The Effectiveness of an Intervention Package on Math Computation

Abstract: Four second-grade students participated in a B-A-B withdrawal single-subject design experiment. The intervention package implemented consisted of three components: self-monitoring, performance feedback, and reinforcers. Participants completed math probes across phases. Accuracy and productivity was recorded and calculated. Results demonstrated the intervention package improved accuracy and productivity for all participants.
Key words: self-monitoring, performance feedback, reinforcers, math computation

Education serves a key objective. It enables students to become independent and self-sufficient individuals. As independent and self-sufficient individuals, they can manage their behaviors without the assistance of others (Cooper, Heron, & Heward, 2007; Lan, 2005; Rafferty, 2010). Students who can manage or regulate their own behaviors do not rely on external controls. Self-management interventions, also called self-regulation interventions, can be taught and used by students of differing abilities and grade levels (Montague, 2007; Rafferty, 2010). There are different types of self-management interventions. The most researched are self-monitoring interventions (Cooper et al., 2007). Self-monitoring begins with the student observing his or her own behavior and then recording the occurrence of that behavior (Rafferty, 2010). Self-monitoring has been utilized in both academic and social behavioral domains. It has been implemented to improve reading and math proficiency as well as to improve social behaviors in the classroom (Rafferty, 2010; Rathvon, 2008).

Mathematical competency, in particular, is crucial for an individual's success in today's society. It is essential not only to success in school, but also to success in adult life. For those students who have a performance deficit in mathematics, self-monitoring interventions can be implemented to improve their mathematical proficiency (Rafferty & Raimondi, 2009). Several studies support the use of self-monitoring in mathematics across students of differing abilities. Typically developing students as well as students with cognitive or behavioral disabilities can benefit from self-monitoring interventions in mathematics (Falkenberg & Barbetta, 2013; Lannie & Martens, 2008; Maag, Reid, & DiGangi, 1993; Rock, 2005; Shimabukuro, Prater, Jenkins, & Edelen-Smith, 1999). These studies have also shown that if implemented correctly, self-monitoring interventions in mathematics improve mathematical proficiency by increasing accuracy and productivity.

Two important studies combine self-monitoring with an additional component in the intervention phase. Lannie and Martens (2008) incorporated self-monitoring with reinforcers. They examined the effects of a self-monitoring program on children's math computation. Four African American fifth grade students participated in this study. The students were presented with math probes (frustration-level math probes). Three performance dimensions were measured: percent intervals on-task, percent correct digits, and digits correct per minute. The teacher was given a reinforcer preference assessment survey to determine appropriate student rewards. Then students chose the rewards they liked best from the list of teacher-approved rewards. Students obtained rewards after meeting their individualized goals in each performance dimension. During the intervention, students were taught to self-monitor time on-task, accuracy, and productivity in sequence. The students wore earphones connected to an audio player that cued the students to self-monitor. They recorded their behaviors on a self-monitoring checklist and graph. Lannie and Martens (2008) defined accuracy as the percentage of items answered correctly and productivity

as the percentage of items completed. Results showed that three out of the four students increased digits correct per minute when self-monitoring productivity plus rewards, but only after meeting on-task and accuracy criteria (Lannie & Martens, 2008).

Falkenberg and Barbetta (2013) incorporated self-monitoring with performance feedback. They investigated the effects of a self-monitoring package on math and spelling homework completion and accuracy rates of four fourth grade students with disabilities. The self-monitoring package consisted of two self-monitoring components (one at home using a self-monitoring sheet that contained homework tips and the other in the classroom using a computer program called KidTools) and a brief conference with the special education teacher to review the self-monitoring sheets (performance feedback). Students completed math and spelling homework. They were taught the self-monitoring package procedures. The teacher checked the spelling and math homework and calculated accuracy and completion (productivity) rates. Accuracy and completion were defined in the same manner as in Lannie and Martens (2008). Results provided strong support for the effectiveness of self-monitoring in improving completion and accuracy of spelling and math homework for students with disabilities (Falkenberg & Barbetta, 2013).

The present study examined the effectiveness of an intervention package, consisting of self-monitoring, performance feedback, and reinforcers, on math computation of students in a general education classroom. Unlike the previously mentioned studies, this intervention combined self-monitoring with reinforcers and performance feedback. This intervention was implemented in a B-A-B withdrawal design. The intervention package created will improve accuracy and productivity of math computation for students in a general education classroom.

Method

Participants

Four second-grade students in a general education classroom participated in all phases of this study (three males and 1 female). There were two African American students, one Hispanic student, and one Caucasian student in this study. All four students were 7 years of age. Their class was composed of 36 children and two teachers instructed them. The teachers chose the four participants based on their average achieving levels in math. Average achievement indicated that the students possessed the skills to complete math computations but were not necessarily consistent in their performance. After the teachers chose the participants, they gave the students consent forms to take home to their parents/legal guardians. All four students brought back the consent forms signed by their parents/legal guardians consenting to their participation in this study.

Setting

This study was conducted in a Miami-Dade County Public School in North Miami, Florida. The school serves grades K to 8. The school was comprised of 1703 students in the year 2012-2013. The demographics for the 2012-2013 school year were as follows: 15.4% White Non-Hispanic, 34.8% Black Non-Hispanic, 47.4% Hispanic, 1.6% Asian, 0.1% Islander, and 0.8% Multi-racial.

All experimental sessions lasted 2 to 5 minutes in the students' classroom during the morning announcements and instruction. The study lasted 3 weeks. The session length varied according to the study phase. Each session was conducted individually at a table located near the teachers' desk with the experimenter seated next to the student. While each of the four students participated in this study the teachers continued classroom instruction.

Materials

Curriculum-Based Measurement in Math (M-CBM)

Math computation probes were created using an online generator on interventioncentral.org, which randomly created problems according to the math skills chosen. Each participant was given one math probe per session for all phases of the study. The math skills chosen were appropriate for second grade. Based on the students' second grade curriculum, the following types of math problems were included in the computation probes: 1-to-2 digit number addition without regrouping, two 3-digit number addition without regrouping, 1-to-2 digit number additionwith regrouping, two 1-digit number subtraction, and 2-digit number subtraction without regrouping. Each probe contained 20 problems arranged in four rows by five columns.

Self-monitoring Graph

The self-monitoring graph was used for each session of the intervention phases. It was used to graph the number of items answered correctly (accuracy score) per session of the intervention. The graph served two purposes it allowed students to record their behavior as well as monitor their progress. It was printed on both sides of an 8.5 inch by 11 inch sized sheet of paper. On each side of the sheet, there were six columns representing six sessions and twenty rows representing the total number of math problems per probe.

Performance Feedback

After each intervention session, the researcher reviewed the self-monitoring graph with each participant. The researcher drew the participant's attention to the previous session's score and commented on each participant's progress throughout the intervention sessions. During performance, feedback the researcher and participant collectively decided whether the participant surpassed the previous intervention session's accuracy score. If the participant surpassed his or her previous accuracy score, he or she obtained a reinforcer from the reinforcer menu.

Reinforcer Menu

The reinforcer menu used was composed of a list of objects that possessed a reinforcing quality for the students participating in this study. It was developed by consulting with the participants' teachers and observing the subjects to find out their likes/dislikes. The completed reinforcer menu consisted of the following: pencils, stickers, and erasers. Subjects were allowed to choose one object every time they surpassed the previous session's accuracy score. Although other stimuli (things to eat, activities, and types of praise or statements) could have been incorporated into the reinforcer menu, they were not due to the potential for classroom disruption.

Measurement

The participants' performance on each math probe determined their accuracy scores. The researcher also noted each participant's productivity per math probe. Participants were given 2 minutes to complete each math probe per session. Accuracy was measured as the percentage of math problems answered correctly. It was calculated by dividing the number of problems answered correctly by the total number of problems (correct and incorrect) then multiplying by 100. Productivity was measured as the percentage of math problems completed. It was calculated by dividing the number of problems completed by the total number of problems (completed and not completed) then multiplying by 100. During the intervention phases (B_1 and B_2), each student counted the number of problems they answered correctly (accuracy score). Next, each student graphed his or her results per intervention session (# correct). Then the researcher calculated and recorded accuracy. Productivity was independently calculated and recorded by the researcher for each student per session. During the baseline phase (*A*), the researcher counted the

number of problems each student answered correctly (accuracy score) and the number of problems he or she completed per session. Then the researcher also calculated and recorded the accuracy and productivity for each student per session.

Experimental Design and Procedures

The B-A-B withdrawal design was used to evaluate the effectiveness of an intervention package consisting of self-monitoring, performance feedback, and reinforcers on math computation. This design was chosen for practicality and the time constraints of this study. The intervention phases (B_1 and B_2) consisted of the participants completing a math probe per session for 2 minutes. Participants then checked their answers with an answer key that was provided. Next participants graphed the number of problems answered correctly (accuracy scores) on their self-monitoring graph. Then the researcher calculated and recorded the accuracy and productivity. Students moved onto the next phase when a stable accuracy score was established. The baseline phase (A) consisted of the participants completing a math probe per session for 2 minutes. The researcher then counted the number of questions answered correctly (accuracy scores) and the number completed. Then the researcher also calculated and recorded accuracy and productivity for each session.

Training Sessions

Before starting the experimental sessions, each student was taught the procedures for each phase of the study (intervention and baseline phases). The researcher modeled the procedures of each phase.

Intervention package phase (B_1 and B_2)

During the intervention package phase, accuracy and productivity were measured. The participant was given the following materials per session: a pencil, crayon, self-monitoring graph, math probe, and answer sheets. The answer sheets corresponded to each math probe. They were identical; the only difference was that the answer sheets included the answers to the problems (www.interventioncentral.org).The participant was given 2 minutes to answer a math probe per session. While the participant completed a math probe, the answer sheets were laid face down on the table. Upon completion, the participant checked his or her answers using the answer sheets. He or she counted the number of questions answered correctly (accuracy scores) and then illustrated the results on the self-monitoring graph using a crayon. The researcher independently counted, recorded, and calculated the number of problems completed (productivity). Performance feedback was given after each session. The experimenter reviewed the self-monitoring graph with each student and commented on his or her progress. Each participant had the opportunity to earn his or her choice of a preferred reinforcer at the end of each session. The student must have surpassed their previous accuracy score to obtain a reinforcer. The intervention package phases continued until each participant demonstrated performance stability. Performance stability was established by calculating a mean line. Once a mean line was drawn for each phase, if at least 80% of the data points fell within a 15% value range of the mean line then the phase was complete, stability was established (Tawney & Gast, 1984).

Baseline (A)

During baseline, the participants were given 2 minutes to complete a math probe per session. No additional materials were provided to the students. For each session, the participants were instructed to complete math problems until the experimenter said stop at the 2-minute mark. The researcher independently measured accuracy and productivity. Performance stability of the data was also established with a mean line.

Inter-observer Agreement

An independent observer collected reliability data. The independent observer was one of the classroom teachers. The independent observer accompanied the researcher on approximately 30% of the observations. The independent observer and researcher checked each participant's responses and recorded data, the number of problems answered correctly and the number of problems completed per math probe. Inter-observer reliability was calculated by dividing the number of agreements by the sum of the agreements and disagreements and multiplying by 100. This resulted in an inter-observer agreement of 100%.

Results

Accuracy

One out of the four participants demonstrated a clear improvement in accuracy of math computation due to the intervention package. Student 1 demonstrated a high volume of correct responses during the intervention phases and a decrease in correct responses during baseline. During the first intervention phase, B_1 Student 1 obtained a mean of 19.25 correct responses. For the baseline phase, A the mean of correct responses decreased to 16.33. In the second intervention phase, B_2 the mean increased to 18.50 correct responses. Although the remaining participants' data does not show a strong improvement across all phases, the data does illustrate an increase in correct responses from the baseline phase to the second intervention phase. Student 2 obtained a mean of 16.25 correct responses in B_1, a mean of 17.77 correct responses in A and a mean of 19.25 correct responses in B_2. Student 3 obtained a mean of 15.25 correct responses in B_1, a mean of 16.33 correct responses in A, and a mean of 18.25 correct responses in B_2. Student 4 obtained a mean of 15.75 correct responses in B_1, a mean of 17.33 correct responses in A, and a mean of 19.25 correct responses in B_2 (see Figure 1). The median performance across participants was calculated to further examine the effects of the intervention on students 2, 3, and 4 (see Appendix B for Figure 3). The median performance across students 2, 3, and 4 depicted an improvement in accuracy with the implementation of the intervention package. A decrease in accuracy was visible in the baseline phase. Overall, the data suggested that the intervention package improved accuracy to some degree across all participants.

Productivity

Data depicted similar results for productivity as it did for accuracy for each participant. Student 1's performance in productivity illustrated an increase in the intervention phases and a decrease in the baseline phase. During the first intervention phase, B_1 Student 1 obtained a mean of 20 completed problems. For the baseline phase, A the mean of completed problems decreased to 16.67. In the second intervention phase, B_2 the mean increased to 18.50 completed problems. Although the remaining participants' data does not show a strong improvement across all phases, the data does illustrate an increase in completed responses from the baseline phase to the second intervention phase. Student 2 obtained a mean of 17 complete responses in B_1, a mean of 18.67 completed problems in A, and a mean of 19.25 completed problems in B_2. Student 3 obtained a mean of 15.50 completed problems in B_1, a mean of 17 completed problems in A, and a mean of 19 completed problems in B_2. Student 4 obtained a mean of 16.25 completed problems in B_1, a mean of 17.33 completed problems in A, and a mean of 19.50 completed problems in B_2 (see Appendix A for Figure 2). The median performance across participants was calculated to further examine the effects of the intervention on students 2, 3, and 4 (see Appendix B for Figure 4). The median performance across students 2, 3, and 4 depicted an improvement in productivity with the implementation of the intervention package. A decrease in productivity was visible in

the baseline phase. Overall, the data suggested that the intervention package improved productivity to some degree across all participants.

Discussion

The purpose of this study was to evaluate the effectiveness of an intervention package consisting of self-monitoring, performance feedback, and reinforcers on math computation of four second grade students in a general education classroom setting. It was found that the intervention package had a highly positive effect on math computation for one participant (Student 1). Both accuracy and productivity increased during the intervention phases. During the baseline phase accuracy and productivity decreased. The intervention package was effective to varying degrees for the remaining three participants (Student 2, Student 3, and Student 4). The intervention package seemed to improve accuracy and productivity the most across baseline and the second intervention phase (B_2) for each of the remaining participants. Thus, the results suggest that the intervention package used to increase math computation, accuracy and productivity, was effective for participants in this study.

The students chosen to participate in this study were average achieving in math computation. These students were inconsistent in their performance of math computation. Thus intervening on the target behavior, accuracy and productivity of math computation, was beneficial for the students. Although , the intervention package improved the accuracy and productivity of the four participants in varying degrees generalizability was established. Results showed that the intervention package increased accuracy and productivity for all four participants. Future researcher could be conducted with more students and using different designs, such as the multiple treatment design, in order to establish a strong functional relationship between one of the components of the intervention package and the target behavior.

Overall, participants' accuracy and productivity increased in the intervention phases and decreased in the baseline phase. Although these results support the intervention package, it is unknown whether a particular component of the intervention package is responsible for the effectiveness of the intervention or whether the combined components are responsible for the overall effectiveness. The intervention package had positive effects on accuracy and productivity in varying degrees across participants. This could be explained by carryover effects of the first intervention phase on the following baseline phase for each participant. Efforts were made to minimize threats to internal validity by implementing the intervention with fidelity. However, it is probable that external factors influenced the results of this study, such as the participants' history and classroom environment. Replications of this study could provide more information on the effectiveness of the intervention package used. Thus in the future, this intervention package could be used with children with learning disabilities or difficulties in math computation.
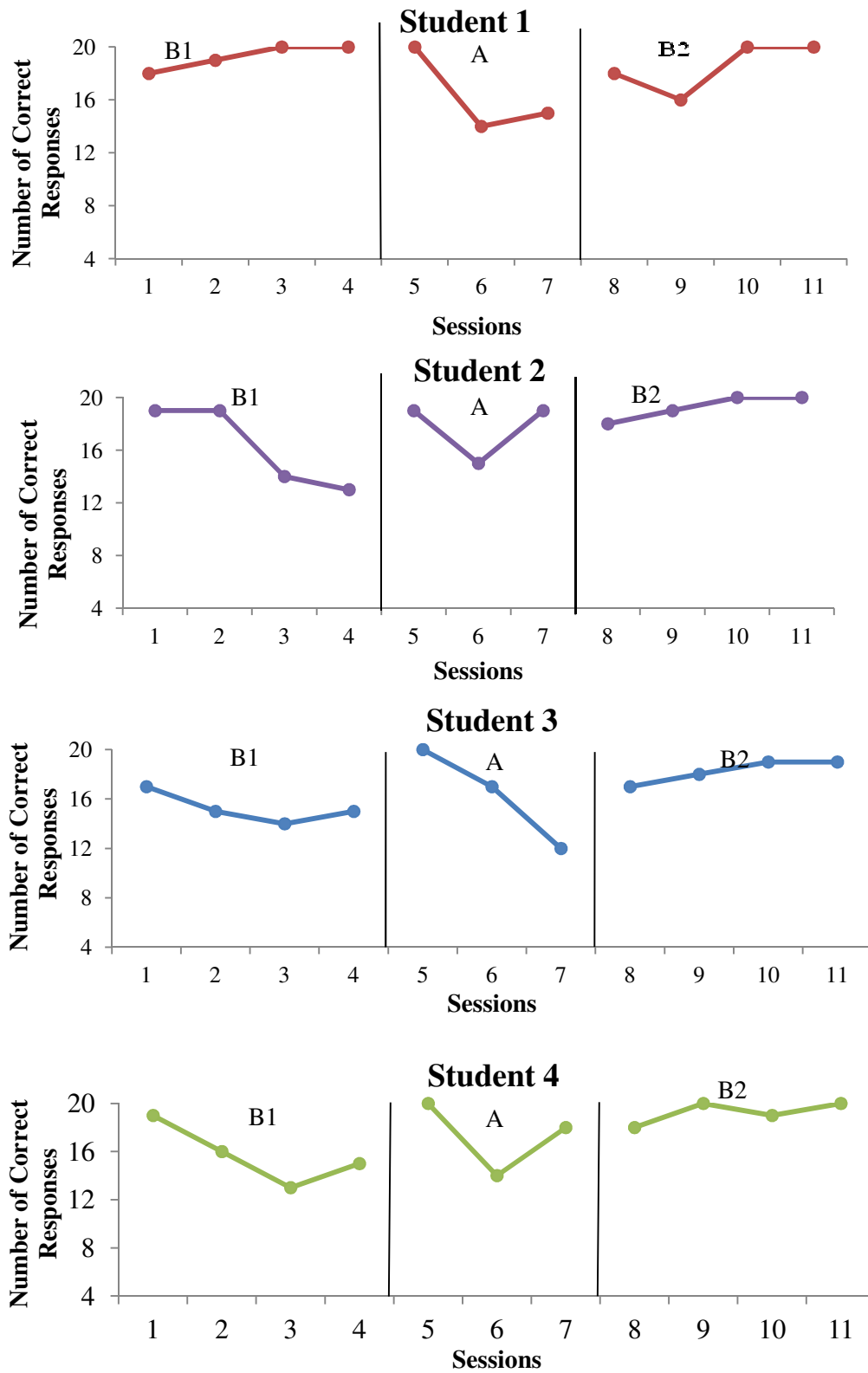
Figure 1: Math Computation Data: Number of Correct Responses

References

Cooper, J. 0., Heron, T. E., & Heward, W. L (2007). Applied behavior analysis (2nd ed.)
Columbus, OH: Pearson.

Falkenberg, C. A., & Barbetta, P. M. (2013).The effects of a self-monitoring package on
homework completion and accuracy of students with disabilities in an inclusive general
education classroom. Journal of Behavioral Education, 22(3), 190-210. doi:
http://dx.doi.org.ezproxy.fiu.edu/10.1007/s10864-013-9169-1

Lan, W. (2005). Self-monitoring and its relationship with educational level and task importance.
Educational Psychology, 25, 109-127.

Lannie, A. L., & Martens, B. K. (2008). Targeting performance dimensions in sequence
according to the instructional hierarchy: Effects on children's math work within a self-
monitoring program. Journal of Behavioral Education, 17(4), 356-375.

Maag, J. W. (1993). Differential effects of self-monitoring attention, accuracy, and productivity.
Journal of Applied Behavior Analysis, 26(3), 329-344.

Montague, M. (2007).Self-regulation and mathematics instruction. Learning Disabilities
Research & Practice, 22(1), 75-83.

Rafferty, L. A. (2010). Step-by-step: Teaching students to self-monitor. TEACHING
Exceptional Children, 43(2), 50-58. Retrieved from
http://ezproxy.fiu.edu/login?url=http://search.proquest.com/docview/815957665?accounti
d=10901

Rafferty, L. A., & Raimondi, S. (2009). Self-monitoring of attention versus self-monitoring of
performance: Examining the differential effects among students with emotional
disturbance engaged in independent math practice. Journal of Behavioral Education,
18(4), 279-299.

Rathvon, N. (2008). Effective school interventions: Evidence-based strategies for improving
student outcomes (2nd ed.). New York, NY, US: Guilford Press, New York, NY.

Rock, M. L. (2005).Use of strategic self-monitoring to enhance academic engagement,
productivity, and accuracy of students with and without exceptionalities. Journal of
Positive Behavior Interventions, 7(1), 3-17.

Shimabukuro, S. M., Prater, M. A., Jenkins, A., & Edelen-Smith, P. (1999).The effects of self-
monitoring of academic performance on students with learning disabilities and
ADD/ADHD. Education & Treatment of Children, 22(4), 397-414.

Tawney, J.W., & Gast, D.L. (1984). Single subject research in special education. Columbus, OH:
Merill.

Wood, S. J., Murdock, J. Y., & Cronin, M. E. (2002).Self-monitoring and at-risk middle school
students: academic performance improves, maintains, and generalizes. Behavior
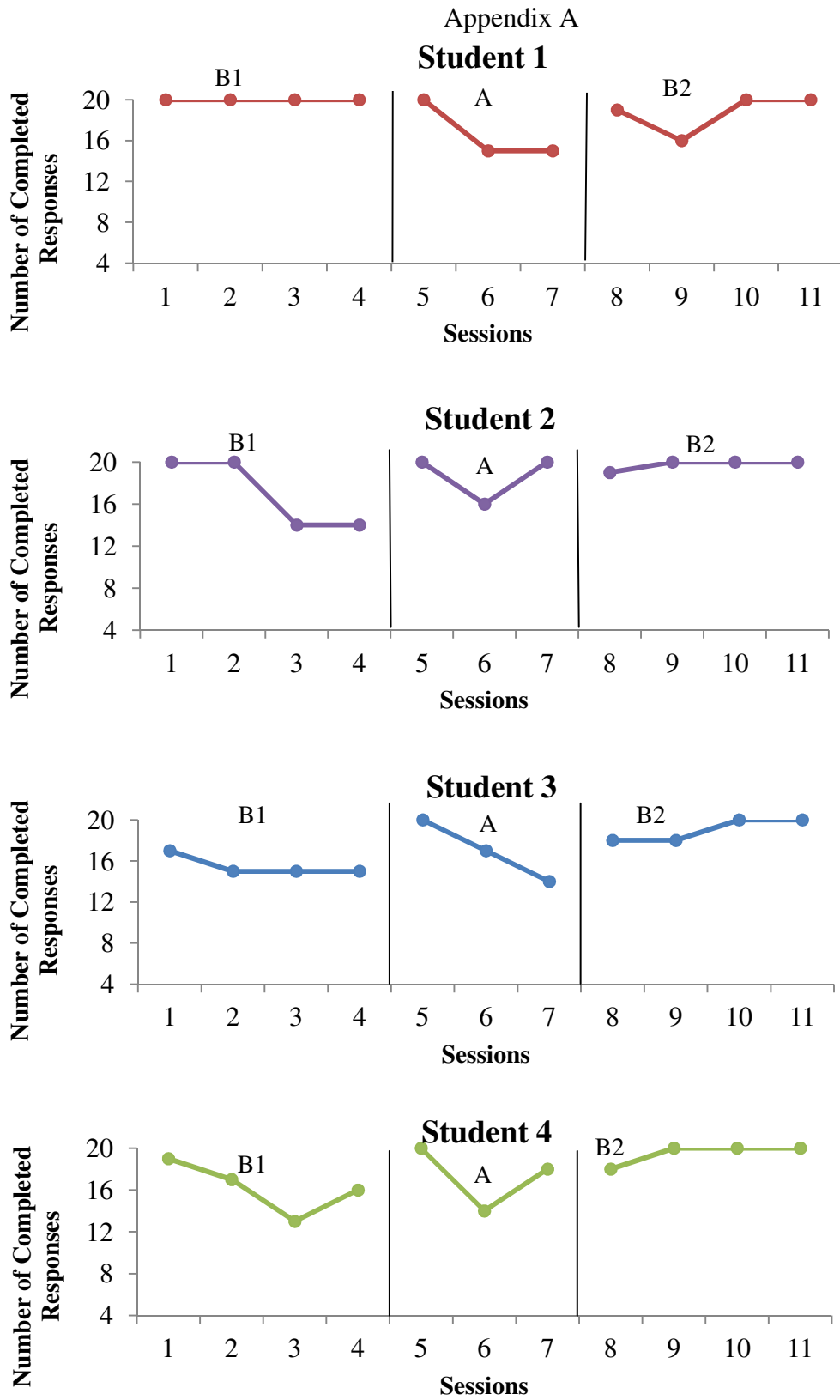Modification, 26(5), 605-626.

Appendix A

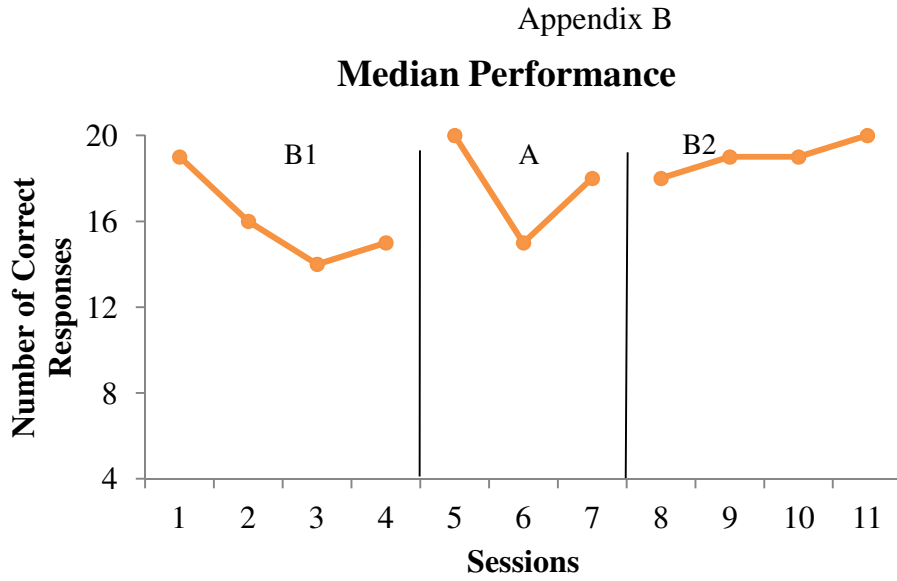*Figure 2:* Math Computation Data: Number of Completed Responses

Appendix B

Median Performance

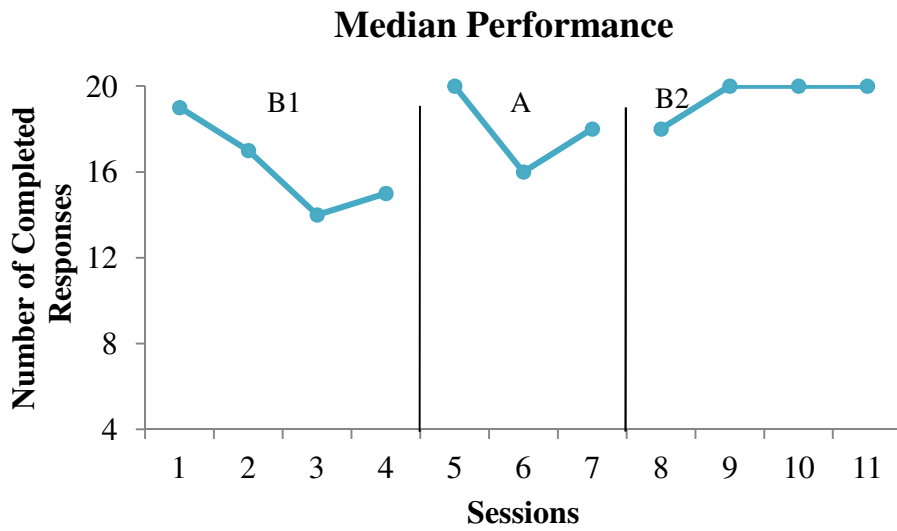*Figure 3:* Median Student Performance: Number of Correct Responses

Median Performance

Figure 4: Median Student Performance: Number of Completed Responses