<u>Research Proposal:</u> Can playing abstract board games improve the introductory statistics course grades of college freshmen with low math SAT scores?

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<u>Introduction</u>

Many college curricula include introductory statistics courses. Additionally, the concepts learned in statistics courses are needed in many upper level courses and practical applications. It is critical that students learn, understand, and can apply these skills when needed. Beaubouef and Mason cite poor math skills and problem-solving abilities as a common reason that students drop out of Computer Science programs. Since these skills are very valuable, it is important to academic success and to real-world success to investigate new ways of teaching and facilitating understanding of these critical concepts. Improving the introductory statistics course grades of college freshmen with low math SAT scores would support their learning and help improve their chances for success in academia and in their subsequent work life. In addition to benefitting individual students, performance improvements in statistics could also benefit higher education institutions since institutions would be more likely to have better retention rates.

Abstract board games are games where the gameplay and strategy are more important than the game's theme or illustrations. These types of games rely more heavily on players' choices and skill rather than chance or luck. Some examples of classic abstract board games include checkers, chess, and go. Since player choices, predicting future game states, and overarching strategy matter, playing abstract board games may help improve math proficiency, particularly in tasks of probability. Additionally, as Jimenez-Silva, White-Taylor and Gomez (2010) said, "Through the use of board games, students can see how mathematics is applicable and valuable in their everyday lives." Previous research has shown that other types of board games do improve math skills and proficiency. Researchers Hawes, Cain, Jones, Thomson, Bailey, Seo, Caswell and Moss found that a teacher-designed and teacher-led numerical board game intervention has a significant impact on numeral identification skills after a relatively short intervention using a number board game. (Hawes et. al., 2019, p.79) Laski and Siegler measured multiple types of math learning including: numeral identification, number line estimation, count-on, and numeral position encoding. Additionally, Laski and Siegler advocate for the cognitive alignment approach to mathematics learning to be discussed in more detail later in this proposal.

Board games could also be used to help children from low-income families make large and quick educational gains in numerical magnitude comparison, number line estimation, counting, and numeral identification. (Siegler, 2009, p. 118) These improvements in math proficiency may help close the existing gap in standardized test scores between low income students and their higher income peers. Through the use of an instructional improvement intervention called Every Classroom, Every Day, scores of 9th and 10th grade students improved on standardized tests of math achievement. (Early et al., 2016, p. 3) Given the successful use of board games with low-income younger children and given the successful instructional intervention that led to improved standardized test scores of math achievement found in previous research, it stands to reason that playing abstract board games will improve math proficiency of low-income students with poor standardized test scores.

Literature Review

For the majority of articles which contain experiments, the research purposes were to study the impact of playing board games on mathematics learning and in most cases on specific math skills. One experiment that differs from the rest was done by Early et al. It set out to determine whether implementing the Every Classroom Every Day (ECED) strategies could improve standardized achievement test scores in both Math and English Language Arts. The Cognitive Alignment theory of mathematics learning is supported by Laski and Siegler. They explain that essentially the more closely the learning activities and the related physical materials are aligned with the desired mental representation, the more likely it is for learners to acquire the desired and intended representation. (Laski & Siegler, p. 854) Number games can be optimized so that they physically illustrate the desired mental representation. In this way the game itself reinforces the envisioned learning outcome.

The main research hypotheses were that an intervention (board games or improved instruction through ECED) would improve math learning. Early et al. set out to test two main hypotheses: (1) ECED will increase student achievement in math and English language arts (ELA), as measured by standardized tests; and (2) the extent to which the ECED components are implemented as intended will be associated with greater increases in student math and ELA achievement. The main independent variables in most of the experiment-based articles was the treatment group, meaning the group that received the intervention. The interventions varied by experiment, but were a specific type of board game or an intervention designed to increase student engagement and improve teachers' skills. In ECED the dependent variables were math achievement and English language arts achievement. For most of the other experiment-based articles early numerical understanding was tested through some of the following specific mathematics skills; counting, numeral identification, number line estimation, symbolic comparison, count-on, encoding, and magnitude comparison.

Randomized controlled pretest and posttests were the preferred type of research design in the relevant articles. Siegler (2009) even followed up about two months after the final game-playing session. Regarding selection, participants were randomly assigned. Most of the articles had a unit of analysis that included individual students aged 4-6 years old. The ECED article had 8,789 participants who were in ninth or tenth grade chosen from twenty schools stratified within five districts. In several of the studies detailed observational notes were collected by teachers and/or instructional coaches. In the studies done by Siegler, and Laski & Siegler, the experimenter played specific types of board games with the participants and gathered data from the pretests, game play sessions and posttests.

The majority of the articles that focus on board games improving math skills and learning are done with a much younger population typically elementary school aged. Additionally, three of the articles have relatively small sample sizes: 54 children (Hawes et al., p.4), 42 & 21 children (Laski & Siegler, p. 855-856), and 36 children (Siegler, p. 120). Early et al. were able to state that improved instruction could improve standardized achievement test scores. In addition to small sample sizes there may be some issues with generalization since the studies were done on a small scale in a small geographic area. However, none of these articles measure the impact of playing abstract board games on math standardized achievement improvement in older students.

Methodology

This proposal aims to improve introductory statistics course grades of college freshmen with low math SAT scores through play of abstract board games. The proposed research question is, "Can playing abstract board games improve the introductory statistics course grades of college freshmen with low math SAT scores?" The first theory that provides support to this research hypothesis is the Situated Learning Theory. The socio-cultural dynamic and participation are central to situated learning (Handley et al., p. 3). Board games are interactive and encourage students to participate in the learning experience. Further, they incentivize learning using the cultural dynamic of competitive play. The second theory underlying this experiment is Accretion, Tuning, and Restructuring: Three Modes of Learning by Rumelhart and Norman. Normal daily learning happens through accretion (Rumelhart and Norman, p. 3) One applicable option for learning is that students can learn through restructuring. Abstract board games provide new information and new organization that accompanies it. Ideally, the student can then use these new structures for new interpretations of knowledge and acquisition of new knowledge. (Rumelhart and Norman, p. 4) The intention is to help students either create or tune new schemata. The Cognitive Alignment Theory is also applicable to this research proposal since ideally students will be shown the desired mental representation, be required to interact with it, and hopefully will adopt it.

Current research supports that playing board games can be used to help young children make large and quick educational gains in math skills. It is reasonable to suppose that abstract board games may be designed to help older students make educational gains in math and statistics skills. The null and research hypotheses are as follows: H_0: Playing abstract board games will not improve the introductory statistics course grades of college freshmen with low math SAT scores.
H_A: Playing abstract board games will improve the introductory statistics course grades of college freshmen with low math SAT scores.

Similar to the articles cited above, the main independent variable is whether the participant played the abstract board game intervention. The dependent variable is the introductory statistics course grades of college freshmen with low math SAT scores. Participants will be randomly assigned from different sections of the same instructors' introductory statistics classes to the control or intervention groups. Statistical analysis will be used to ensure that the control group and the intervention groups are not statistically different regarding other variables such as age, grade level, gender, race, socioeconomic status, etc. Controlling these factors helps ensure that if a difference is observed, then the proposed independent variable would be the likely cause. The proposed design will be a randomized experiment, where the participants' low math SAT scores will serve both to qualify participants and as an informal pretest to provide a baseline for the level of participants' math skills prior to intervention. Introductory statistics course grades will serve as an informal posttest. Participants will be college freshman with low math SAT scores operationalized as a math SAT score below 500. For this proposal, each participant is considered a unit of analysis. As Siegler did, the experimenter will teach participants how to play the abstract board game that best displays the concepts learned in the introductory statistics class and then create detailed logs of game play, duration of game play, and observational notes. Since the research hypothesis is directional, a one-tailed hypothesis test would be used to ascertain whether the intervention of playing abstract board games is effective and statistically significant.

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