Journal of Education and Human Development
September 2017, Vol. 6, No. 3, pp. 38-52
ISSN: 2334-296X (Print), 2334-2978 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jehd.v6n3a5
URL: https://doi.org/10.15640/jehd.v6n3a5

Students with Disabilities and LEGO© Education

Shirley Disseler[1] & Gabrielle Mirand[2]

Abstract

This study examines the effects of inquiry-based learning on students with mild or moderate disabilities. After all materials and preliminary procedures were completed, students participated in a series of lessons, along with the completion of a pre-assessment and post-assessment to gather baseline and intervention data. Each lesson utilized inquiry-based learning methods through the use of LEGO© Education EV3 Mindstorms. These activities targeted areas involving force, motion, direction, and distance. The students' conceptual understandings were measured by an assessment created by the principal investigator. Results indicate a positive increase in content knowledge and disposition toward learning. The intervention process consisted of two weeks, actively using eight days to investigate these concepts. The discussion focuses on the various methods necessary to take in order to make STEM education and active progress more accessible to students with mild or moderate disabilities by making changes in instruction, inclusion, and attitudes.

Keywords: inquiry-based learning, STEM approach, STEM literacy, mild and moderate disabilities, special education, constructivism, sociocultural theory, integration, 21st century skills, free and public education (FAPE), LEGO© Education

An Inquiry-Based Approach to Improve Growth in Mild and Moderate Disabilities

Introduction

The United States federal government has recently noted a critical lack in the level of involvement in science, technology, engineering, and mathematics (STEM) fields in relation to globally competitive career opportunities for future populations. The implementation of STEM education was initially meant to challenge gifted students within these areas. Society continues to experiencea technological revolution that is demanding more STEM jobs in the global marketplace. "Although degrees in some STEM fields (particularly biology and computer science) have increased in recent decades, the overall proportion of STEM degrees awarded in the United States has historically remained at about seventeen percent of all postsecondary degrees awarded. Meanwhile, many other nations have seen rapid growth in postsecondary educational attainment – with particularly high growth in the number of STEM degrees awarded" (Kuenzi, 2008, p. 1). As a result, teachers are highly encouraged to become more knowledgeable in STEM fields through professional development and improved teacher preparation. Teachers are acquiring integration strategies in order to promote problem-solving skills and show real world application necessary for students to become proficient in 21st century acquirements. In addition to promoting STEM education, the government is also investing in STEM research and development. About three billion dollars of federal funding is being allocated to STEM education.

[1] Associate Professor and Chair, Elementary and Middle Grades Department, High Point University, LEGO Education Ambassador, NA
[2] Special Education Teacher, High Tech High ,San Diego California

With this amount of money being invested, all students need to be included into this equation in order to account for FAPE – free and public education. Nonetheless, hesitancy remains present when discussing and attempting to integrate STEM approaches into special education. More than six million students represent the mild and moderate disability category of preK-12 schools throughout the United States and this population makes up about thirteen percent of the total population of students in the nation (Kinson, Ormsbee & Jensen, 2011). In order to achieve the initiative of global competitiveness, and be able to fill STEM related fields in the future, this category of students cannot be ignored or overlooked. According to Evmenove and others (2014) individuals with disabilities are employed in only five to six percent of STEM-related jobs in the United States currently and though these statistics are alarmingly low, a more positive aspect to note from the statistic is that students with mild and moderate disabilities "can" occupy STEM-related fields.

The purpose of this research was to investigate the effects of inquiry-based learning methods on the growth of students with mild and moderate disabilities. To provide clear parameters of the mild and moderate disabilities category, this heterogeneous group of individuals is best described as unique learners with behavioral differences, often needing a simple adaptation or modification to the curricula, teaching materials, or special management strategies in order to perform up to their highest potential achievement levels. These students may exhibit any number of special needs, including but not limited to, learning disabilities, emotional or behavioral disorders, attention deficit disorder, cognitive disabilities, and autism (Kinson, Ormsbee & Jensen, 2011). Special education services currently allow students with disabilities to receive the necessary accommodations, modifications, and remediation to make growth in various areas despite any limitation. Inquiry-based learning through STEM education is a strategy being implemented in many general education classrooms across the nation, but has not reached most special education resources and programs. It has become a popular notion that STEM education through inquiry-based learning is a strategy that can only be implemented with students who do not have any disability barriers, showing potential to excel in STEM fields through previous success with the core subjects. An investigation of the effects of inquiry-based learning through STEM education on students with mild and moderate disabilities could elicit further research and development of programs to be created for this select group of students. How do inquiry-based learning strategies, such as those used in programs like? This study will investigate howLEGO© Education, impacts growth in students with mild or moderate disabilities. This study includes pertinent definitions and literature available on the topic as well.

Definitions

STEM and Inquiry-Based Learning Background

A full understanding of STEM Education, coupled with an understanding of special education is important to interpreting the relationship between the two areas. First off, STEM education or STEM literacy is the balance and fusion of multiple academic disciplines (science, technology, engineering, and mathematics) that encourage students to communicate, critically think, and troubleshoot to become creative and innovative learners (Howard-Brown & Martinez, 2012). The National Research Council (2011) defines STEM literacy as "the knowledge and understanding of scientific and mathematical concepts and processes that required of personal decision making, participation in civic and cultural affairs and economic productivity for all students" (p. 5). This system of integration, or the breakdown of isolating content areas, is the core of the STEM approach. The STEM approach allows students to explore and brainstorm strategies to perform tasks to evaluate and revise proposed ideas. Not only does the STEM approach eradicate the idea of isolated subjects, but also it incorporates 21st century skills and inquiry-based learning (Vasquez et al., 2013).

With the rise and quick expansion of technology, the demands of society are changing rapidly and requiring students to develop interactive skills in order to prepare for a future in the 21st century. These 21st century skills incorporate the ability to communicate effectively, using models and tests to provide evidence of thinking. These skills also encompass the social skills engrainedwithin collaboration in order to encourage students to work with others, and to respect other group members' contributions.Our global economy drives business and trends that can affect the entire population of a given country and understanding the implications of global issues and events is essential to problem solving and critical thinking skills necessary of the 21st century.

The 21st century calls for new skills beyond an Internet connection, as well as, knowledge and ways of learning to prepare students with abilities and competencies to address the challenges of an uncertain, changing world. (Collier Kuhlthau, 2010). An education that utilizes STEM-based ideology allows students to develop these skills using the integrated approach to test ideas, and theories. Students learn through trial and error, testing various aspects, and understanding how to manipulate variables in order to receive an accurate perception of the test results. Learning through STEM education provides all students with a foundation of integrated concepts and processes to allow the content and activity to become more applicable to the students' lives as well as the surrounding world to develop indispensable skills for the unpredictable future.Inquiry-based learning is complementary to STEM education. "Inquiry requires more than simply answering questions or getting a right answer. It espouses investigation, exploration, search, quest, research, pursuit, and study. It is enhanced by involvement with a community of learners, each learning from other in social interaction" (Collier Kuklthau, 2010, p. 2). This type of learning,which involves probing questions, trial and error, and revision through exploration, mirrors the engineering design process used in STEM education. In the STEM approach, students are encouraged to question and develop ideas through brainstorming and collaboration; then use these ideas to devise a plan and blueprint for how to test new ideas. Students perform the procedure and evaluate the results, deciding if the test was successful or if the ideas need to be revised. Even though students do not necessarily know how to perform the processes, the students understand why and how these scientific and mathematical processes occur through trial and error. Teachers probe students with questions in order for critical thinking and problem solving to occur. Ultimately, this process leads to conceptual understanding and content growth.

Theoretical Framework

Special education has consistently faced a stigma in its own label. Students with mild and moderate disabilities are often seen as incapable of participating in opportunities, such as STEM integration and inquiry-based learning, due to preconceived and generalized notions regarding content capabilities. Psychologist Lev Vygotsky states that students' learning experiences are impacted by social interaction with adults and peers, and that learning is impacted by cultural beliefs and attitudes imposed on instruction strategies. The expectations and attitudes created by societal stigma, has continually influenced the access of children with disabilities to sociocultural knowledge, experiences, and opportunities to participate in shared or joint activities with peers.According to Boris Gindis(2003), "the search for positive capacities and qualitative characteristics in the upbringing (nurturing) of children with disabilities is the trademark of Vygotsky's approach whereby he passionately insisted on changing negative societal attitudes toward individuals with disabilities and called for the identification of a disability in a child from the perspective of strengths, not weaknesses" (p. 203). Hence, sociocultural theory is imbedded within special education, explaining how societal attitudes and cultural practices impact students with disabilities. (p. 203). This explanation of Vygotsky's sociocultural theory suggests that attitudes and cultural practices hold an immense amount of power upon student growth. With a positive attitude and a focus on strengths, the students have the opportunity to achieve growth. Another theory that is quite relatable to sociocultural theory is constructivism, entailing that academic achievement is constructed through the interaction of ideas and experiences dictated by students. Both sociocultural theory and constructivism take a very active role in learning, encouraging social settings to create experiences and learn from others, especially for students with mild and moderate disabilities. This type of active learning requires active facilitation, not a passive role from teachers (Harris & Graham, 1996). This active role can be accomplished through inquiry-based learning and STEM education. Both systems advocate social collaboration and troubleshooting to connect ideas to experiences. In addition, inquiry-based learning achieves Vygotsky's notion of the zone of proximal development, "the distance between what children can do without assistance and what they can accomplish with the assistance of a capable other" (Trent, Artiles & Englert, 1998, p. 286). Not only do inquiry-based learning and STEM education allow for opportunities to participate in active learning, but it provides social support to build upon ideas for students with mild and moderate disabilities.

Review of Related Literature

A review of the literature in the areas of inquiry-based learning with Special Education, and LEGO© Education seeks to look closely atexisting research regarding the correlations between student achievement and inquiry-based learning through LEGO Education programs. Positive outcomes as well as limitations to the use of LEGO© Education will be addressed. Specifically, the way in which this program has been utilized with special education programs will be discussed through the literature review.

Inquiry-Based Learning in Special Education Programs

Inquiry is often equated with science content due to the discrete features of the scientific process. However, the definition and use of this word has transformed in order to apply to all disciplines and across the disciplines through integration. Inquiry is now referred to as a concept that requires students to apply analytic skills to provoke thought and the application of these skills to better understand concepts and processes (Quigley, Marshall, Deaton, Cook & Padilla, 2011). One study, published by the Journal of Agricultural Education, seeks to investigate the effects of inquiry-based learning on special education students using agricultural education as the STEM aspect. This study used one group in which a pre- and post- test were disseminated. The teachers taught ten to twelve weeks to encompass the entirety of the inquiry-based unit which was split into seven lessons. This study used a large sample size to ensure effectiveness of the study. In addition, teachers were evaluated daily through an analysis of audio recordings. The results were evident. The study concluded that inquiry-based learning does not negatively affect the content knowledge achievement for students with mild and moderate disabilities. It was also determined that the process helped teachers gain confidence in utilizing this teaching method, which with the right topic area, can assist students of all the various educational need levels found in their classroom" (Easterly III & Myers, 2011). The Individuals with Disabilities Education Act of 2004 (IDEA) requires that students with special needs receive individualized instruction that meets their needs in the least restrictive environment which for most students with special needs, includes being mainstreamed into the regular classroom for at least part of the school day. Presently, ninety-seven percent of students with disabilities are in general education courses for at least forty percent of the day but it has not been determined the degree to which current methods of instruction are relevant for this group. If the methods are not relevant, new instructional methods need to be developed to meet the needs of these learners. (Easterly III & Myers, 2011). The integration of STEM education and inquiry-based learning being implemented with students with mild and moderate disabilities proves to be compatible through this study.

Inquiry-Based Instruction and Learning Disabilities

Inquiry-based learning is not a new teaching concept/strategy in the classroom and has been used in classrooms for many years to make learning more applicable and interactive for students. However, the prevalence of the stigma behind students in special educationcauses a hesitancy to include these students in this type of pedagogical style. A research team from the University of Tennessee designed a program to evaluate the effectiveness of inquiry-based learning with students with learning disabilities, a category of mild and moderate disabilities. They designed the study to explore the effects of Electric Circuits Kit Books on students with learning disabilities at the elementary level. The Electric Circuits Kit Book is an inquiry-based program designed to develop students' understanding of electricity and magnetism, simple electric circuits, parallel circuits, and conductors and insulators (Aydeniz, Cihak , Graham & Retinger, 2012). The research team notes that students with learning disabilities are often set up for failure when the proper accommodations are not made or accessible. Often, deficits in reading ability are the factors that inhibit student ability to enhance their knowledge content. Students were given a daily quiz with a time limit of twenty minutes before each session. Each session was fifty minutes in length, with a total of nine sessions. Students of both general education and those classified with a learning disability (LD) participated in the sessions together.

As a result of this study, all students made improvements in simple circuit problem solving and parallel circuit problem solving. In addition, students were able to maintain understanding of concepts and applied skills even six weeks after. The findings from this study suggest that the use of inquiry-based learning kits such as this one can have a significant influence on the learning outcomes of students with learning disabilities at the elementary school level; and that these students engage in science learning more effectively when curriculum emphasizes inquiry and performance-based assessments, and when the teacher is conscious of students' struggles (Aydeniz, Cihak, Graham & Retinger, 2012).

Students need to be engaged in the learning experience in order to take ownership. A sense of curiosity and investigation through inquiry-based learning is essential for students to identify with their strengths and weaknesses, collaborate, and analyze results to make revisions. This study proved that effective implementation of inquiry-based learning is very beneficial to the growth of students with learning disabilities. However, the results may have been limited by a few factors, including the small sample size. A larger sample of students would not limit the generalization of the program. In addition, the sessions were performed outside of the classroom in a resource room.

Performing this study in the classroom during instruction hours may be more conducive to what the study is trying to achieve. Lastly, confounding factors such as student group work and teacher effects were not controlled. The limitations of this study are not enough to diminish the results of the study. Using strategies that enforce scaffolding and creativity is essential for academic growth, especially for students with mild and moderate disabilities. Therefore, inquiry-based learning is one more successful pedagogical strategy to use for these students.

LEGO© Education and Inquiry-Based Learning

LEGO© Education provides a variety of programs that allow students to be active in learning experiences through building, engineering, and designing. The present research involving investigations about the effects of LEGO©Education on a variety of populations of students is centered on whether robotics education in general and in relation to LEGO© Education is long lasting or only a trending educational tactic. Another area of ambiguity is how robotics enables children to learn. The Tufts Center for Engineering Educational Outreach (CEEO) has been working over the past decade to discover if LEGO© Mindstorms, a robotics program, would be practical and accessible even for elementary grades. A program was designed to offer after school programs for teachers, parents, and children to teach about programming and constructing. This program also offered conferences to allow teachers to build a community as well as provide teacher support for the product. Despite what the program has to offer, LEGO© Education encouraged and aided students to make growth unless the program was disseminated by ill - prepared teachers that simply provided the answers or by the improper use of pedagogical content (Brophy, Klein, Portsmore & Rodgers, 2008). As this study suggests, students learning through LEGO© Education gain achievements through the Engineering Design Process as well as collaboration and socialization with other classmates. According to Johnson (2003), "robotics is the most effective way of motivating and supporting the study of many areas of the curriculum. The evidence is that robotics also has an impact on children's social skills, and helps them develop teamwork skills. Robotics certainly encourages children to use their imagination and be innovative in design" (p. 20). The limitations of this study originate from the lack of teacher training as well as the lack of funding for teachers to purchase programs such as LEGO© Education.

In another study conducted by Wendell and Rogers (2013), a program was designed to implement engineering design process units in relation to the curriculum for third to fourth grades. Using Science Through LEGO© Engineering, the researchers were investigating the relationship between this program and the science content knowledge and attitudes of the students. The study focused on four main domains – animal adaptations, material properties, simple machines, and sound. For a two-year period, this study attempted to answer the question of whether engineering had an impact on student's knowledge and attitudes towards science content in comparison to students who learned the content through traditional teaching methods. Students were divided into two groups, implementing Science Through LEGO© Engineering and using traditional science methods of teaching. As a result, students participating in LEGO© Engineering made significantly greater gains in animal adaptations, materials properties, and simple machines than students using traditional teaching. Although students in LEGO© Engineering did achieve growth in the sound category, it was not a significant difference between the LEGO© Engineering group and the traditional group. Overall, the study concluded that the LEGO© Engineering group's use of the engineering design process, a form of inquiry-based learning, had profound achievement effects on students. This integration method proved to provide a valuable learning experience (Wendall & Rogers, 2013).Despite the success of thestudy, there exists few limitations to implementing this type of program into schools. First,this program requires a great amount of time for teacher preparation in order to implement the engineering design challenges. Another limitation of this program is the amount of time it takes to completely implement the units. Promoting the engineering design process in conjunction with inquiry-based learning can utilize an immense amount of time. Lastly, the financial investment required for the programs is very high making it difficult for schools to be able to afford both the material and the training. The limitations that surround this study can deter many schools from using this program simply due to lack of time and money. However, the results are loud and clear. "The study's findings suggest that engineering design-based science instruction can be an effective and engaging method of science education. Its results give continued support for efforts to include engineering in K-12 science instruction and highlight the need for deep study of the mechanisms by which engineering design facilitates young students' science learning" (Wendall & Rogers, 2013, p. 534).Due to the gap in the current literature base, it is difficult to make a claim that LEGO Education Ev3 Programs are successful within the special education classroom.

The current study not only seeks to evaluate the relationship between LEGO© Education and academic growth among students with mild and moderate disabilities, but also adds to the literature base to fill the current gap and promote the need for more research in this area in order to create change in special education methods.

Method

Subjects

Participants in this study included eleven children (*n=11)* with mild or moderate disabilities (seven males and four females) ranging in age from 9-10 years of age. The males make up 63.6% of the subjects. The females compose 36.4% of the sample. The disabilities varied among the students; however, each of the students has been labeled with a mental/intellectual disability. It should be noted that each of these students is one to two years behind students within the same peer age group without learning disabilities. The identification of the participant's disability will remain confidential throughout this study. The students volunteered to participate under the permission of the child's guardian. Therefore, each student and student's guardian received and signed two forms in order to participate - a child consent form and a guardian permission form. Participants were not randomly selected due to the fact that they were assigned to the class into which the researcher conducted the study. The participants of this study were selected due to convenience sampling at a private school in the state of North Carolina. At this school, all students receive services within their classes, keeping class sizes to a maximum of fifteen students. It is important to note that most of these students have played with LEGO© products before, but not necessarily LEGO© Education Solutions for Learning. Some students participate in afterschool clubs involving engineering, robotics, and programming. Other than the few experiences, inquiry-based learning is not a part of their normal routine in school.

Materials

A researcher-created assessment was used to measure the growth of the students after implementing LEGO© Education as the inquiry-based learning program (Appendix 1) Due to the specific age range of the students and maintaining accordance with the science standards of the state of North Carolina, the assessment was created to measure growth in areas covering force and motion. The pre-assessment, or baseline, gathered information about the students' demographics and previous experience with inquiry-based learning. However, the pre and post assessments contained the same ten questions about force, motion, and coordinate maps. Using the same ten questions will show progress, digress, or stagnant development through the inquiry-based learning process. These questions consisted of fill in the black with a word bank. It also consisted of free response answers, calculations, and multiple-choice to provide variety to different kinds of learners. The inquiry-based learning program used during this study was LEGO© Education EV3 Mindstorms. Lesson plans were designed with the post- assessment, or intervention, in mind. The kits also required the use of iPads with the Mindstorms software in order to manipulate the EV3 bricks. Another piece of software used during this study was the SparkVUE application, downloaded onto a mobile device. This application was used to measure the acceleration rate of the cars, allowing students to realize that gravity was the force pulling their car down the slide. Butcher paper and markers were used to understand coordinates and maps. Lastly, masking tape was used to create an obstacle course for the students to follow. Besides the EV3 Mindstorms kits, the rest of the materials were at a very low cost, if not free. Table 1 provides a summary of the learning activities and experiments done during the intervention process.

Table 1 LEGO© Education Intervention Lessons and Activities

Skills	Learning Activities/Experiments
Force and Motion	Students constructed a car using pieces from LEGO© Education EV3, designed to hold an iPhone 6, to send down a slide to measure the acceleration rate using an application called SparkVUE. Students programmed EV3 bricks using Mindstorms application on the iPad to make their bricks travel at a certain speed to make accurate turns in a premade path.
Distance and Direction	Students programmed EV3 bricks using Mindstorms application on the iPad to make their bricks travel through a premade path without touching the edges of the "road" (tape). Students created a treasure map using a coordinate map, plotting points of destruction and obstacles at particular coordinates. Students programmed EV3 bricks to travel along their treasure maps along a designated path to avoid set obstacles to make it to the treasure, or X. Students calculated the distance their EV3 brick traveled to get to the treasure, or X.

Students were asked questions while performing each of the tasks about force and motion concepts as well as distance and direction. Students also did a review session of these concepts before starting any activity to refresh their memory of the concepts they are learning through this program.

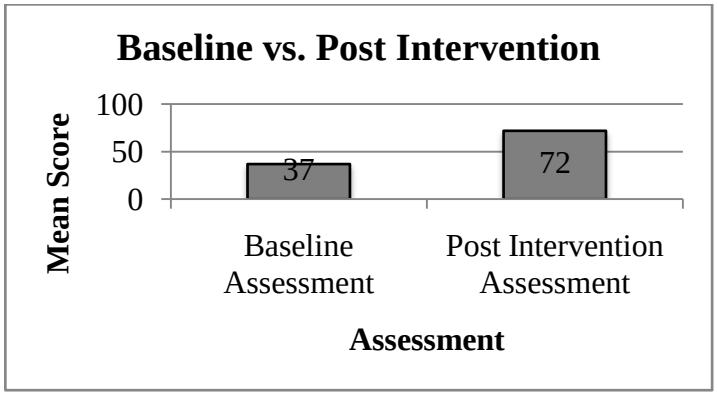
Procedure

After all forms were collected and reviewed, the students were issued a pre-assessment to gather demographic information as well as collect baseline data before any implementation of the inquiry-based LEGO© Education Solution. To accommodate disabilities, each question was read aloud and repeated three times. The students participated in six lessons involving LEGO© Education after the day of the pre-assessment. On the last day, the students were given the post-assessment as well as interviewed by the principal researcher. Each student was asked three qualitative questions about their experience using the LEGO© Education Program. This mixed-methods study includes information gathered from the pre and post assessments andthe study also included interview questions and observations. Students were also asked questions before each lesson about different components learned in order to review concepts. This data was not recorded due to its purpose. However, the students were asked questions about personal views and opinions of inquiry-based learning and STEM education to understand how views and opinions may have affected their performance.

Analysis

This study evaluated the effects of inquiry-based learning on students with mild or moderate disabilities using LEGO© Education EV3 Mindstorms. The baseline test proved that the students did not know much about force or motion, and little to nothing about direction and distance. After participating in six inquiry-based learning lessons involving LEGO© Education EV3 Mindstorms, the students were retested using the same questions to evaluate their growth. In comparison to the baseline test, the students grew a total of 35 points from the previous mean, averaging at a score of 72 as noted in figure 1 below.

Figure 1Baseline and Post Intervention Assessments Results



However, this data does not include data points from one subject due to the outlier information that may skew the scores. The growth rounds to a 95% increase to the post intervention assessment. This progress shows the benefits of using inquiry-based learning methods on students with mild or moderate disabilities. An evaluation of the baseline assessment, post intervention assessment, and growth levels (Table 2a and 2b)was conducted to see if the differences in gender affected their achievement. After analyzing the t-values and p-values in the independent samples t-test, the significance level was not low enough to provide even a 95% confidence level.

Table 2a: Independent Sample T-Test Group Statistics of Gender (with the Outlier)

Group Statistics				
	Gender	**N**	**Mean**	**Std. Deviation**	**Std Error mean**
Baseline	Female	4	32.50	20.616	10.308
	Male	4	41.43	14.639	5.533
Intervention	Female	4	52.50	35.940	17.970
	Male	7	72.86	17.995	6.801
Growth	Female	4	20.00	49.666	24.833
	Male	7	31.43	16.762	6.335

Table 2b: Independent Samples T-Test of Gender (with the Outlier)

Levine's Test of Equal Variances		t-Test for Equality of Means						
F	Sig	t	Df	Sig. (2-tailed)	MeanDiff	Std Error Diff	95% confidence interval diff	
							Upper	Lower
Baseline								
Equal variances Assumed	1.986	.192	-.845	9	.420	-8.920	10.572	-32.845 14.988
Equal variances not assumed	-	-	-7.63	4.7(f) 79 (m)	.481	-8.29	11.699	-39.424 21.567
Intervention	1.93	.194	.127	9	.233	20.35	15.936	-56.407 15.692
Equal Variances Assumed								
Equal Variances---- Not Assumed	------		1.05	3.8 81	.351	20.35	19.214	-74.353 33.639
Growth								
Equal Variances Assumed	3.686	.087	-.574	9	.580	11.42	19.915	-56.479 33.622
Equal Variances Not Assumed	-----	------	-.446	3.3 96	.683	11.42	25.628	-87.863 65.006

According to Table 2a and Table 2b the lowest confidence level, with or without the outlier data points, is a 0.087. Even though this p-value is low, it is not low enough to provide a significant confidence value. Due to the lack of significance, it would be fair to make an assumption that although gender could have been a factor, the significance level does not provide enough confidence that it impacted the results. In addition, there were 3 more boys than there were girls in the study. Due to the small sample size, the evaluation of gender impacting scores would not provide a valid significance level. A larger sample size would be needed in order to evaluate the relationship.Different factors were compared to the data results to evaluate for any type of correlation in the study.

Various correlational tests (Tables 3-6) were run to examine the relationship between the progress of the students and their particular attributes previous to the intervention. Students were given a demographic and preference survey attached to their baseline assessment to gather more background information about the students. Students were asked if they participate in any kind of afterschool club that involves STEM or one of the STEM fields. About 8 of the 11 students answered that they participated in some kind of club. Some involved robotics while others simply involved an extracurricular science component. A correlational analysis was conducted, to evaluate for any relationship between achievement and previous experience in a STEM related afterschool club. The results proved that previous experience in an afterschool club and growth on the post intervention test were not strongly related according to the R-value that was closer to 0 than to -1 or 1.

The data regarding how the student learned science bestwas also evaluated as four correlational factors, the data for how the student learns science the best, based upon personal learning styles. To evaluate this, this information was broken up into four different correlational factors. None of the students marked the first option, reading a science textbook. Therefore, it would have been redundant to prove that there is no correlation by running a test. The next two options were discovering science explorations online and working in teams to solve problems through trial and error. About 8 out of 11 students indicated a preference for discovering science through online modalities.

About 4 out of 11 students identified a preference to work in teams to solve problems using trial and error strategies. A correlational test was conducted on both aspects separately. Both preferencesdid not show any relationship to the progress on the post intervention assessment. The last option, doing experiments and hands on activities, did show slightsignificance to the growth of the students on the post intervention assessment (*p=0.02)*. About 10 out of 11 students responded with a preference to do experiments and hands on activities when learning science. This option took the majority of the preferences when it came to learning science. In addition, the data indicates a high R-value *(R=0.828)* for the preference to learn science doing experiments. With a high R-value, the relationship between preferring to learn science doing experiments and hands on activities and the post intervention assessment score is positively correlated. Similarly, it could be stated that if the student enjoys doing experiments and hands on activities, then the students would have done well in the intervention process, allowing them to achieve growth in the post intervention assessment. Although this cannot be definitely defined, this positive correlation relates to the nature of the study. The inquiry-based intervention of LEGO© Education by nature is hands-on and experimental. Logically, the positive correlation between the two factors suits the nature of this study.

Table 3: Correlation Between Pre- Total, Post- Total, and Previous Experience

		N	Intervention	Club
Intervention	Pearson Correlation	11	1	-.438
	Single (2-tailed)	11		.178
Club	Pearson Correlation	11	-.438	1
	Single (2-tailed)	11	.178	

Table 4: Correlation Between Pre- Total, Post- Total, and Learning Methods #2

		N	Intervention	Learn Best Option 2
Intervention	Pearson	11	1	-.275
	Sig. (2-tailed)			.414
Learn Best Option 2	Pearson	11	-.275	1
	Sig (2-tailed)	.414		

(p<.05)

Table 5: Correlation between Pre-Total, Post Total, and Learning Methods #3

		N	Intervention	Learn Best Option 3
Intervention	Pearson	11	1	.213
	Sig. (2-tailed)	11		.529
Learn Best Option 3	Pearson		.213	1
	Sig. (2-tailed)		.529	
(p<.05)				

Table 6: Correlation between Pre-Total, Post Total, and Learning Methods #4

		N	Intervention	Learn Best Option 4
Intervention	Pearson	11	1	.828**
	Sig. (2-tailed)	11		.002
Learn Best Option 4	Pearson		.828**	1
	Sig. (2-tailed)		.002	
(p<.05)				

Findings

After evaluating the data points in the descriptive statistics analysis as well as the independent samples tests, the students made progress from thebaseline assessment to the intervention assessment. (Table 7) As a group of eleven students, the participants received a mean of 38.18 on the baseline assessment. About three to four questions out of ten questions were answered correctly as the average for the group. This average jumped up to 65.45 after evaluating the intervention assessment, averaging six to seven questions correct out of ten questions ($\overline{x} = 65.45$). The standard deviation of these assessments describes how far the data points are from the mean of the group for both assessments. For the baseline assessment, the standard deviation is 16. 624. This score measures to be about sixteen to seventeen points away from the mean of 38.18 in both directions on the bell curve. Therefore, the highest and lowest scores on the baseline assessment are about 10% and 50%. Comparing this information to the post intervention assessment, the standard deviation is 26.216. Although this standard deviation is much higher than the baseline assessment, even the minimum score is higher than the mean of the baseline assessment. The maximum and minimum scores for the post assessment would be close to 40% and 90% since the mean is 65.45. The standard deviations show growth from baseline assessment to post intervention assessment as a collective group. However, it is important to note that this information is based off of the data that includes all 11 subjects, including the outlier data points.

Table 7: Means and Growth Percentages by Students

Summary of Student Means							
Student ID		Force & Motion			Distance & Direction		
		(Questions:8, 9, 11, 13, & 14)			(Questions: 10, 12, 19a, 19b, 20)		
	Gender	Pre	Post	+/-	Pre	Post	+/-
1012	M	20	100	60	40	80	40
1013	F	20	60	40	0	60	60
1014	M	40	60	20	0	60	60
1015	F	80	60	-20	20	80	60
1016	F	80	0	80	20	0	20
1017	M	60	80	20	20	40	20
1018	M	80	100	20	40	60	20
1019	M	80	100	20	40	100	60
1020	F	20	100	80	20	60	40
1021	M	40	60	20	40	80	40
1022	M	60	60	0	20	40	20

The data points were recalculated to consider the study without the outlier data points to evaluate for any significance. (Table 8) When taking this data into consideration, a more positive affect is noted. The mean of the baseline data is very close to the original at 37.00. The standard deviation score for this assessment is also very similar to the original at 17.029, with a minimum of 10% and maximum of 60%. This range is slightly higher than the data that includes the outlier information.

The most discrepancy occurs when evaluating the post intervention assessment mean and standard deviation scores. The mean for the post intervention scores is 72.00; this mean is about 7 points higher than the mean including the outlier data. The standard deviation for the 10 subjects compared to the mean is 15.492. This standard deviation is much lower than those from the previous evaluation. This difference means that the outlier information affected not only the average of the group's progress; but also how far the data points are from the mean on an individual basis. The data including only the 10 subject's data points is a much more accurate picture of the intervention's results. The outlier information is a result of many absences and a few behavioral issues that hindered the subject's ability to participate and gain anything from the intervention. Therefore, the descriptive statistics using 10 subjects is a more valid result than the descriptive statistics involving 11 subjects, which includes the outlier.

Table 8: Descriptive Statistics (with the Outlier)

Descriptive Statistics (with the Outlier)					
	N	Range	Mean	Std. Deviation	Variance
Baseline Assessment	11	50	38.18	16.624	276.364
Intervention Assessment	11	100	65.45	26.216	687.273

Table 9: Descriptive Statistics (without the Outlier)

Assessment Comparisons					
	N	Minimum	Maximum	Mean	Std. Deviation
Baseline Assessment	10	10	60	37.00	17.029
Post Intervention Assessment	10	50	100	72.00	15.492

Another test was evaluated in order to understand the confidence level of this study. The results of this test can be seen in Table 10 below. A one-sample t-test was used to evaluate the t and p scores for this study. In the test ran with the outlier data present, the significance level (p-value) shows to be 0.000. Being that this is less than 0.01, the confidence level for this study is higher than 99%. This level of significance is a rare finding, but quite plausible when an intervention succeeds. In the one-sample t-test without the outlier data point, the significance value prove to be the same. In conclusion, the p-value for both tests are p=0.000, which is enough significance to reject the null hypothesis. The probability of being wrong in rejecting the null hypothesis is extremely low. Therefore, the intervention methods of inquiry-based learning in this study proved to be of significant impact on the students' progress and growth, despite their disabilities. In both cases, with and without the outlier data, the t-value is less than one standard deviation from the mean. Therefore, the data points show that the group of participants was able to make considerable growth collectively.

Table 10: Confidence Level

		N	Mean	SD	t	Sign(2-tailed)	
Baseline	Without Outlier	10	37.00	17.029	6.871	.000	
Assessment	With Outlier	11	38.18	16.624	7.618	.000	
Intervention	Without Outlier	10	72.00	15.492	14.697	.000	
Assessment	With Outlier	11	65.45	26.216	8.281	.000	
(p<.01)							

Discussion

The purpose of this study was to examine the impact of inquiry-based learning on students with mild or moderate disabilities using LEGO© Education EV3 Mindstorms. It examined the acquisition and understanding of force and motion concepts as well as direction and distance concepts. The results of this intervention indicated a positive impact and were statistically significant enough to be 99% confident in order to reject the null hypothesis.

Even though this statistic does not include the outlier data points, this statistic does not change for despite the regression in those points. With or without these data points, the data proves to be 99% confident to reject the null hypothesis. This study has shown that although one of the eleven students regressed in conceptual understanding, ten of the eleven students made considerable growth. This one student's data points are considered outliers for this study. For the purpose of research, a discussion of the meaning of these results examines various areas in order to enhance the educational experience and increase academic growth. These areas include the impact of LEGO© Education Program on students with mild or moderate disabilities and using inquiry-based learning programs and methods to enhance pedagogical knowledge of special education and general education teachers to provide a more inclusive environment.

The data shows that this intervention is beneficial to the students' growth in STEM achievement. The growth not only shows in their academic achievement, but also in their behavior as well. The majority of these students are on behavioral contracts due to talking out of turn, physical disputes, verbal disputes, and defiance. During these two weeks of intervention, the students' behavior improved and the students felt empowered and gained confidence in their own abilities. Students that began the intervention shy and hesitant ended the intervention leading the show. Giving students with disabilities the ability to participate in STEM activities that involve inquiry-based learning gives them encouragement to think for themselves which is important for students who have been given a label that may hinder their confidence levels. The intervention also allows the law to be followed to the fullest extent. Most students with a mild or moderate disability are under inclusion services, allowing them to be apart of the general education classroom with modifications, accommodations, or occasional assistance from an aid or pull out services with a special educator. Keeping these students in the classroom during these types of activities keeps them included into the mainstream classroom, providing a fair educational experience under FAPE. The longer the students are included, the more the students feel "normal", allowing them to grow socially with their peers.

Impact of LEGO© Education on Student Attitudes and Preferences

Students were asked to identify the preferences and attitudes towards learning science concepts, as well as working with others. Students with mild or moderate disabilities, especially those diagnosed under the Autism Spectrum, tend to have difficulties socially and working with others in collaboration. On the pre-assessment, or the baseline test, the students were asked to fill out a few survey questions about their demographic information as well as their preferences. Most of the male students preferred to work alone rather than working with others in order to complete a task. Most of the female students had the opposite response, preferring to work with others to complete a task. In addition, most students participate in an after school activity that involves STEM or a field of STEM. Based on observation of the students' behavior and comments, the students were excited to work with LEGO© Education; however, when told they were to work in teams of two or three, the students became much more hesitant to begin working. A few students in the class are known to not get along together. It was important to the principal researcher to mix up the groups each session in order to give students the opportunity to work with different personalities. At the end of the intervention, the principal researcher interviewed each student to reevaluate their attitudes and preferences about inquiry-based learning and LEGO© Education. All except one student expressed that they enjoyed working with LEGO© Education and felt more confident in the material that they learned. Most of the students also claimed that they learned more about their classmates. These participants commented that working with partners makes the work easier and puts less stress on them individually. The three students that did not like working with partners expressed that they accomplished more on their own. These three students have also had the most experience with LEGOs© previous to this intervention. These students are known to lack sharing capabilities in class as well. Ultimately, this intervention allowed the students to learn more about different personalities and how to utilize people's strengths instead of focusing on their weaknesses.

Limitations

This study has lead to possibilities for future developments. Delving into the methods of the procedure, the assessment may need to be revised. The assessment, for this group of individuals proved to be a little too long. Students with mild or moderate disabilities often become discouraged when being given a packet of paper. The assessment can be shortened to two pages, front to back, while still obtaining the necessary information. In addition, the researcher did not anticipate the amount of time it would take to complete the assessment. Each question needed to be repeated three times in a slow format. This obstacle can also be avoided by shortening the length of the assessment. One of the questions on the exam did not have the proper answer in the word bank provided.

This problem was immediately resolved when the researcher asked the students to skip this particular question. Eradicating this type of problem will prevent any type of confusion on the students' behalves, allowing them to focus on the questions they can answer. A few of the students fixated on the fact that this question was not going to be answered. This problem could be avoided in the future by simply removing this question from the exam. Aside from the assessment, the lessons were thorough and detailed. However, after every lesson, students should write in a journal about what they have learned – a component that should be added to future studies. This study needed more qualitative data to compare to the quantitative data points. In addition to these limitations, this study needed to incorporate a larger sample size for a more accurate statistical analysis. Due to the small sample size, the significant value did not show to be 95% confident.

It would be of benefit to gather a sample size of twenty to thirty students. Another option would be to implement this study across a few classes of the same grade or age level to gather an even larger sample. Lastly, time was another issue when implementing this study. The participants in this particular study have a daily routine of science class for forty minutes. One of the biggest limitations of this study is access to LEGO© Education EV3 Mindstorms. Each of these kits is very costly, making it unaffordable or feasible for schools that lack significant funding sources. LEGO© Education does accept grants for schools that cannot afford this type of inquiry-based program. The lack of this kit does not limit STEM or inquiry –based learning. The use of these instructional strategies will challenge students to participate and become invested in their learning experience. Even though the LEGO© Education kits provide a directed structure to inquiry-based learning and STEM, a teacher with adequate pedagogical knowledge of these strategies and STEM education can scaffold the students' learning experience instead of relying on the LEGO© Education kits.

Future Implications

The purpose of this study was to develop an understanding of the benefits of inquiry-based learning on students with mild or moderate disabilities. The use of inquiry-based learning programs, such as LEGO© Education, has become more widely used in general education classrooms across the nation. This study encourages and provides educators the confidence to implement such programs with special education students as well. Not only did this study find a positive relationship between inquiry-based learning and performance, but the students felt more confident in their capabilities. Students' attitudes about the program and science in general were much more positive by the end of the study. These students were also able to retain more information simply due to the application and problem-solving component of inquiry-based learning. Students worked together in order to devise a solution, which encouraged social skills development as well. Using a program such as LEGO© Education allows students to connect with the materials being common toys found in many households Collaboration encouraged them to take turns and share their ideas in order to complete the task at hand. LEGO© Education is a program that is very student driven, leaving the teacher to scaffold their learning process and guide them to success without being in charge of their learning. The idea that students with learning disabilities are unable to participate in STEM activities, such as LEGO© Education and other inquiry-based learning programs, originates from a lack of belief or confidence in the students' and/or teachers' capabilities. With an understanding of the students' strengths and weaknesses, students with mild or moderate disabilities thrive in this type of learning environment. Professional development for general education and special education teachers is essential for both to understand not only how to implement this type of learning style into the classroom, but also to understand how to accommodate and modify with students who have mild or moderate disabilities in addition to understanding how to implement the STEM approach into the classroom. With STEM at the forefront of education across the United States, inquiry-based programs are essential among all students to form real world connections and prepare them for possible future careers.

References

Aydeniz, M., Cihak , D. F., Graham, S. C., & Retinger, L. (2012). *Using inquiry-based instruction for teaching science to students with learning disabilities*. International Journal of Special Education, 27(2), 189-206. Retrieved from http://files.eric.ed.gov/fulltext/EJ982873.pdf

Brophy, S., Klein, S., Portsmore, M., & Rogers, C. (2008). *Advancing engineering education in P-12 classrooms*. Journal of Engineering Education, 97(3), 369-387. Retrieved from http://search.proquest.com/docview/ 217948345? Accou ntid =11411

Collier Kuhlthau , C. (2010). *Guided inquiry: school libraries in the 21st century*. School Libraries Worldwide, 16(1), 1-28. Retrieved from https://comminfo.rutgers.edu/~kuhlthau/docs/GI-School-Librarians-in-the-21-Century.pdf Easterly III, R. G., & Myers, B. E. (2011). *Inquiry–based instruction for students with special needs in school based agricultural education*. Journal of Agricultural Education. Retrieved from http://files.eric.ed.gov/fulltext/EJ955689.pdf

Evmenova, A., Jones Ault, M., & Bausch, M. (2014, January 1). *Students with Disabilities CanParticipate and Succeed in STEM Education*. Retrieved from http://www.tamcec.org/wp-content/uploads/2013/02/STEM-4-MATN.pdf

Education, 52(2), 36-46. doi: 10.5032/jae.2011.02036

Gindis, B. (2003). *Vygotsky's educational theory in cultural context*. (pp. 200-221). New York: Cambridge University Press.

Retrieved from https://books.google.com/books?hl=en&lr=&id=mfCHutwHT-cC&oi=fnd&pg=PA200&dq=sociocultural theory and students with disabilities&ots=ugqSn8sWlA&sig=BLI6A6vvRSjc3dejjf4CHQAYUdY

Harris, K. R., & Graham, S. (1996, February 1). *Memo to constructivists: Skills count, too*. Retrieved from http://www.ascd.org/publications/educational-leadership/feb96/vol53/num05/Memo-to-Constructivists@-Skills-Count,-Too.aspx

Howard-Brown, B., & Martinez, D. (2012, May 6). *Engaging diverse learners through the provision of STEM education opportunities*. Retrieved from http://secc.sedl.org/resources/briefs/diverse_learners_STEM/

Johnson, J. (2003). *Children, robotics, and education*. Artif Life Robotics, 7, 16-21. doi: 10.1007/s10015-003-0265-5 (Johnson, 2003)

Kinson, K. D., Ormsbee, C. K., & Jensen, M. M. (2011). *Collaborating to teach students with mild to moderate disabilities in the inclusion classroom*. Differentiating Science Instruction and Assessment for Learners with Special Needs, K–8, Retrieved from http://www.sagepub.com/upm-data/40149_ch1_finson.pdf

Kuenzi, J. J. (2008). *Science, technology, engineering, and mathematics (STEM) education: Background, federal policy, and legislative action*. CRS Report for Congress, Retrieved from http://fas.org/sgp/ /misc/RL33434.pdf

National Research Council. (2011). *Successful k-12 stem education: identifying effective approaches in science, technology, engineering, and mathematics*. Washington D.C: National Academies Press. Retrieved from http://www.nap.edu/catalog/ 13158/ successful-k-12-stem-education-identifying-effective-approaches-in-science

Pandian, C. (2012, October 25). *Lego and autism: Considerations from the scientific research*. Retrieved from http://www.ageofautism.com/2012/10/lego-and-autism-considerations-from-the-scientific-research.html

Quigley, C., Marshall, J. C., Deaton, C. C. M., Cook, M. P., & Padilla, M. (2011). *Challenges to inquiry teaching and suggestions for how to meet them*. Science Educator, 20(1), 55-61.

Trent, S. C., Artiles, A. J., & Englert, C. S. (1998). *From deficit thinking to social*

constructivism: A review of theory, research, and practice in special education. American Educational Research Association, 23, 277-307.

Wendell, K., & Rogers, C. (2013). *Engineering design-based science, science content performance, and science attitudes in elementary school*. J. Eng. Educ. Journal of Engineering Education, 102(4), 513-540. doi:10.1002/jee.20026