 IMPROVING MOTOR SKILLS OF STUDENTS WITH DISABILITIES VIA ENGINEERING EDUCATION

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Abstract – Schools in Montreal have adopted various kinds of technologies and programs to help students with learning or speech impairments succeed based on one of the Quebec’s Education Minister’s mandates, notably through integrating these tools into the classroom. At La Société des Handicapés du Québec, students (ages 3-18) get the opportunity to interact with robots by building and programming them. The purpose of the study is to observe how teaching robotics can develop their motor skills or other cognitive abilities.

Over the course of 12 weeks, students (ages 3-4) were given building instructions and kits, and asked to build and program their robots. Students with robotics experience were grouped and considered as a baseline. The other students were separated into two other groups and had no prior experience. All three groups had students with and without special needs. The study aimed to analyze how motor skills and various other abilities improved over the 12 weeks in comparison to the children’s performance during the first session of the term. The number of lessons required for the three groups to reach similar results was also tracked. Overall, all students showed significant improvement in motor abilities. Both groups with no experience were able to reach similar precision and accuracy results as those with experience.

Keywords: robotics, education, disabilities, motor skills, engineering

1. INTRODUCTION

Learning about science is a provincial education requirement. Students, both elementary and secondary, are required to acquire various competencies in order to graduate, many of which include scientific and engineering concepts. Although the material taught is important, the way in which it is presented is often more important, but overlooked.

Children learn differently and have a wide range of interest. Being able to convey information can be a challenge, especially when a classroom has both regular development children and ones with special needs at the same time. These types of classrooms are found at various schools across the Canada and the most effective ones embrace the fact they have a diverse group of students who all learn in different ways [1]. Many teachers use the science, technology, engineering and mathematics (STEM) education requirements to teach cross-curricular skills, especially at the preschool level. The initial intent behind STEM education was to get students interested in pursuing science related fields post secondary. Fortunately, it has been observed that STEM activities actually help young children focus, increase vocabulary, collaborate with other children, and create scientific relationships [2]. Examples of such activities include having children build ramps to allow marble to slide down or build small funnel systems to watch how different sizes allow or restrict fluid flow.

Teaching children, with or without disabilities, requires constant stimulation. Whether through activities or by continuously asking questions, it is imperative that they are constantly engaged to remain focused. The best learning comes from a mixture of both planned and spontaneous learning [3]. When planning a STEM activity, teachers must ensure there is a knowledge and encouragement rich environment, which is achieved by establishing a framework where students are engaged and able to deepen their understanding through inquiry and thinking through their questions [4].

According to DeVries, a good STEM activity that allows the development of physical knowledge is when four aspects are included. The first being that it has to be producible. The child has to use his own actions to ensure that something is produced. The second is that what he produces has to be immediate. As soon as the child acts, the object has to do something. The third aspect is that the child has to see what happens. The final aspect is that the child has to be able to observe changes or variations based on inputs that they do themselves. Physical knowledge activities are extremely important and considered to be the best types of educational activities because they stimulate not only intellectual development, but also social ones [5].

Teaching, regardless for children with special needs or not, requires preparation, but also flexibility. Educators need to prepare but also anticipate that the lesson may take a different direction depending on the interest or skill level of the students. One of the most effective ways to plan a classroom activity, especially one related to STEM,
is through the Universal Design for Learning (UDL) [3]. This method is meant to help teachers adapt their lesson plans to ensure that the three parts of their student’s brain are being activated while learning. By having teachers present the information in various different ways and by encouraging participation, the “how”, “what” and “why” of learning are activated and developed in the brain [6]. Using this method, the activity is broken down into a basic guideline, with multiple add-ons available for the students who require additional challenges. Teachers are encouraged to allow their students to challenge themselves by taking on more add-on and by asking questions to develop their “what” skills further. Examples of such questions could be “What do you see?”, “What do you think we could do to improve?” etc. By having the child directly see how their changes affect the results keeps them engaged and is one of the four aspects that define an effective STEM activity. Keeping the students present is especially important for children with special needs, who often require greater assistance remaining engaged [3].

Certain schools have started to use technology as a way to incorporate different elements into teaching activities. After a curricular change that took effect in all provinces, schools were mandated to teach a technology component to their science classes, many schools decided to comply by teaching robotics [7]. In addition to compliances, research suggests that robotics can also be used to develop motor skills and abilities. In the article “Can Lego bricks and other construction toys boost your child’s STEM skills?” [8], the author stipulates that allowing children to play with such toys greatly improves their mental abilities, especially if done in the early development years. The author explains a small study that was conducted with 100 three-year-olds. They were asked to place three different colored and sized LEGO brick blocks in specific orientations. Out of the 100 students, there was a success rate of 40% for the easy task and 10% for the more advanced setup. Additionally, there were some positions that none of the children could get correctly. The reason being that “the three-year old brain exerts less executive control, and has less working memory capacity - which means kids find it harder to keep track of several different things simultaneously” [8]. Throughout the experiment, children made more mistakes when the designs incorporated a greater number of bricks, especially when their position changed directions. Furthermore, the children did not realize the importance of counting the pips to see if the bricks were aligned correctly. The researchers’ main hypothesis being that pre-schoolers struggle with the ability of thinking about objects in different ways. They saw the bricks as something they could build with, but not something they could subdivide.

Children with a naturally strong spatial skill may be more drawn to playing with toys that involve building and analyzing, which is why they might do better in a spatial awareness skills test, but the question remains can that skill be developed or improved through practice. For that reason, a study was conducted observing the brain activity of children while completing tasks. They were assigned two groups of 8-year-old children to participate in a series of organized play sessions [9]. One group played with structured blocks, while the other played word games, such as “Scrabble”. Before the sessions started, the researchers tested the children to determine a baseline of their spatial abilities. They were asked to examine letters from the alphabet and determine if they were flipped or just rotated. The children were recorded for both speed and accuracy in addition to measuring brain activity by functional magnetic resonance imaging (fMRI). There was no difference between both equally matched groups from the baseline. The children had to be matched based on gender, age, math test scores, education level of their parents, and how much time of spatial play they had before. After just five, 30 min sessions, which was spread over a period of approximately 12 days, there were significant improvements in the group that played with blocks. The children’s mental rotation abilities had improved, both in terms of speed and accuracy. Their scans also showed an increase in areas of their brain associated with spatial processing. Due to their play sessions, they were able to solve mental rotation problems in a new way [9]. It is evident that further studies need to be conducted, especially with a larger sample pool, but evidence points towards the fact that spatial ability is a muscle that can be strengthened through practice.

Education based research focuses on how to better the learning process for students and ensure that they are prepared for further studies. Based on the textbook Qualitative, Quantitative, and Mixed Methods Approaches by Creswell, the sample size for education research are often “convenience samples because they are naturally formed” [10]. In essence, if a certain theory is to be tested on a group of students, the test groups will be dependent on how the different classes are broken down and when students are available during the day or time of year. The sample size is organically formed based on factors that cannot be controlled by the researcher. For that reason, the different groups at the daycare were primarily formed from the different daycare classes and occur over 12 weeks because that is the length of an academic semester. In addition to using convenient sampling, many education based research projects either use qualitative, quantitative, or a mixture of both data collection methods. This research will use a mixed method approach, as it will have both qualitative and quantitative data. Qualitative data will include observations on behavior, participation and overall attention. Quantitative data will be the count of errors for the different predetermined categories. Lastly, Creswell also describes the notion of sequential procedures, which
is where a theory is tested on a smaller sample size more qualitatively, and then tested again on a larger group with more quantitative backing. A similar process will be applied during this research as well [10]. The first iteration of this research was conducted on a smaller group of students, yielding positive results. Future research will focus on larger pools of students who will be observed over longer periods of time.

Based on recent research in the field, there is evidence to support the notion that STEM education can improve spatial awareness of children. Combined with an engaging activity that the child can produce on their own and watch how different changes in design or programming can impact what they built, these activities can not only keep the child interested, but through practice, can also improve their motor skills. The objective of the present research was to observe how spatial awareness and motor skills developed in children through the use of robotics. This was done by creating and teaching a 12-week program that combined the Universal Design for Learning (UDL) method and the four aspects that make a good STEM activity. Development of motor and other skills was measured via a set of parameters described next. In each class, there will be a mixture of students, both with and without special needs, to compare the rate at which both groups develop. The results obtained suggest that robotics is a hands-on activity that ticks off the “how” “what” and “why” of learning and facilitates learning scientific concepts, but also improves students’ motor abilities.

2. METHODOLOGY

As the objective of the present study is to assess the impact of learning robotics on the development of motor skills, three groups of 10 students were observed over a 12-week period under a mixed method research approach. With the use of LEGO Education WeDo 2.0 kits, students were asked on a weekly basis to build and program different robots based on a set of instructions. Their progress was tracked over the course of the twelve-week term measuring a set of skills such as numeration, visual matching, spatial awareness, color identification, size identification, and precision. Student’s progress over the twelve weeks was measured using parameters such as time, errors, how independently students worked, and qualities assessment of the level of focus.

2.1. Program Outline

With the use of LEGO Education WeDo 2.0 kits and material found online, weekly lesson plans were made. The students were divided into smaller groups and each student got a turn completing one of the steps. Student collaboration was encouraged, by asking other students in the group ensure each step is being done correctly. If they required any assistance or were missing pieces, they were asked to raise their hand and wait until a teacher came around. Every week’s activity had a different objective or theme. All activities ended with a short race of a demonstration of their complete robot. The engineering concepts from week to week built up on each other and repetition was used to reinforce the notions, while the activity at the end was to ensure that the students had fun. For example, the concept of a pulley was incorporated into many activities because the word and concept was new to the students. Knowing they could play or race their robot at the end gave them an objective to work towards. The activity ensured their focus throughout, while still being fun. The combination of the two meant that students wanted to do another activity and learn more the next week.

2.1.1. Initial Assessment and Final Assessments

The first week’s activity was called the Science Rover. Its length and level of difficulty was rated average in comparison to the other scheduled activities. For this reason it was used as the baseline activity. It combined most of the skills that would be used and taught during the twelve weeks, notably numeration, size matching, spatial awareness, color identification, size identification and precision. In addition to building a robot, the students programmed and raced their creation. The objective of the baseline activity was to demonstrate to the students exactly what to expect from the following 11 activities. Some student had never built a robot before, therefore they were unsure what to expect. Furthermore, the engineering concepts that were to be conveyed during the activity were the impact of wheel size on the speed of the robot. Some teams chose larger ones, while others opted for smaller ones. During the race, the students compared their robots and determined that the faster robots were the ones with larger wheels. They noticed that for every motor rotation, the robot traveled further because of the larger wheel circumference.

Throughout the following weeks, students participated in similar activities. Engineering topics included crankshaft mechanism, balance, how to build a stable structure, and the importance of alignment. During the final week, students were asked to build the science rover again. Their performance was compared with the first week’s results to see if an improvement was made during the past twelve weeks.

2.2. Class Arrangement

The students ranged from three to four years of age and were broken down into three groups. Each group consisted of a random mixture of boys and girls, and students with and without disabilities. All students’ progress was tracked over time. Special attention was placed on the students with special needs. This type of sample is in keeping with convenience sampling, which is
when a sample is pre-defined based on factors that cannot be changed.

For the purpose of this research, the first group was a class of ten 4-year old students. The entire class had experience working with robotics and performed similar activities last year. Within the class, there were two students who were sensitive to loud sounds and one with minor speech impairment.

The second group also had ten students the same age, but none of the students had ever done robotics before. One of the students in the class was on the Down’s syndrome spectrum. She was also extremely shy and calm, but was very interested in participating.

In the final group, composed of twelve students aged 3, none having ever done robotics before. Two of the students were on the Down’s syndrome spectrum and one with autism.

2.3. Measured Skills

Eight quantitative and three qualitative skills were tracked each week. The present study can therefore be categorized as a mixed method research since it investigated quantitative and qualitative skills. This type of approach is often used in education based research projects [10].

Skills were assessed via an errors count. For each activity, a potential error count was determined based on the total number of places the students could make a mistake. For example, during the first activity, there were 19 steps in which the student could have made a numeration error out of the total number of 29 steps. In order to make conclusions on the students’ progress, the first week’s activity was used as a baseline. In addition, Group 1, the more experienced group, was used as a baseline. Overall, the procedure aimed to investigate how Group 2 and 3 showed improvement in comparison to the experienced Group 1. Improvements were tracked through the number of errors and the length of time it took for both groups to exhibit similar levels of abilities. Errors were assessed by the comparison to the number of potential mistakes they could have made, the mistakes made by the experienced group, and the number of mistakes they made during the first week.

2.3.1. Numeration

Numeration was based on the student’s mathematical ability. This skill was measured when students had to either count the number of holes a certain piece had to determine if it was the right size or not, or count the number of pins on the top of a brick to ensure that it was placed correctly.

2.3.2. Visual Matching

Each week, the students received a set of instructions with a step-by-step breakdown of every procedure for building the robot. Each step contained a detailed figure of what needed to be assembled and the items required to do so. The students were required to find the correct piece from a larger tray of parts. As they were building, they were expected to match every piece to the ones in the instructions. Most of the pieces had unique shapes and different colors, which facilitated the task of matching for the students. The skills focused less on the color or size of the object, but rather their general shape.

2.3.3. Spatial Awareness

Throughout the building process, the students were expected to identify the orientation of their robot based on the instructions provided. The LEGO pieces had to be positioned on the correct side of the robot and in the correct orientation. Space position is an important skill that comes in use when students need to orient letters, words, or numbers.

2.3.4. Color Identification

While building their robot, the students were expected to choose the same color as the one in the instructions. Students were asked to first identify the color printed on the sheet, then to find the correct colored object in the tray. The measured success of the skill was dependent on the child’s ability to differentiate colors. When a student chose the right colored object, but the wrong shape, it was deemed successful for color identification, but not for visual matching.

2.3.5. Size Identification

Students were required to select the pieces that were the right shape, but also the right size. For certain pieces, students had multiple versions of the same one, but different in size. For more complex parts, students were required to combine size identification with numeration.

2.3.6. Fine Motor Skills (Precision and Control)

The students were asked to perform very accurate moves that required a certain level of dexterity. By the age of three to four, students are expected to be able to manipulate large objects, but their fine motor skills are not fully developed yet [11]. In this study, activities that encouraged the development of fine motor abilities included positioning a red pin in the middle of a hole on the motor, and aligning two parts together.

2.3.7. Gross Motor Skills (Pushing Down)

Students were asked to put blocks together. It required that they apply enough force to keep the piece locked in place, but not too much that they break others off.

2.3.8. Additional Qualitative Skills

In addition to analyzing how the children’s different skills improved over time, other factors were also measured. These included the duration of the activity, the number of times the students required to be re-focused, and if they were able to do the activity independently or not. The first week was used as a baseline and then compared to the results from the following weeks. During the final week, the groups were asked to build the same
robot as the first week in order to see how much they improved overall. Group 1 was also used as a baseline to see how the subsequent groups improved and how quickly they reached a similar level of expertise as Group 1.

2.4. Universal Design for Learning Method

The Universal Design for Learning (UDL) has become increasingly popular because of its focus on ensuring that teachers prepare lesson plans that give equal learning opportunities to all students [6]. Due to the fact that every student learns differently, the information for each activity was presented in various different ways. At the start of each class, the students partook in a mini introduction. During this time, the activity was explained, as well as a clarification for some of the more complex steps. For those who were not auditory learners, buildings instructions were made available for each group. This helped the visual learners follow along and participate. Tactile learners were involved as well as they participated in the construction of the robot.

3. RESULTS AND DISCUSSION

During the twelve weeks, the number of errors the students made was compared to the number of baseline errors from the first week. The more experience group, Group 1, was also compared to the other two with less experience. Time was measured as a rate per step based on the total completion time for the first week. The following weeks were then compared to that rate. Lastly, the qualitative skills, focus and independence, were tracked based on observations.

3.1. Errors

The following table represents the number of errors that could have been made during each activity and referred to as the potential ones.

<table>
<thead>
<tr>
<th>Table 1: Potential Errors for Weekly Activities</th>
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<tbody>
<tr>
<td>Week</td>
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<tr>
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<tr>
<td>1</td>
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<td>10</td>
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<tr>
<td>11</td>
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<tr>
<td>12</td>
</tr>
</tbody>
</table>

In many cases, the students did not make all of the potential errors, but the same ones numerous times. An error was counted if the students did not follow the instructions provided, mainly by using the wrong piece or by placing it in the wrong spot or orientation. In order for it to count as an error, the student would have had to move to the next step without them, or one of their teammates, realizing that they had made a mistake. If they reach a later step and realize they need to go back, the error is still counted, but it shows a level of independence because they caught their own mistake further along.

3.1.1. Numeration

Overall, the number of numeration errors reduced as the weeks progressed. During the first week, the students were not accustomed to the activity. They needed to be reminded or taught how they should find all of the pieces, how to follow the instructions, and how to assemble each part. The numeration skill was not only used to count the number of holes on a certain piece in order to select the right one, but also to count the number of pins on the top of a brick to ensure the part was being placed on the correct spot. As the weeks progressed, the students struggled with this part, mainly by forgetting to do so.

Throughout the twelve weeks, the number of numeration errors decreased overall for all students. During the start of the program, the students struggled with counting as a skill. Even though the students made errors, it was always less than the total number they could have made, which is shown in table 1. In many cases, the error arose when they had to select the correct length of two blocks or axle of similar lengths. As the weeks progressed, their ability to count improved, but they still struggled with keeping track of which hole they were trying to count. They ended up either skipping a hole or counting more than there were. By the twelfth week, they were very comfortable counting and visibly improved their method. They no longer got confused as much and remembered to double-check that the number they were searching for was the same as the one they found. During the firth week, there was a spike in error count, mainly due to the “Earthquake Activity”. It was significantly more challenging than the activities from the weeks before, but the students learned from their errors and an overall improvement was made in each category for next week.

3.1.2. Visual Matching

A majority of the steps involved matching what was on the building instructions what students were doing. In addition to developing their visual matching skills, they were also working on their hand-eye coordination. During
the first week, the students struggled with double-checking their work. Once they were able to successfully place two parts together without anything else breaking or falling off, they moved onto the next page without ensuring that what they did was correct. Overtime, they slowly started to check after each assembled part. There was an increase in errors at times, but this was related to the increase in activity level of difficulty.

For example, many of the students confused black with grey and other darker colors. During the first week, the youngest group struggled, but they significantly improved after the first activity. By the twelfth week, the children became very familiar with the colors and no longer made any errors related to that.

3.1.3. Spatial Awareness
One of the skills many of the students struggled with was spatial awareness. The figure below depicts the amount of errors made by each group.

Unfortunately, many of the students would get to a certain point and have to go back because they realized they placed a part on the wrong side of the robot. For the students with special needs, they struggled with seeing how to orient the robot, but with a small hint, they were able to place the pieces correctly. This suggested that they may have difficulty orienting themselves initially, but they are in the process of developing the skills and with assistance and further practice, they would be able to achieve it on their own. As the weeks progressed, their abilities drastically improved, as demonstrated in Figure 4. During the first activity, the students from Group 2 and 3 were very confused with what they were expected to do. They had trouble following instructions, which directly correlated to more spatial orientation errors. However, they quickly started to improve as of week 5 and reached similar level of ability as Group 1 by week 12.

3.1.4. Color Identification
Identifying colors was often a challenge for the students, especially those in Group 3. The issue could have been a result of the color tones on the printed sheet.

For example, many of the students confused black with grey and other darker colors. During the first week, the youngest group struggled, but they significantly improved after the first activity. By the twelfth week, the children became very familiar with the colors and no longer made any errors related to that.

3.1.5. Size Identification
The main reason for size identification errors were that students did not count correctly or would forget to count. As the weeks progressed, the students continued to make mistakes, but as they slowed down their count, they made fewer errors. They also started recognizing the shapes and sizes with greater ease, which allowed them to select pieces faster. Instead of taking every axle and counting the length until they found the one they wanted, they noticed that there were only a limited number of sizes, so they would pick 2 or 3 that were close to the length they needed, and then measured those ones, instead of all they could find.

3.1.6. Fine Motor Skills (Precision and Control)
The student’s ability to line up small objects through other small holes was considered to be a fine motor skill. Depending on the student, some struggled. They would either push so hard that the pieces would fly out of their hand or they would break the already completed section of the robot. Although they knew what needed to be done, they would struggle getting it correctly on the first shot. Compared to the first week, significant improvements in the skill were achieved by week five. At week five, students were able to do the correct step from the first try.
Even the students with special needs were able to do the most complex of the fine motor skills. One of the hardest examples was when they had to get a peg in a certain hole, but instead they placed it in the one right next to it. This mistake was very common and would often need to be corrected by the teacher, but as the weeks progressed, not only did the students stop repeating this error, but they also started correcting themselves. The trends can be seen in the figure below.

Figure 7: Fine Motor Skills Errors Chart

3.1.7. Gross Motor Skills

The building blocks section of LEGO's is when the gross motor skills were applied the most. Due to the fact that many of the students are used to playing with LEGO's, it was no surprise that after the first week, the number of errors would be extremely low. Nevertheless, they still struggled with placing the motor and placing the think brick. In most cases, the students did not apply enough force and the piece would fall off. As a way to check their work, they were often told to flip their robot upside down to make sure none of the pieces fall out.

Figure 8: Gross Motor Skills Errors Chart

3.2. Time vs. Number of Steps

In order to determine if the students were progressing through the program faster or slower than anticipated, the approximate time for the students to build the robot was divided by the total number of steps. This operation created a rate of time vs. number of steps. The rate was used a baseline and a potential activity time was determined for all activities by multiplying the rate by the total number of steps. As the activities became longer and more complex, it was expected that the students would take longer to finish. However, it was observed that as the activities got longer, the amount of time remained constant, since their level of expertise had improved. For the most part, the activities rarely exceeded an hour.

Table 2: Number of Steps and Duration of Activities

<table>
<thead>
<tr>
<th>Weeks</th>
<th>Activity Title</th>
<th>Number of Steps</th>
<th>Duration of Activity (min/group)</th>
<th>Rate (min/step)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Science Exper.</td>
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<td>12.60</td>
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<tr>
<td>2</td>
<td>Creek</td>
<td>13</td>
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</tr>
<tr>
<td>3</td>
<td>Race for</td>
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<td>1.48</td>
</tr>
<tr>
<td>4</td>
<td>Ping</td>
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<tr>
<td>5</td>
<td>Election</td>
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<td>1.08</td>
<td>1.08</td>
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<td>Model</td>
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<tr>
<td>7</td>
<td>Rescue Control Creek</td>
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<td>55</td>
<td>1.08</td>
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<td>Finder Line</td>
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<td>Century Hidden (Part 1)</td>
<td>78</td>
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</table>

3.3. Focus and Independence

The level of focus and independence throughout the weeks varied. During the first activity, the students from Group 2 and 3 did not know what to expect. They needed the teachers to walk them through each step. By the end of the activity, they were in complete shock by what they were able to accomplish. From that week on, they were very eager for the activity and keeping focus was easier. That being said, when certain steps were long, some of the students tended to get distracted because there was nothing for them to do. The students in Group 1 were more experienced and were able to work independently, while the teacher walked around and surveyed them to ensure everything was going well. The students in Group 2 and 3 needed a teacher at their table to ensure that the students remained focused and did not interrupt each other. As long as they remained focused, they made fewer errors.

In order to help the students remain focused, reducing the wait time between each turn made a tremendous difference. This was done by forming smaller groups, having some students work individually, or by giving each student a specific part of the robot, which they could assemble with the other members of their team. This allowed each student to continuously be building which improved their focus, while still being apart of a team. This meant that they could ask each other for help or correct their peers. By remaining focused, the students not only finished the activities faster, but also made fewer mistakes. In addition, the more focused they became, the more independent they also became.

Each week, the students were expected to become more independent. This meant that they did not require a teacher to remind them to stay focused, to help them count the number of holes on a piece, or to guide them...
through the assembly. In the first week, a teacher was assigned to every group. Their job was to ensure that the group was sharing, that every student had their turn, and that the robot was being built correctly. For Group 1, after the second week, some of the students were able to start working alone. For Groups 2 and 3, this was not the case. They required a teacher at their table to ensure the students stay focused and no fighting started. Nevertheless, as the weeks progressed, the students of Group 2 and 3 became more independent. Teachers still remained at the table with the students, but they rarely intervened.

Although focus and independence are two distinct qualitative skills, they are related. The more the students became focused on their activity, the more comfortable they became. As their confidence increased, so did their independence. Instead of asking the teacher after every step if they were building correctly, the students turned to each other and worked together. This correlation can be applied to preschool students, with and without special needs, but also older students. Throughout the activity the program was designed, students are able to learn the concepts by following instructions that were presented to them in different ways and able to manipulate their robots to see how their inputs would change the way the robot responded. A similar method can be used across all levels of education. By presenting an idea to a student in various forms and then having them manipulate it, they are able to stay focused on the task, which then leads to them understanding it better, which increases their confidence, and finally develops their independence. In university, the more focused students are during the lecture or lab, the greater they are able to grasp the material, and the more confident they feel when they attempt problems on their own. Through the UDL system, the students were able to stay focused on their activity, and develop their independence as their confidence levels increased.

3.4. Social Skills

The main focus of the research was to see how robotics would improve the motor skills of the students with special needs, but it was able to do more than that. As the weeks progressed, some of the more reserved students found their voice. The students became more vocal and more involved. Two of the students with Down’s syndrome also exhibited improvements in their social skills. Throughout the activity, the students would stay at the table and want to be involved in the activity with the rest of their classmates. This was considered a big step for the students.

3.5. Robotics and Motor Skills

Throughout the 12 weeks, each activity had a specific engineering related topic, which was better understood once the children modified their creations. Through these modifications, the students develop their motors skills. Unlike other activities, such as arts and crafts or sports, robotics allowed the students to work on their fine and gross motor skills during the same activity. For example, fine motor skills were employed when students were asked to place a wheel on an axle, as they need to ensure that the “X” on the axle lined up with the “X” on the wheel. Gross motor skills came in to play when they needed to push the two together. Meanwhile, the same activity allowed them to practice their hand eye coordination by having to control the force applied between the axle and the wheel as to not overshoot the target by pushing to hard. Similarly, gross motor skills were practiced whenever students had to place two blocks together, which called for developing the various muscles in their hand without breaking what they have already built. Robotics makes a significant difference in motor skills development for children with special needs, not only because of the way the information is received, but also because activities can be adapted easily depending on the child’s needs. Traditional activities used to develop motor skills, such as gym class, are challenging for children with disabilities. Some are confined to a chair, which results in the child being excluded from the activity or the teacher having to make modifications to the game [12]. Those who do not have a chair often struggle with keeping balance as they stand. Some schools use art as a way to develop motor skills, but it requires high level of supervision and an excess of material. There is also an increased probability that the student will make a mess by dropping supplies on the floor. The benefit of doing robotics, especially with a kit, is that it can be done from the tray table of a wheel chair and the pieces can be reused from group to group. Many students drop their robot on the floor, which is not a problem because they are durable and can be easily rebuilt. Activities can easily be incorporated into a classroom setting. Instructors do not need to be trained engineers because of all the comprehensive and free online material available. They can also easily change the level of difficulty of the activity depending on the student’s abilities. This could be as simple as asking the students to create attachments of their own or to add sensors. Robotics can be used as a tool to teach engineering concepts, but it can also be used to develop student’s motor skills.

4. Conclusion

During a 12-week study, motor skills and other abilities were measured for students aged 3 to 4, and improvements were recorded as the students participated in building, programming, and racing robots. It was found that students without prior experience in robotics reached similar levels of motor abilities as experience ones. This indicated that the robotics activates were effective in accelerating the development of fine and gross motor skills.
Furthermore, it was observed that the most effective activities were the ones that required the use of multiple abilities simultaneously and were following by an interesting or a fun activity such as a race. The science rover was selected as a baseline activity because it effectively required the use of multiple skills. It was also considered an average level of difficulty activity and it could easily be adapted to make it more challenging or simpler. It provided students with multiple opportunities to practice each of the measured skills, while not being too long that the students get bored or distracted.

The UDL method was implemented in all robotics activities. Even though this clearly helped the students learn no matter what type of learner they were, the effectiveness of the UDL method was still dependent on the students willingness to learn. The more the students were excited about learning, the more they paid attention, which meant that they were able to build a better robot faster with fewer errors. The UDL method allowed students to make deeper connections, but learning was amplified when students were excited about what they were learning.

Being excited about learning enables students to retain the information easier and for longer and develop a deeper understanding of the material [6]. UDL can be implemented in university courses through project-based learning. At Concordia University, a typical example of applying the UDL method to an engineering core-course is the “Steam Car” competition, a project offered in a thermodynamics course. In the project, students have to apply thermodynamic principles to build a steam car, which then competes in a race [13]. In order to build a car, students have to apply theory learned in class and observe how specific design parameters affect the speed of their car. In this project, the students’ objective is to compete in a race for the fastest car. This highly increases their motivation to do the work required, stay focused, and showcase their lifelong learning abilities, an engineering attribute that can be difficult to nurture and assess.

4.1. Future Works

The current class composition includes students with and without handicap. In order to further develop the program, a larger sample size of students with disabilities would be used. Students would also be able to work one-on-one as to allow the observer to focus on that student’s skill set and how they are improving. In addition, the results from the solely handicap class would be compared to another class without any special needs students.

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