

Learning Counting Skills through CRA: The Case of Children with Intellectual Disability

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Abstract

The project below is a research on how to apply the CRA method (Concrete-Representational-Abstract), in math, on a student of toddler age with intellectual disability. Children with intellectual disability have a limited understanding of math senses, resulting in facing a lot of difficulties in various daily tasks. Primary math senses are directly related with obtaining skills during toddler age, such as counting and connecting numbers and quantities. Through this essay we are aiming in researching if there can be an improvement in understanding primary math senses after applying the CRA method (Concrete-Representational-Abstract). More specifically, researchers have focused a lot on creating connections between actual quantities, counting numbers and the use of official math words and symbols.

Subject Areas

Education, Psychology, Sociology

Keywords

Intellectual Disability, CRA (Concrete-Representational-Abstract)

1. Introduction

Knowledge and acquiring Math, is a very important qualification, which can be used in various daily activities, that help the social development of each person as an individual. It is commonly accepted, that people with Intellectual Disability, face many difficulties, when it comes to understanding different math senses [1].

Based on many researches that have been made and studied, by many different scientific sectors, are being applied, so that people can define the teaching methods and the interferences in Math, which are considered to be effective, in order to help people with disability or/and special educational needs, realize and understand math senses, targeting in deploying their workforce, so that they can participate in many different social activities [2].

According to many scientific findings, one of the most effective strategies in interfering Math, is the teaching method of CRA (Concrete-Representational-Abstract), which targets in human development and evolution through the Discovery Learning. According to Bruner, each stage of the Discovery Method, represents also a stage of the human development path, their way of thinking, but also the teaching tools that are being used [3] [4].

2. Theoretical Background

For the conceptual determination of Intellectual Disability, definitions, criteria, and diagnostic procedures suggested by the Diagnostic Manuals of World Health Organization (WHO), and the American Psychiatric Association (APA), are being widely used [5].

The fifth and most recent version of the Diagnostic Manual DSM (Diagnostic and Statistical Manual of Mental disorders), of the American Psychiatric Association replaced the term Mental Retardation, with the term Intellectual Disability—intellectual developmental disorder and defines Intellectual Disability as "a disorder that appears during the development period and includes limitations on both cognitive and adaptive functionality in perceptual, social and practical domains [6].

The definition of Intellectual Disability according to DSM-V, includes some criteria, which are needed, both for understanding the terms as well as applying it and are the following:

1) The limitations in the mental function (syllogism, programming, abstract thought, critical thought, problem solving, academical and empirical learning etc.), which has to be checked by clinical and personalized-off the shelf intelligence measurement assessments and

2) The limitations in the adaptive functionality, which relate to the individual's independence and social responsibility due to the failure to meet the developmental, social, cultural standards and tasks of daily life (communication, independent living, social participation) [6].

In the last version of the diagnostic manual ICD-10 (International Statistical Classification of Diseases and Related Health Problems) which is issued by the World Health Organization (WHO), Mental Disability is defined as "a" condition characterized by growth retardation or incomplete brain development, and impairment of developmental skills or skills that contribute to the overall level of intelligence, such as cognitive, motor, and social skills. Delay can occur with or without any other mental or physical condition. The degree of mental retardation is conventionally assessed by the use of weighted intelligence tests. These can be accompanied by tests that assess social adjustment in a given environ-

ment. These measurements provide an approximate indication of the degree of mental retardation. Diagnosis will also depend on the overall assessment of cognitive functioning by an experienced expert. Mental abilities and social adjustment can change over time and improve after training and rehabilitation efforts. Diagnosis should be based on current levels of functionality [7].

Concerning "Mathematical Education", it refers to all the practices that contribute to the learning and teaching of Mathematics, which are developed through formal and/or informal frameworks within which mathematical thinking and communication take place. It also refers to the set of practices used and have to do with research and studying on Math teaching and learning [8] [9].

Teaching Math involves many arithmetic, numerical concepts such as time and money and aims to enable people with intellectual disabilities to acquire experiences and knowledge related to mathematical concepts. Developing practical thinking and problem-solving skills plays a key role in the day-to-day lives of people with Mental Disabilities as it will ensure their successful transition from education to adulthood. The purpose of the mathematics teaching interventions is to help people with intellectual disabilities make the most of their potential so that they can participate actively in various social activities [2].

CRA Teaching method was originally introduced by Brunner, in 1966, in his book, Towards Theory of Instructions, targeting in human development and evolution, through discovery learning. According to Brunner, each and every stage of the discovery method represents some stage in the developmental course of the individual their thinking and the teaching tools used [6].

For Bruner, learning is a process of inquiry, designed to enable students to learn how to handle their environment and solve problems that they may encounter on a daily basis. A basic principle of Bruner's theory is that the learner can access new knowledge and new skills through practice and experimentation [6].

In 1980, Underhill, Uprichard and Heddens presented the theory above in a clearer and more instructive way, divided into levels of learning, which was established in the educational level [10].

More specifically, the CRA (Concrete-Representational-Abstract) intervention model is a safe and supportive framework through which students are invited to understand mathematical concepts through the relationship that is being developed between specific objects, their visualizations and other abstract symbols. The CRA strategy integrates discovery methods that involve the student in the discovery process with the help of the teacher, with the result that knowledge emerges as a creation of the learner, enhancing self-confidence and confidence in self-efficacy [4] [11]. It consists of three interdependent levels, Discrete, Representative and Symbolic-Abstract, and each stage is built on the previous one to enhance student learning [12].

In the discrete part of the strategy, mathematical concepts are modeled with discrete, aesthetic and tactile materials, such as everyday objects, magnetic

tables, geoplanets, puzzles and other games familiar to students [9]. In this stage, students can experiment with materials and use them in their own way, so that they can understand the mathematical sense, needed [13].

At the conceptual stage of the strategy, the discrete model is transformed into a conceptual one, and students are invited to paint pictures, complete worksheets or create collages in order to represent the tangible materials used in the previous stage without them existing. This specific way works as a link between the discrete and the symbolic-abstract stage of the method, since the images are not explicit representations, nor abstract ones [3] [4] [13]. At the final stage of the strategy, symbolic-abstract, symbolic modeling takes place. Numerical and mathematical symbols are introduced to represent the shapes, dots, etc. Students at this stage are asked to think about concepts and solve problems without using tangible materials or images [3] [4] [13].

After completing the CRA strategy, students should be able to move easily between the three levels, with the course varying either from the distinct stage to the symbolic-abstract or from the symbolic-abstract to the discrete one [10].

3. Method

3.1. Research Design

For the conduct of the research, the method considered most appropriate is the qualitative research method. Qualitative research collects data from the researcher through a multi-faceted process [1]. The data that is collected explore in depth the various concepts, attitudes, perceptions, motivations, emotional and symbolic data from human life and come from interviews, observations, personal experiences, case studies and text analysis.

The main purpose of the qualitative research methodology is to understand in depth and within a specific context an incident so that there is a holistic understanding and not a mere description of it [14].

3.2. Sample-Participants

In the present research the strategy of purposeful sampling was applied (purposeful or purposive or just judgmental sampling), in which the researcher actively and deliberately selected that sample, which will best serve the purposes and questions of her research. To achieve this, the researcher relied on his knowledge of the phenomenon under study and the existing references [15]. The sample selected for the research is a student with Intellectual Disability who studies in a special kindergarten.

3.3. Research Tools

3.3.1. Pre-Test/Post-Test

At the start of the research, a performance criterion was granted to the student (pre-test), based on the Analytical Curriculum (curriculum based assessment) of the Kindergarten, in order to investigate the level at which the student is in logi-

cal-mathematical thinking. The exact same performance criterion was given to the student during our last meeting (post-test), in order to investigate if the student was able to understand the primary mathematical senses using the CRA Method (Concrete-Representational-Abstract).

The performance criteria, which are designed and used by teachers as assessment tools, according to the Curriculum, are intended to identify the difficulties the student is facing. The performance criterion which was given to the student from the researcher consists of 15 activities, which mainly use images. More specifically, it includes questions and activities related to skills:

- Counting,
- Use of numbering words,
- Solving numerical problems,
- Matching,
- Comparison,
- Grading and,
- Sorting.

3.3.2. Intervention

During the research, the intervention research strategy through CRA method (Concrete-Representational-Abstract) was used in a student with Intellectual Disability, so that we can investigate in what level he can understand the primary mathematical concepts.

Through the intervention strategy, a supportive framework was created, in which the student had the opportunity to understand the relationship between specific objects, illustrations and abstract symbols.

Intervention material

In each researcher meeting with the student a mathematical concept was taught, with various materials based on CRA Strategy, which aim to help the student understand the senses of counting and quantity. More specifically, hands-on tutorial material is used as a tool in the CRA strategy for teaching mathematics and helps students with disabilities and/or special educational needs to understand abstract mathematical concepts as well as develop their previous knowledge experiences. The use of handwriting materials includes, in addition to teaching materials, everyday objects, familiar to students with Intellectual Disabilities, such as money, calculators, rulers, etc., which help them perform arithmetic tasks, which they can later generalize. In addition, the use of educational toys can help increase the student's time in mathematics and increase their mood towards them.

Objects used during the intervention are some flexible shapes, abacus, puzzles, everyday objects, and other toys such as animal figures, cars and the snake game floor. Finally, various types of cardboard were used to create the collage.

3.3.3. Semi-Structured Interview

Semi-structured interviewing is a data collection method used in qualitative re-

search methods [16]. It consists of a set of predefined questions and is often used by researchers to provide a guide to the topics they wish to cover during the interview. It includes closed-ended questions, like structured interviewing, but open-ended questions are also asked in order to gain a better understanding of the answers. The interviewer starts with an initial topic but then is guided by the respondent's answers.

This type of interview is characterized by flexibility, as the content of the questions is always modified according to the respondent, the order in which the questions are asked, the addition or removal of questions, and the deepening of some issues with participants, who are considered appropriate [16].

This study used the method of semi-structured interviewing with the special educator of the student in order to investigate whether the intervention has assisted in the development of counting, number recognition and sequencing skills.

3.4. Research Questions

From the hypothesis above several questions are being emerged:

1) What is the impact of the CRA strategy on developing counting skills in students with intellectual disabilities?

2) What is the effect of the CRA strategy on the use of counting words in students with Intellectual Disabilities?

3) What is the impact of the CRA strategy on developing number recognition skills in students with intellectual disabilities?

4) What is the impact of the CRA strategy on the development of number-to-number matching skills in students with intellectual disabilities?

5) What is the impact of the CRA strategy on developing sorting skills in students with intellectual disabilities?

4. Data Analysis

Reliability in the present study is achieved by the use of the performance criterion (pre-test, post-test), at the beginning and at the end of the intervention, and by the fact that the research tools will be derived from the references.

Also, in order to confirm the results of the research, time triangulation was performed, as the performance criteria were given to the student within one month, with the analysis of the content and content, as well as with the semi-structured interview with the student's special educator.

5. Results

1st week of intervention

In the first meeting of the researcher with the student, prior to the intervention, the child was given a pre-test in order to identify the difficulties they are facing. The same post-test criterion was given to the pupil during the intervention for one month in order to determine its effectiveness. During the first week, two meetings were held with the student. The first was on the 9/5/2019 and the second on the 11/5/2019. Both related to numbering, counting and number recognition skills, based on the illustrative activities from the book "Early Mathematical Concepts" [17]. Also, counting skills play a key role in the development of early logical mathematics and range from verbal enumeration to 10 [10].

At the beginning of each meeting with the student, the researcher placed the numbers 1 to 10 on a cardboard table and asked the student to count together until 10, looking at the numbers. At both meetings, the researcher chose to base intervention activities on the recognition and identification of numbers from 1 to 6. The student was given worksheets, each of which had to identify and circle the required number, which had different modes of representation. These specific number recognition and visualization activities are based on the subtractive part of the CRA strategy, which means that the student is able to subtract the remaining numbers and circulate those requested. The student was able to easily identify and circle the required number, but without remembering the name of the number at the end of the activity. Furthermore, he was unable to find and circle the numbers that were much smaller than the others, which can be seen in the following pictures which has to do with deficits in visual perception [10].

By completing the above activities, the student was given another worksheet and a puzzle. In the worksheet the student was asked to paint the picture in the color that each number mentioned. Specifically, there were numbers in the picture at various points from one to five, which the student had to identify and color according to the colors indicated by each number. The puzzle given to the student was vertical, consisting of five pieces and was based on his preferences. Each piece had the number that had to be put in the correct order to make the puzzle. The student at first tried to follow the numbers and put them in the correct order to complete the puzzle, but did not remember the sequence of numbers, resulting on him mistakenly continuing his quest and completing it based on the picture. The student devoted enough time to complete the puzzle, although it consisted of only five pieces.

Short-term, long-term, and working memory deficits increase the difficulty of problem solving and exercises, as well as deficits in information recall [15] [18].

In **Figure 1**, we can observe the student's improvement in recognition of numbers, 1 to 4, from pre-test to the first two days of intervention.

2nd week of intervention

In the second week of intervention, three meetings were held with the student. As in the first week, the researcher placed the numbers on the table and asked the student to count them together until 10. When asked by the researcher if he knew any of the numbers, he identified and named the numbers 1 and 2. He also seemed to count more easily up to 4, and then sought the help of the researcher to continue. In these three meetings, the researcher chose to base the activities on recognizing and identifying numbers from 6 to 10. At the beginning of all



Figure 1. Recognition of numbers.

three meetings, the student was given worksheets, which he was required to distinguish and circle the numbers needed, as well as the activities of the first week, based on the Kindergarten Curriculum and the illustrative material in the book "Primary Mathematics Meanings" [19]. These worksheets were designed based on the abstract step of the CRA method. Apart from the number he was called upon to find and circle on each worksheet and without being asked, the student showed the researcher the numbers 1 and 2 with great enthusiasm, saying "this game has become very easy".

Upon completion of the above worksheets, the student was given two additional activities per day respectively. The first one was based on the skill of layout and asked the student to join the numbers to form a picture and then if he wanted to paint it. The second activity was based on identifying and matching numbers in a collage. He asked the student to find and stick the apple with the right number on the apple tree. The student completed both activities in a short time, without the need for help from the researcher.

On the third day of the week, the researcher chose the "snake" floor game as an activity. This activity was chosen with the aim of making the student understand and conquer the concepts of alignment and number matching through the game [3]. Initially, a dice was given to the student in order to get to know it and to process it. The student knew what the dice was and how it was used. So, after his researcher explained that all of his sides correspond to a number based on his dots, he gave him a worksheet in which he had to match each side of the dice with a number. The student began by counting the dots and then matching them to the correct number until number two, which he was able to identify [20]. But then, while he was counting correctly the amount of dots on each side, he was unable to identify the number required and thus sought the help of the researcher. Upon completion of the worksheet, the researcher opened the board game and each one picked their pawn, placing it on the starting point. After the researcher explained the rules of the game to the student, the game started. Each time one of the two rolled the dice, he should count the dots, show the number on the cardboard holder, so that his pawn could move as many steps as the number on the dice. The student was very excited about the game, but much more about the fact that he was counting properly and taking the necessary steps. In the first round of the game, it was quite difficult for the student to identify the number needed on the cardboards, but in the second and third round, the student was able to identify almost all the numbers quite easier. The student appeared to participate willingly and complete the activity, while at the same time he seemed to have an upward course as he repeated the activity. This particular activity of the day was designed based on all three stages of the CRA strategic method (concrete, representational, abstract-symbolic), moving the student from one stage to another and vice versa [18].

Figure 2 shows the student's success rate in recognizing numbers from 1 to 6. In the third week of intervention (**Figure 2**), the researcher chose to base the design of her activities on quantitative identification.

At the first meeting of the week, the activity was designed based on all three stages of the CRA strategy. Initially, the student was given ten car figures, from which he had to select as many as the researcher had asked for each time, as well as show the corresponding number on the board they had at all their meetings on the table. At the beginning of the activity, the student, while quantifying the correct number of cars the researcher was requesting, found it difficult to show the numbers from five to ten on the cardboard, while it was easier for him to show the numbers 1 to 4. He then easily recognized the numbers 5 and 6, while still finding it difficult to find numbers from 7 to 10. At this point, the student seemed to remember and recognize the numbers he had worked out the previous week with the researcher in the game "snake". Through the game, the student managed with constant repeat to identify the dice numbers (1 to 6), with the remaining numbers not mentioned. Thus, the researcher continued the activity by asking the student for cars with the largest numbers, ie from 7 to 10. The student found it difficult to show the researcher the numbers 7, 8 and 9, and was able to identify 10.





The researcher then provided the student with a worksheet that needed to count the means of transport in each box and circulate the corresponding number. The student did very well, recognizing the numbers up to 6, and then sought the help of the researcher to properly circle 7 and 8.

In the third part of the activity, the pupil was given a game of wooden puzzles, in which he was asked to count the objects of each piece in order to match them with the correct piece-number.

As it can be seen from Chart 3, while the student is able to identify the numbers 1 through 6 through the interventions, it is very difficult for the numbers 7, 8 and 9, but this is due to the student's memory deficits [19] [21] [22].

In the fourth and final week of intervention (**Figure 3**), and with only one day of intervention left, the researcher decided to work again on the concepts of counting and alignment to see if the student had improved and had indeed mastered the concepts learned through the stages of the CRA strategy, but also to become even more familiar with identifying the numbers that appeared to be difficult.

At this meeting, the student was asked to count to ten, as in the first meetings, and to indicate the numbers requested by the researcher on the board. The student for the first time managed to count to five, waiting for the researcher to tell him the next number to continue. Later on, he confused the numbers 8 and 9, however, the second time he was asked to recount, he did so himself, as well as at the end of the meeting. Also, the student immediately recognized the numbers 1, 2, 3, 4 and 10 immediately on the cardboard, with a little help and repetition he recognized 5 and 6, and it appeared to be quite difficult at 7, 8 and 9. Right after two toys were given to the student. The first game was a puzzle game similar to the one used in the first week of intervention and the second was a number matching game with the amount of objects. The pupil responded successfully to both games and as he was shown by his expressions and words he was also very pleased and satisfied with his performance. Finally, the student was given a





worksheet on which a staircase with missing numbers was designed. Around the staircase there were circles with dots corresponding to the stair numbers. After the pupil placed the numbers on the ladder, he joined the dots with the corresponding numbers. In both cases, he got into trouble at numbers 8 and 9. At the end of the meeting and while the student was very excited about what he had done, he asked the researcher to play snake again, saying that now that he had done so well, he would surely win her.

On the last day of intervention, the researcher chose to insist on the skills of number recognition, numbering and sequencing, which the student appeared to have major difficulties with, both during the pre-test and during the intervention. The activities were designed based on all three stages of the CRA method and the student showed to have improved significantly and responded better to the pre-test but also to the first meetings with the researcher, something that we will see later in the analysis of the post-test.

In the last diagram (6) the improvement of student performance after intervention with CRA is evident. The student improved both in counting and in recognizing numbers, maintaining a consistent performance (Figure 4).

6. Discussion

The special educator, as shown by her answers, was quite pleased with her pupil's performance since the beginning of the intervention. As she said, she observed from the beginning the improvement of the pupil in early mathematical concepts and was particularly surprised that he was able to count for himself up to 10, even occasionally, as she was aware of the pupil's deficits in memory and difficulty recalling information. As she explained later on in the interview, the student was not able to count at all times until 10, however, after a little help from the special educator and little practice, he remembered to count. Also, through exercises that were done together in the classroom, the student was able to recognize most of the numbers as they appeared during the intervention and in the post-test.





Figure 4. Improvement of student performance.

Also, after interfering with the CRA strategy, the student could also quantify the objects with the most numbers.

Finally, in the sorting skills explored in the last subject, the pupil, according to the special educator, showed great improvement. Through various games that the special educator chose to play, she noticed that he had become accustomed to the numbers, resulting in him succeeding on many levels.

Through the interview of the researcher with the student's special educator, but also through the pre-test and post-test, it seems that the CRA strategy has worked quite a bit. The fact that it moves on three different levels (discrete-representational-abstract), made it possible for a child with Intellectual Disabilities to conquer early mathematical concepts at a fairly large rate.

7. Conclusions

The results of the CRA intervention were quite promising, as there was a marked improvement in all areas chosen by the researcher. The sector where there was the greatest improvement over the pupil level, as shown in the pre-test, was the sector of number recognition, numbering and counting. The student had great difficulty counting up to 10, visualizing numbers from 1 to 10, and quantifying them. For this reason, the researcher chose to devote more time and activities to these sectors. At the end of the intervention with CRA, through the post-test and the interview with the pupil's special educator, it was found that the CRA method worked really well to the child.

Given the limited duration of the intervention, it can be argued that the student could benefit and improve his performance even more, if this intervention was incorporated into daily educational practice at school and during a school year.

8. Study Limitations-Future Propositions

There are certainly several limitations to this research. Although the above research is very useful to provide some guidance on intervention with the CRA strategy in Mathematics, in children with Mental Disabilities, it was conducted only on a single student and that is a very small sample, in order to generalize the results. In conclusion, a future study of a larger number of students could be more informative in generalizing its results. However, in this particular study, the performance criteria of the student over a long period of time were useful, excluding the memory test and the interview with the special educator. The interview with the special educator shows that the results of the CRA intervention were also examined in the context of the child's classroom.

Also, one fact that determined the student's performance during the intervention might have been the choice of activity topics, as they were all based on his interests, therefore he showed a greater willingness to engage.

Another important factor limiting the research was the limited time during which the research was conducted. The short time it took to complete the survey did not allow more data to be collected. In general, according to [16], in all experimental and research conditions, the repeated measurement of dependent variables is an important factor in order to determine the effect of the independent variable.

Another factor contributing to the limitations of research is that the overall aim of all interventions is to bring their results into the school context. In particular, it would be advisable for the specific teachers' approaches [23] [24] [25] to be implemented within the school contexts in order to maintain pupil performance and to generalize the results of the CRA intervention.

In conclusion, these restrictions are a trigger for future investigations to remove the aforementioned obstacles.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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