygotskian theory, or constructivism'(B.J. Zimmerman, 2001, p. 2), The theory suggests that the use of appropriate external stimuli, in this case the immediate-teacher-feedback as a positive re-enforcer, would kindle self-regulated learning skills in the students. The intervention in this study was designed based on different stages of self-regulated learning process, namely, 'self-monitoring, self-instruction, self-evaluation, and self-reinforcement' (p. 10). However, as the theory suggests, it is imperative that the self-regulated learning is not a voluntary process and that supporting environment provided by the intervention process would play a key-role for the process(Schunk, 2001).

Another foundational framework for this study was the Distributed Cognition Theory. The process of learning, as per (Schwartz, 2008), the learning process is distributed across the learner's mind and the learner's social and physical environment. The intervention for this study was created to enable the students, teacher, and the learning environment could communicate effectively using SRS. Clearly, the learning activities should enhance the learners' ability to learn more effectively, as per the tenets of the Distributed Cognition Theory(Hollan et al., 2000). The suggestions gathered from the literature review based on studies that used SRS interventions and the tenets of the theoretical framework suggested that the effective feedback using SRS had the potential to improve student achievement, especially in mathematics(Edgerton et al., 2008; Kim et al., 2011; Payne & Biddle, 1999; Thomas & Stockton, 1999; Vega & Travis, 2011).

2.3. Research Question

The purpose of this 'untreated control group [quasi-experimental] design study with dependent pretest and posttest samples'(Shadish et al., 2002, p. 36)is to determine whether there is a statistically significant difference in the math achievement of eleventh-grade students who receive immediate feedback using a Student Response System at a suburban high school in Georgia.

2.4. Limitations

It is important to note the limitations of the study. The participants of this study were from only one school. I used only one particular type of hardware and the corresponding software for student responses. However, most of the hardware and software available for providing feedback for student responses follow the same pattern as used in this study. The use of the *SRS* was not a novel experience for the participants in this study. Another limitation of the quasi-experimental study is that the selection of participants for the study lacked thorough randomization. The intervention was designed particularly for the coursework of the participating students, which might become an issue for replication of this study. Further, it is important to understand that various factors—construct validities, including novelty, compensatory rivalry, and resentful demoralization—beyond my control in this study might affect the generalizability of the results obtained from this study. In addition, I assumed that the students who participated in this study had the same learning opportunities, were interested to learn the mathematical concepts taught, and that the participants did not cheat on pretest or posttest.

2.5. Significance of the Study

The beneficiaries of this study to investigate the effects of SRS include teachers, students, teacher education institutions, and policymakers. The SRS has the potential to provide effective, fast, and less time-consuming feedback for teachers. Teacher education institutions could make decisions about integrating SRS training as an intuitive tool for upcoming teachers. Further, policy makers could make informed decisions about purchasing an expensive educational tool that might support education and help to reach the educational goals of the entities they represent. This research provides a systematic insight into the effect of using SRS as a learning strategy to improve student achievement. The theoretical frameworks—theory of distributed cognition and self-regulatory learning theory—amply support the use of SRS in the improvement of student achievement. I employed this study to find out the effect of using SRS as an immediate feedback tool on the participant students' academic achievement.

3. Methodology

The following methodology was employed for this study to investigate the effects of using SRS as an immediate feedback tool on the participant students' academic achievement.

3.1. Research Question

The study investigated whether there will be a statistically significant difference between the educational-district-generated, benchmark posttest scores of students who received immediate feedback using SRS and those who did not receive the intervention of immediate feedback using SRS, when controlling for state-generated-pretest scores, giftedness, gender, and economic status of students enrolled in eleventh grade accelerated precalculus course in a suburban high school. The level of significance for the study was set to.05.

3.2. Sample Population

The sample population consisted of 53 eleventh grade accelerated pre-calculus students in a suburban high school in Georgia. Sixty two percent of the school's students were eligible for free or reduced lunch. Of the 53 students who participated in the study, 25 students received the intervention of receiving immediate feedback using SRS during instruction (experiment group), while 28 students

The control groupin this experiment consisted of 28 students. They did not receive immediate feedback using SRS (control group). The experiment group of the study, selected randomly between the two classes using the application from Random.org (Random.org, 2014), was comprised of approximately 25 students. These students received immediate feedback using SRS continuously during instruction. The accelerated precalculus course was designed for students who had successfully completed accelerated analytic geometry coursework. Consequently, the stakes are high for students who enroll in this advanced math course. The students in both experimental and controlled group had similar educational experiences. In addition, the population of the students enrolled in the course shared similar demographical characteristics of the school population.

3.3. Research Design

In this 'untreated control group [quasi-experimental] design study with dependent pretest and posttest samples,'(Shadish et al., 2002, p. 136), I investigated math achievement using a posttest, which was actually a midterm assessment designed for the course, successfully used for a couple of years as midterm-summative-assessment for precalculus course in the educational district. The posttest comprised of 30 multiple choice questions that conformed to the format and calculator use policies of accelerated precalculus course as prescribed by GaDOE(Georgia Department of Education [GaDOE], 2014). I used the scores of the test as the dependent variable, namely, the posttest scores.

The independent variable of the study was the immediate feedback provided to the learning responses of the students in the experiment group of the study. The control group received feedback without using SRS. In addition, I investigated how giftedness, economic status, and gender of the students in both the groups influenced student achievement as measured by the posttest.

The dependent variable, the posttest, consisted of a district-designed benchmark containing 30 multiple-choice questions. The educational district produces valid and reliable tests to evaluate the students, incorporating standards of the course, as per the guidelines of GaDOE (Georgia Department of Education [GaDOE], 2014). I used the midterm assessment previously used in the precalculus classes of the educational district where the study took place.

3.3.1. Covariates of the Study

I administered the pretest, the first covariate, at the beginning of the study. One of the requirements of eleventh grade accelerated precalculus course was that the students enrolling in the course should have successfully completed either accelerated analytic geometry course. Consequently, I selected the End of Course Test (EOCT) test form for analytic geometry, released by GaDOE(Georgia Department of Education [GaDOE], 2014)for pretest at the beginning of the course to determine the readiness of students in the control group and in the experiment group. I obtained data for the second covariate, giftedness, directly from the teacher portal of the educational district. Every gifted student enrolled in the class was designated 'gifted' in the rolls. Therefore, I marked the dichotomous categorical variable as either 'Gifted (1)' or 'NotGifted (0).'The sample selected for this study, which represented the school population, consisted of economically disadvantaged students, students from the middle-class and from affluent families. Therefore, the third covariate, economic status, played a key role in the successful implementation of student response system as an effective and immediate feedback tool. I categorized the economically disadvantaged students as (Disadvantaged—0) and all other students as (Not Disadvantaged—1) as obtained from the Georgia's Statewide Longitudinal Data System (Georgia Department of Education [GaDOE], 2014), a statewide data system provided by the educational district, to determine the economic status of students. I surmised that controlling the outcome with the fourth covariate, gender, would enable me to understand the influence that gender might have on the use of SRS as an immediate feedback tool. Therefore, I assigned the category, Male – 1 for all male students and the category Female – 0 for all female students participating in my investigation.

3.2. Validity of Pretest and Posttest

The pretest was created based on the Georgia State's Board of Education's approval and included the assessment of the state-mandated standards (Georgia Department of Education [GaDOE], 2014). The posttest was created by the school district as a collective effort of educators experienced in teaching accelerated precalculus course. The test and its variations had been employed in the district as an effective assessment for many years.Further, the posttest contained elements to test students' knowledge in terms of comprehension and application for all the standards relevant to the course in the fall semester.

3.3. Reliability of Pretest and Posttest

As per the recommendations by Field (2009), I attempted to measure the reliability of the tests used in this study. Even after several attempts to contact the test makers, I was not successful in finding the reliability measures of the pretest. The posttest, developed in educational district of this study, did not have any previous reliability measures associated with it, despite its consistent use to test students enrolled in the accelerated precalculus course. Therefore, I conducted a post hoc analysis on the pretest data and the posttest data to determine the reliability of the tests to measure the comprehension levels of students in both experiment group and control group. The relatively medium values of Cronbach's for both the pretest (α = .75) and the posttest (α = .71) supported the reliability of the two instruments used to measure the math achievement levels of students in this study.

3.4. Intervention Procedures

The independent variable of this quasi-experiment using a pretest-posttest with control group design was the intervention of using student response system (SRS) as an immediate feedback tool, continuously and consistently for the entire study period. To accomplish this, I used ActivExpression, a student response device developed by Promethean(2015), and the ActivInspire software(Promethean Limited, 2014), developed by the same company as the student response system in this study.

<u>3.4.1. Anonymous Feedback</u>

I provided immediate group feedback to the students in the experiment group using the anonymous feedback feature of ActivExpression. I required students to provide a short rationale for their answers together with their responses. Students could type in the rationale for this particular question using the SRS keypad in a few words or in complete sentence. The anonymous feedback provided by the system would enable the students to identify their erroneous thought process if they erred or would confirm the accuracy of their critical thinking if they were correct. Consequently, students could self-regulate their learning process based on the immediate feedback obtained through SRS. The participants in the control group did not receive immediate anonymous feedback using SRS. However, I tried to provide personal and anonymous feedback to students in the control group without using SRS.

<u>3.4.2. Self-Paced Quizzes or Warm-Up Activities</u>

I created self-paced quizzes or warm-up activities using the software, ActivInspire(Promethean, 2015). It was possible to arrange questions to appear on the screen of the ActivExpression one after the other at a student's own pace. Marzano, Pickering, and Pollock(2001)contended that providing feedback after the whole test had larger significance with higher effect size when compared with providing feedback after every question. The idea of self-paced questions, followed by a feedback at the end of the test, is consistent with the recommendation of Marzano et al.Students in the control group had opportunities to solve the same questions, for both warm-up and formative quizzes, without using SRS. In the case of warm-up, we discussed the problems, and clarifications if needed, in the class. Students in the control group received feedback for their formative quizzes after I graded their paper quiz. The main difference in obtaining the feedback for quizzes between the control group and the experiment group was that the former had to wait until I manually graded their papers and the latter received their feedback instantaneously.

4. Data Analyses

The entire design of the quasi-experiment using a pretest-posttest with control group design led me to use Analysis of Covariance (ANCOVA). As per Field (2009), Analysis of Covariance (ANCOVA) could be used to effectively investigate the influence of the covariates on the outcome variable. The null hypothesis of the investigation was that there will not be a statistically significant difference between the educational-district-generated-benchmark posttest scores of students who received immediate feedback using SRS and those who did not receive the intervention of immediate feedback using SRS, when controlling for state-generated-pretest scores, giftedness, gender, and economic status of students enrolled in eleventh grade accelerated precalculus course in a suburban high school. The p value for the intervention parameter was set to be less than or equal to .050 for the rejection of the null hypothesis.

4.1. Assumptions for the Analysis

The posttest data, the dependent variable, were continuous in nature and all the data were independent to each other. The interactions of the groups and covariates, namely, pretest, $F(1,43)$ = 0.03, p = .863, Gender, $F(1,43)$ = 2.26, p = .140, Economical status, $F(1,43)$ = 0.01, p = .905, and Giftedness, $F(1,43)$ = 0.73, p = .398 were not statistically significant, thus meeting the assumption of homogeneity of regression slopes. The results obtained from the independent samples t tests indicated that there were no statistically significant differences for pretest scores, $t(51)$ = 0.09, p = .929, Gender, $t(51)$

= 1.24, p = .220, Economic Status, $t(51)$ = -0.80, p = .425, and Giftedness, $t(51)$ = -0.46, p = .645 between the values of the control and the experiment groups. The homogeneity of variances was established by the Levene's test of standardized residuals, $F(1, 51)$ = 0.06, p = .803. The histogram of standardized residuals, in *Figure 17*, illustrated normality. In addition, the results of Kolmogorov-Smirnov test, which used Lilliefors significance correction, $D(53)$ = 0.10, p = .200, established normality of standardized residuals. Thus, all the assumptions for the ANCOVA test were met.Thus, the data collected for this studyrepresented an ideal situation to conduct ANCOVA.

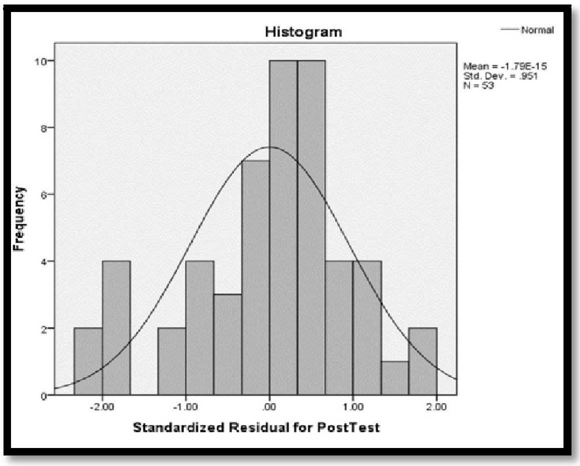

Figure 17. Standardized Residual Histogram for Posttest

4.2. Report of ANCOVA

There was a statistically significant difference in the posttest scores of students who received immediate feedback through SRS and the students who did not receive immediate feedback through SRS, $F(1,47)$ = 5.99, p = .018, *partial*η^2 = .11, when controlling pretest scores, gender, giftedness, and economic status of the students. However, none of the covariates, namely, pretest, $F(1,47)$ = 2.19, p = .146, *partial*η^2 = .04; Gender, $F(1,47)$ = 0.17, p = .681, *partial*η^2 = .00; Economic Status, $F(1,47)$ = 1.10, p = .300, *partial*η^2 = .02, or Giftedness, $F(1,47)$ = 3.43, p = .070, *partial*η^2 = .07, had any statistically significant effect on the posttest scores. Further, students in the experiment group scored better in posttest, M = 76.89, SE = 1.75, 95% *CI*s [73.15,80.63], when compared to the posttest scores of students in the control group, M = 70.57, SE = 1.74, 95% *CI* [67.04, 74.09], when controlling for their pretest scores, gender, giftedness, and economic status.The existence of a statistically significant difference in the values of dependent variable, the posttest, indicated that the intervention, namely the immediate feedback for student responses had an effect on student achievement. In Figure 18, I illustrate the statistical significance of the intervention as the graph of percentages of posttest scores of students in the control and the experiment groups after adjusting the means for the effects of the covariates in the study.

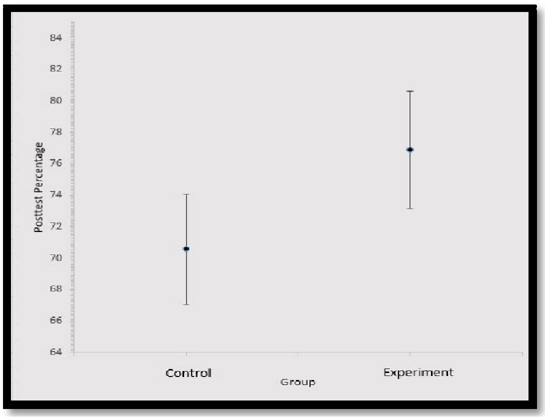

Figure 18: Error Plot for Adjusted Means of Posttest

5. Findings, Discussions, and Recommendations

The results of this study were consistent with various, prominent theories of feedback, including the Feedback Intervention Theory (FIT) developed by Kluger andDeNisi(1996), and the results of subsequent studies(Brookhart, 2012; Chappuis, 2012; Krenn et al., 2013; Wiliam, 2012). Gifted students, equipped with technological tools, were well equipped to improve their learning experiences, especially when using SRS as immediate feedback tool(Duan et al., 2010; Hong & Aqui, 2004; Rotigel & Fello, 2004). Ritzhaupt, Liu, Dawson, and Barron(2013), with small values of effect size (*partial* η^2 = .034, .024, and .028), could not explain an observed digital divide using socio-economic status, gender, and ethnicity. In the case of the covariate of gender, literature analysis did not unanimously suggest any significant gender effect on academic achievement in general, favoring either male or female students, even though individual studies reached their own questionable conclusions. Thus, it was not a surprise to see that in the current study, the covariate, gender, did not make a statistically significant effect on student achievement. Further, the covariates of giftedness and economic status did not significantly affect the posttest scores of the participating students in both the groups.

The major implication of this study is that it is necessary to design a feedback system to suit student responses to affect learning outcomes of the students. Exploring and implementing rigorous activities to generate student responses that enable the educator to identify the conceptual flaws in students' understanding of the topic are very critical for an effective immediate feedback system design. Even though the effect size of the statistically significant difference between posttest scores was medium, this study largely exposes the importance of a well-designed immediate feedback system to be in place to enhance the learning outcomes, and eventually student achievement.

Other implications of this study include the necessity and worthiness of spending resources to implement an effective feedback system in classrooms and providing the necessary training and ongoing support to educators who are willing to implement immediate feedback using SRS or similar technological systems. It is fitting and crucial that we start to communicate with students in their favored mode of information acquisition. Thus, providing effective, immediate feedback to student responses is not an option, but a necessary component of current educational practices.

One of the limitations for this study was its period of implementation. Consequently, I suggest that future researchers aim at observing and providing feedback for longer terms. Even though it is important to probe students' conceptual understanding, it is equally important to investigate how students who used SRS retain their learning outcomes. Long-term research is necessary to investigate such a query.

In addition, I suggest that further studies should involve more students and include more subject areas simultaneously. It is also important to see students from different grade levels are also included in the study. Throughout the intervention period, I observed that the students in the experiment group were highly engaged in providing their responses and reacted positively to the feedback they received. Consequently, I recommend well-designed, mixed method studies of the qualitative aspects of receiving immediate feedback through SRS. Teacher preparation and the consequent teacher proficiency in designing, managing, and analyzing student data from SRS are inevitable in the successful implementation of immediate feedback using SRS. Hence, I recommend further studies that investigate the role of teachers in providing immediate feedback using SRS.

6. Summary

The use of SRS to provide immediate feedback requires further investigation. The design of learning experiences provided using SRS and the consequent feedback strategies need improvisations. The availability of different SRS tools, namely, online, offline, machines, and virtual machines provide sufficient opportunities to improve the learning experiences of students who receive immediate feedback through them. Further, it is inevitable to train educators to use immediate feedback and the associated technology to provide the students with better learning experiences that use the strategies of immediate feedback. I also recommend further investigation towards the effective use of SRS as an immediate feedback tool to help educators determine the need for reteaching the missed concepts. With further authentic research and consequent development of learning experiences using immediate feedback strategies, coupled with successful implementations of SRS, the current millennial generation of students will definitely benefit from the best practices of educational experiences, matching their dexterity in using technological devices.

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