DIRECT INSTRUCTION VERSUS GUIDED DISCOVERY WITH AT-RISK STUDENTS IN ALGEBRA I

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Abstract

Though research has indicated that successful completion of algebra is vital to high school academic success (Heppen, Sorensen, Allenworth, Walters, Rickles, Taylor, & Michelman, 2017), the most effective methods for teaching students who are at risk for failure have not been definitively identified. Direct instruction and guided discovery are two instructional strategies that have been identified as potentially effective in helping at-risk students learn. This study explored whether guided discovery was more effective at helping at-risk students learn algebra content. Participants in the study experienced either direct instruction or guided discovery for the same mathematical content. Results of the study indicated that guided discovery was not significantly more effective than direct instruction for at-risk students, nor was guided discovery more effective overall. Further research is needed to examine the differences between the two teaching methods.

Keywords: algebra, direct instruction, guided discovery, mathematics instruction

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Beginning with the passage of No Child Left Behind (2001), special education students, at-risk students, average students, and above average students were placed into the regular mathematics classrooms together. The implication is that teachers are being expected to address the needs of a diverse student population in the high school mathematics classroom. "The emphases on heterogeneity, special education inclusion, and reduction in out-of-class services for gifted learners, combined with escalations in cultural diversity in classrooms, make the challenge of serving academically diverse learners in regular classrooms seem an inevitable part of a teacher's role" (Tomlinson, Brighton, Herthberg, Callahan, Moon, & Brimijoin, 2003, p. 119). Teacher education programs in the United States train teachers extensively in keeping the average student engaged. However, it seems that there is less of a focus on the most effective ways to engage special education or at-risk students.

There is significant research on the effectiveness of specific interventions in areas, such as reading, with at-risk students; however, there is very little research exploring effective mathematics interventions for students who are at risk of failure (National Research Council, 2002). Research suggests the use of certain instructional strategies are more effective in the inclusive classroom, including direct instruction, discovery learning, cooperative learning, team teaching, and differentiated instruction. However, which of these instructional strategies is most effective for at-risk learners remains unclear.

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Literature Review

Research states that "students who fail algebra are significantly less likely to graduate on time" (Heppen, Sorensen, Allenworth, Walters, Rickles, Taylor, & Michelman, 2017, pg. 272). There are many reasons that students who are considered at-risk are falling behind in the mathematics classroom. Pugalee (2001) suggests that at-risk students often do not receive the best curriculum resources and are frequently placed in low-level classes that lack rigor. Furthermore, due to the emergence of the inclusion movement, a major concern for educators is figuring out how best to teach the at-risk student and match instruction to his needs (Miller & Mercer, 1997) while still meeting the needs of the regular education student. According to Miller and Mercer, "[i]n addition to designing a curriculum that takes into account learner goals, teachers of mathematics must implement curriculum using effective instructional techniques with research support" (p.53).

Two techniques that have been utilized in teaching at-risk learners are direct instruction and discovery learning; however, the research on the effectiveness of these strategies is contradictory. Supporters for each type of instruction claim that their technique is the best for reaching students who are at-risk in the mathematics classroom. According to Rosenshine (2008), one problem with the research is that it is seldom explained explicitly how direct instruction differs from discovery learning.

Direct Instruction

Direct instruction is an approach where the instruction is led by the teacher (Rosenshine, 2008). Rosenshine (2008) goes on to further elaborate that direct instruction is based on the premise that every student is capable of learning mathematical concepts in well-structured lessons. Those lessons include ensuring well-designed instruction that students can easily follow, allowing students to practice problems and receive proper feedback, and allowing students to advance through the curriculum at a regular pace. Research has shown that direct instruction is an effective instructional strategy for students with learning disabilities (Steedly, Dragoo, Arafeh, & Luke, 2008). However, there is limited research on the effectiveness of direct instruction with the broader category of at-risk students. One study found that direct instruction was a more successful instructional strategy than the discovery approach for students when they are learning more difficult topics, such as Algebra (Anderson, Corbett, Koedinger, & Pelletier, 1995).

Discovery Learning

Discovery learning is also known as inquiry teaching or open inquiry learning (Mandrin & Preckel, 2009). "Learning theorists characterize learning to solve problems as discovery learning, in which participants learn to recognize a problem, characterize what a solution would look like, search for relevant information, develop a solution strategy, and execute the chosen strategy" (Borthick & Jones, 2000, p. 181). Bicknell-Holmes and Hoffman (2000) describe discovery learning as a student-centered approach where students explore a problem and make general assumptions through their inquiry based on the integration of their existing knowledge with their new general assumptions.

Spencer and Jordan (1999) noted that discovery learning should have a specific framework for the student to work through, should give the student the responsibility to work through the material and discover the new concept, should include a guide to help the student focus and direct his or her own learning, and should have a way for students to reinforce the concepts learned. This type of discovery learning is called guided discovery learning. In guided discovery, the teacher uses guides and references to help the students through the discovery process and guide them to the desired result (Mandrin & Preckel, 2009). According to Mandrin and Preckel, discovery learning has been shown in the past to improve students' ability to transfer skills from topic to topic.

In the debate of discovery learning verses direct instruction, more empirical research has been conducted on the impact of the direct instruction approach with at-risk students. Kirschner, Sweller, and Clark (2006) point out that little empirical evidence exists to support a purely discovery based approach to teaching mathematics. They also note that there exist years of evidence to support direct instruction. An implication of the direct instruction verses discovery debate, with

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regard to at-risk students, is that there is a need for more empirical studies to compare the effectiveness of the two instructional strategies.

Methodology

The purpose of this study is to examine whether at-risk students who experienced guided discovery teaching methods for an Algebra unit demonstrated higher achievement than at-risk students who experienced direct instruction. Therefore, this study seeks to explore the following research question: Is guided discovery or direct instruction more effective in teaching mathematics to at-risk students?

Participants

For the purpose of this research, the definition of "at-risk learner" as established by the school district in which the study was conducted was used. Therefore, a student was categorized as at risk if he or she was at least 1 year behind in math, was on free and reduced lunch, was identified by the teacher as at-risk of failing the current math course, and/or was receiving special education services for a learning disability. A regular education student was identified as any student who was not identified as at-risk.

Participants in the study were students who were enrolled in two Algebra 1B classes at a high school located in the south central United States. Students were in the 9th, 10th, or 11th grade, and ranged in age from 14 to 17 years old. Parental permission was obtained for all students prior to any data collection. Prior to data collection, 13 students were in the control group (direct instruction) and 22 students were in the treatment group (guided discovery). Both classes contained at-risk and regular students. Three at-risk students (1 from the control group and 2 from the treatment group) were eliminated from the study due to missing pre-test scores.

Table 1
Demographics of Participants

	Regular	At-risk
Control	10	2
Treatment	12	8

Research Design

Students in both classes learned the same material for a unit of instruction on graphing linear equations. The classes proceeded at the same pace, and the same homework and class-work assignments were given to all students. Both classes were taught by the same teacher. The unit was taught over a three-week time span.

For the control group, the teacher utilized only direct instruction. Each class period consisted of approximately 45 minutes of direct teacher instruction and 45 minutes of practice time. Lesson objectives were clearly written and defined on the board. Each lesson in the unit was structured in the same manner:

- A review of the previous lesson's material was presented by the teacher.
- Instruction on new material was completed by the teacher presenting the mathematical procedures through a series of examples, using small steps and allowing the students to practice the steps after the examples were given.
- The students practiced the new material, receiving assistance and feedback from the teacher during seatwork time.

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Students in the treatment group were taught the same material but were given guided discovery activities instead of direct instruction. The guided discovery lessons followed the following guidelines:

- A review of the previous lesson's material was presented by the teacher.
- Students were provided with a discovery learning worksheet to use as a guide during the guided discovery activity. Students were instructed to work individually for 15-20 minutes while the teacher acted as a facilitator. The teacher then led a class discussion of the students' discoveries and recorded a summary of the discovered material on the board.
- The students practiced the new material, receiving assistance and feedback from the teacher during seatwork time.

Data Collection

A pre-test and post-test assessment of 20 multiple-choice questions was administered to all participating students, with the exception of 3 at-risk students who were absent on the day the pre-test was given. The assessment was developed by the classroom teacher and was designed to assess the specific material that was covered in the unit. The pre-test was administered on the first day of the unit and the post-test was administered on the last day of the unit.

Results

Descriptive statistics showed that at-risk students in the control group scored considerably lower on the pre-test than at-risk students in the treatment group and regular students in both groups. However, the at-risk students in the control group showed the largest gain from pre-test to post-test (see Table 2). The gain scores for the other three groups were similar, with the regular students in the control group showing the least amount of gain.

Table 2
Pre- and Post-test Descriptive Statistics for Type of Instruction and At-risk Status

Group and At-Risk Status	n	Pre-Test Mean	Post-Test Mean	Mean Gain
Control, Regular	10	5.20	12.10	6.90
Control, At-risk	2	3.50	13.00	9.50
Treatment, Regular	12	5.58	13.50	7.92
Treatment, At-risk	8	5.50	12.75	7.25

Because of the small sample size, nonparametric analyses were used to compare mean gain scores. To answer the research question, the Wilcoxon Exact test was conducted using only the at-risk students from both control and treatment groups. Results showed that there were no significant differences between the gain scores of at-risk students in the control and treatment groups ($T = 12.00$, $p = 0.80$).

Post Hoc Analysis

A post hoc analysis was conducted to determine if there were differences in overall gain scores between the control and treatment groups. The Wilcoxon Exact test was conducted to compare the two types of instruction. Results showed that there were no significant differences between the mean gain scores of the control ($M = 16.25$) and treatment groups ($M = 16.65$; $T = 195.00$, $p = 0.46$).

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Discussion

The results of this study showed that guided discovery was not more effective for at-risk students than direct instruction. At-risk students in both the guided discovery and the direct instruction classroom showed gains from pre-test to post-test, but there was not a significant difference between the mean gain scores of the two groups. Though the at-risk students in the guided discovery classroom showed a higher mean gain score than those in the direct instruction classroom, these gains can be primarily attributed to a gain score of 17 points for one at-risk student in the guided discovery classroom.

It is interesting to note that the regular students in the direct instruction classroom showed the least amount of gain from pre-test to post-test. Visual inspection of the data revealed that, out of the 35 participants, only two students scored lower on the post-test than on the pre-test, and both of those students were regular students in the direct instruction classroom. The two scores substantially lowered the mean gains for the regular students in the direct instruction classroom, which raises the question of whether direct instruction is effective for all students.

The post hoc analysis demonstrated that overall mean gains were not significantly different between the direct instruction and the guided discovery classrooms. Since the pre-test scores for the two groups were also similar (4.92 for direct instruction; 5.55 for guided discovery), this result shows that the use of discovery learning did not have more or less of an impact on student learning than direct instruction. The majority of the students in this study scored at least 8 points higher on the post-test than the pre-test, regardless of the type of instruction.

Limitations

It should be noted that the very small sample size, particularly for treatment group, had a substantial impact on the statistical results of the study. Future research with a larger sample may yield different results. In addition, guided discovery was not the typical method of instruction for the teacher in this study, and the lack of familiarity with the guided discovery process on the part of both teacher and students may have influenced the amount of learning that took place. Implementation of guided discovery on a regular basis may impact the results of future studies.

Conclusions

The results of this study indicated that, in general, direct instruction and guided discovery are equally effective in helping students learn mathematics. This contradicts the work of Anderson, Corbett, Koedinger, and Pelletier (1995), which indicated that direct instruction was more effective for teaching difficult material to at-risk students. More research is need to explore how at-risk students respond to both teaching strategies and which is most appropriate for students who are at-risk for failure.

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