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Robotics for inclusive education: Combining active methodologies in a classroom

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ABSTRACT

In light of the growing diversity of students in the classroom, there is a pressing need to address the potential for discrimination against minorities, arising from cultural, socioeconomic, special needs, learning styles, and other differences. It is, therefore, essential to establish inclusive learning environments that guarantee equitable learning outcomes for all children and young people. This study aims to determine the impact of educational robotics (ER) in promoting emotional, cognitive, and social inclusion attributes through active methodologies among secondary students in public institutions. The applied methodology is composed of elements typical of active methodologies implemented in education and cited in the theoretical framework. The instruments employed to measure the classroom intervention process across various stages demonstrated a gradual improvement in the reference attributes of inclusive education. The findings suggest that ER can serve as a valuable tool for promoting inclusion in diversity contexts.

Keywords: diversity, educational robotics, educational technology, inclusion

INTRODUCTION

Freire's theories, which date back to the 1960s, have enriched the concepts of inclusive and multicultural schools. These theories continue to be the subject of analysis by many educational researchers, especially those interested in the diversity of students in terms of social, cultural, political, economic, and special educational needs (Muñiz, 2016), the interpretation of the process has been multi-dimensional (Dueñas, 2010). Educational policies at the international level seek to make all training institutions increasingly inclusive. The United Nations organization, with its 193 participating states, has approved the 2030 Agenda for Sustainable Development. This agenda includes 17 objectives that will guide the work of member nations until 2030, with inclusion being a protagonist in its objectives (Román Graván et al., 2017). The agenda aims to achieve quality and equity in education that welcomes diversity of students in the classroom, without any distinction based on race, sex, religion, beliefs, etc. To achieve this goal, various methodologies and strategies have been provided that cover the entire population, in search of better results that address personal, social, and cultural wealth (López, 2022).

Educational robotics (ER) has been integrated into the curriculum of both public and private schools due to its significant contributions to students' development (Cebrián et al., 2021). It promotes the four essential skills of the 21st century, which are collaboration, creativity, communication, and critical thinking. Combining various learning areas fosters motivation and creativity, helping students consolidate their knowledge (Márquez & Ruiz, 2014). Moreover, it has demonstrated positive effects in different educational contexts, affirming its potential as a valuable educational resource (Ruiz Vicente, 2017).

This study focuses on the support and opportunities provided to students in four dimensions or risk factors proposed by some authors, namely, special needs, socioeconomic level, cultural diversity and gender balance (Daniela, 2019). Several authors have identified factors that make robotics an ideal tool for inclusion (Conchinha et al., 2016), which include: interest (Barrios et al., 2015), motivation (Herrera González, 2018), creativity, collaborative work (Syriopoulou-Delli & Gkiolnta, 2021), social skills (Newhart et al., 2016), and problem-solving (Catlin & Blamires, 2019; Conchinha, 2015; Conchinha et al., 2016; Delgado et al., 2019).

Robotics is an inclusive tool that can help students improve their emotional and cognitive profile. The emotional aspect has two elements: interest and motivation, which can help students set goals. To develop social skills such as collaboration, communication, leadership, and participation, students will need to communicate with each other. The second component of robotics is cognitive. This is identified by the phrase "to be able to do", and should enable students to develop abilities, skills, or competencies. It has two elements: creativity, which seeks to propose different solutions to a problem, and problem-solving, which involves finding solutions to problems or needs that the student sets based on their motivation (Rincón & Herrera, 2024).

This study aims to investigate how ER affects various components that foster inclusion in high school students from public schools. These components include emotional aspects such as interest and motivation, cognitive aspects such as creativity and problem-solving, and social skills. The study has several specific objectives, which include the following:

1. Developing a fundamental robotics course with kits and working guides for eight sessions.
2. Implementing active project-based learning (PBL) and challenge-based learning (CBL) methodologies to promote the transfer of cognitive and emotional inclusion attributes.
3. Setting up a flexible learning environment using tools such as Moodle, Zoom, Tinkercad, and a robotics kit to address the challenges of distance learning due to the COVID-19 pandemic.
4. Using a measurement instrument to analyze the components or attributes that support inclusion.
5. Analyzing changes in students' learning, such as emotional aspects (interest and motivation), cognitive aspects (creativity and problem-solving), and social skills after participating in the robotics course.

This document includes a *Theoretical Framework* that analyzes the research related to ER and its role in supporting inclusion in education. The framework also examines the active methodologies, learning styles, and components that promote inclusion. The next section explains the methodological framework used to establish the research objectives and develop each scope. The *Results* section presents the findings, followed by an analysis of those results. Finally, the *Conclusions* section summarizes the overall research outcomes.

THEORETICAL FRAMEWORK

Educational Robotics as Support for Inclusion

UNESCO has been a leading proponent of inclusive education under the banner of "education for all" (EFA). This approach aims to address the needs of individuals who have been excluded from education due to various factors such as social, economic, cultural, physical, or care-related issues. Special educational needs are a key focus of this organization in recent meetings.

In recent times, ER has gained popularity in classrooms, bringing about new teaching methodologies and strategies that provide more opportunities to reach students through active learning approaches. Researchers such as Conchinha and de Freitas (2015) have analyzed the impact of ER on inclusion. They conducted a study with sixth and seventh grade students, some of whom had special educational needs, (Conchinha, 2017), the researchers worked with a group of students with varying learning styles and rhythms, using virtual robotics methodologies to promote collaboration and higher levels of inclusion. Daniela and Lytras (2019), in the study ER for inclusive education, analyzed the inclusive approach in four dimensions:

special needs, socioeconomic status, cultural diversity, and gender balance. Syriopoulou-Delli and Gkiolnta (2021) examined the social, cognitive, and functional skills that children with disabilities can develop through the intervention of robotics. They found that children's abilities improved significantly. Finally, Sun and Ching (2022) concluded that educational robots can help students better understand life science knowledge and the problem-solving process.

Active Methodologies

In the theories of constructivism and constructionism, the student's knowledge is built based on previous concepts about their environment. They think socially with mutual and cooperative benefits, always in an active disposition in search of a positive result. These pedagogical principles are pursued by ER (Almendárez, 2021; Evripidou et al., 2020). These conceptual theories allow the emergence of didactic methodologies where the student is an active protagonist in the construction of their knowledge. To develop an instructional learning design, consider the following active methodological options as a research guide:

Project-based learning (PBL)

This methodology in the construction of knowledge to acquire skills. Getting to knowledge requires an active and participatory process between student and teacher that promotes research, cooperative work among peers (González & Becerra, 2021). Posed in this way, the problem or task constitutes the learning challenge that concentrates the student's activity supported by a laboratory kit, a work guide, multimedia resources, and the teacher's advice. PBL supported by robotics requires a series of stages:

1. Forming students' working groups and assigning specific activities.
2. Researching and synthesizing the cited data.
3. Deploying via robotic kits.
4. Socializing.
5. Propose conclusions that will be the contribution or construction of their knowledge (Cobo & Valdivia, 2017).

Challenge-based learning (CBL)

Is an approach that involves students in a real problematic situation related to their environment. They must provide practical solutions by actively participating in the process, promoting exploration, research, and collaborative work. The goal of this approach is to connect their pre-existing knowledge with new knowledge to solve the challenge (Bolaños & Pérez, 2019).

The elements that make up the methodological framework are:

1. **General idea:** Or attractive concept for the student.
2. **Essential question:** Guiding questions based on the interest and needs of the students.
3. **The challenge:** It arises from the essential questions looking for a coherent solution with the available resources.
4. **Implementation and evaluation of the solution:** Using the kits, the solution is implemented, and it is determined if the challenge is met satisfactorily.
5. **Publication:** The experience is shared with all the work groups and, if possible, with other degrees.
6. **Reflection:** The solution and the contributions are analyzed as new knowledge (Apple, 2011).

Collaborative/cooperative learning

This methodology is understood as a "carefully designed system of interactions that organizes and induces reciprocal influence among the members of a team" (Johnson & Johnson, 1999, pp. 115-125), where all members are committed to a common goal. To achieve this, the teacher uses working group methodologies that involve the interaction of the different team members in search of the appropriation of knowledge and construction of new learning. The constructivist approach is the base of these methodologies (Serrano & Pons, 2011). This approach postulates that the students themselves, transforming it into concepts with which they can relate, and reconstruct as they progress through new experiences. This methodology allows students to assume roles from their learning styles that, at the same time, offer information of methodological interest to design activities that favor the different styles of the group class such as: active, reflective, theoretical, and pragmatic (Lago et al., 2008).

These active methodologies are usually considered in experiences with ER mentioned above, starting from the distribution of students in small groups that are based on collaborative learning (Poco, 2018).

Learning Styles

Learning styles are cognitive, affective, and physiological traits that serve as relatively stable indicators of how students perceive, interact, and respond to their learning environments and they are classified as active, reflective, theoretical, and pragmatic (Gallego et al., 1997). Sullivan (1993) defines the learning style as the way in which students concentrate, process, internalize and remember academic information. Likewise, Cazau (2004) mentions that the main characteristic of learning styles is that they are not static, but some environmental factors can influence the students such as age and customs, which leads to the belief that a person may develop more than one learning style during their lifetime. The learning style serves to conceptualize a set of orientations (preferences) that the person tends to use habitually and stably when facing learning tasks that include types of information processing and other cognitive components of learning (Esteban et al., 1996).

For the organization of the collaborative groups, the Honey and Alonso test (CHAEA test) is applied, which allows for determining four learning styles: active, reflective, theoretical, and pragmatic, from which workgroups emerge with the various roles seeking to strengthen the abilities of each style (Alonso & Gallego, 2000) (**Appendix A**).

Attributes or Components that Support Inclusion

Assessment scales will be used to measure five aspects of the proposed experience, analyzed from a practical pedagogical approach with robotics studies (Rincón & Herrera, 2021):

1. **Interest:** It refers to the ability to capture a student's attention, attract, surprise, and motivate them to carry out an activity (Bustamante, 2018; D'Abreu, 2017; García et al., 2017; Pinto-Salamanca et al., 2010; Pittí Patiño et al., 2012; Rodríguez et al., 2013; Román Graván et al., 2017; Sánchez, 2019; Solon Guimarães et al., 2018).
2. **Motivation:** It is the driving force that encourages individuals to take initiative, foster curiosity, and develop their abilities through practical experience and trial and error. It enables students to become more autonomous and solve complex problems by planning and executing tasks based on their skill levels. This concept is supported by various research studies, including (Acosta Castiblanco et al., 2015; Castro & Acuña, 2012; García & Reyes, 2012; García et al., 2017; Ghitis & Vásquez, 2014; Márquez & Ruiz, 2014; Ocaña, 2012; Sánchez, 2019).
3. **Social competencies:** Also known as, soft skills refer to the ability to manage emotions in different situations, whether positive or negative. These competencies enable individuals to interact effectively with others, validate how their actions affect their learning, and enhance teamwork. Some relevant sources on this topic include references (Acosta Castiblanco et al., 2015; Almeida & Canarias, 2017; Caballero & García, 2020; da Silva & González, 2017; Eguchi, 2016; García et al., 2017; Gonzalez, 2011; Lombana, 2014; Mora & Prada, 2016; Muñoz & González, 2019; Romero, 2020; Sánchez, 2019; Vargas et al., 2019).
4. **Creativity:** It is a positive factor in learning as it focuses on the imaginative quality and fluidity of ideas. This approach motivates the student to find the best solution through trial and error, stimulating confidence in the process (Bustamante, 2018; Hervás-Gómez et al., 2018; Márquez & Ruiz, 2014; Nemiro et al., 2017; Solon Guimarães et al., 2018).
5. **Problem-solving:** The student begins by analyzing a problem in its context, connecting it to pre-existing knowledge, creating a mental or visual representation, and determining the most appropriate solution (Acosta Castiblanco et al., 2015; Chavarría & Saldaño, 2010; Hervás-Gómez et al., 2018; Nabeel et al., 2017; Ramírez et al., 2021; Zapata et al., 2018).

Related Works: Educational Robotics Experiences

1. *Impact of robotics on the motivation and socio-affectivity of high school students (Flores Tena et al., 2020):* This study aims to determine whether using ER integrated with active methodologies in the classroom can increase students' interest and motivation, as well as improve their relationships with each other. To measure interest and motivation, the study uses an instrument with 10 items. The study involves five phases and uses an Ecured robotic kit. The results show that using ER increased motivation for learning and improved socio-affective relationships among students, creating a more conducive environment for collaborative work.
2. *Design and development of a low-cost open-source robotics education platform (Darrah et al., 2018):* The objective is to create an open-source ER-learning environment that is both practical and affordable. The authors assess learning through pre and post-tests as well as have introduced a curricular course to evaluate the effectiveness and usability of the learning environment. They conclude that this approach is feasible and attractive for teaching robotics, and that its implementation is cost-effective.
3. *Integration of ER with active didactic methodologies in primary school (Álamo et al., 2019):* This research aims to merge ER with active teaching methodologies like PBL and cooperative learning to strengthen the emerging pedagogies of the future. The researchers employed a survey method to assess the proposed integration and determine the most useful methodology. The study concluded that collaborative learning and PBL are two crucial elements to consider when introducing robotics in the classroom.
4. *Educational robotics in primary education. A case in Greece (Chaidi et al., 2021):* This research examines the impact of introducing ER in an educational institution that caters to students with special educational needs and aims to promote integration. The institution uses a mixed teaching model that includes both face-to-face and virtual classes to reach out to all students. The CODESKILLS4ROBOTICS project, which brings together several countries including Greece, Cyprus, Belgium, and Sweden, serves as a guide for the study, with an aim to develop digital skills. The study highlights the active participation of all students, particularly those with special educational needs, who experienced an improvement in their self-esteem.

METHODOLOGICAL FRAMEWORK

Research Empirical Approach

This study adheres to educational design frameworks such as "differentiated instruction" (Glatzel, 2017), "universal design for learning (UDL)" (Pastor, 2018), "competency framework for inclusive teachers (CFIT)" (Donnelly, 2013), which acknowledge the diversity of students in cognitive, emotional, social, and physical aspects, and emphasize the importance of high inclusion levels. Additionally, the research called "developing teachers' competences for designing inclusive learning experiences" (Navarro et al., 2016), provides guidance for designing inclusive educational resources.

Based on the previous premises, a research process is developed that includes a series of resources combined with ER, active methodologies and measurement instruments to analyze specific aspects of learning according to previously analyzed learning styles.

Figure 1 summarizes this methodological process.

The population under study is made up of 2,150 high school students from a public school located in Colombia in the department of Boyacá in Duitama city. These students reside in urban areas of this city.

The selected sample is made up of thirty-two students, seven of them are girls and twenty-five boys belonging to the tenth grade/levels with ages ranging between fourteen and sixteen years old. The methodological development is the following two phases:

Phase I: Resources

1. The course is designed to include a test that helps identify the learning style of each student. The test used for this purpose is called CHAEA (Alonso & Gallego, 2000); it is an instrument applied to identify

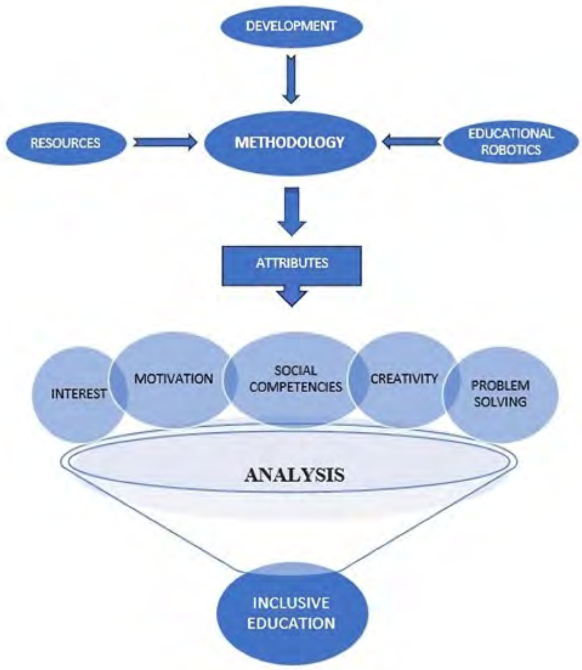
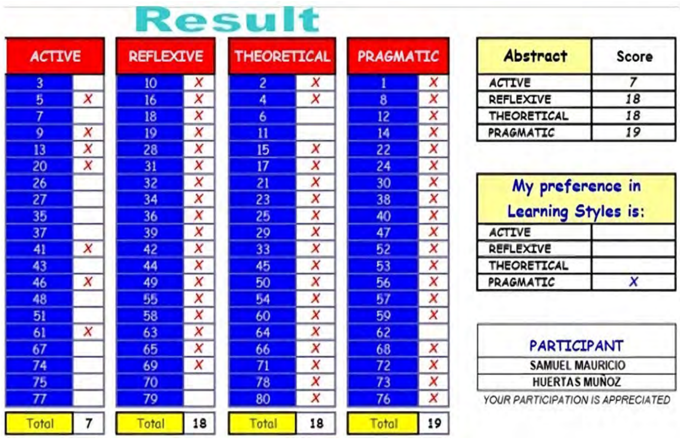


Figure 1. Research process (Source: Authors)



Result

ACTIVE		REFLEXIVE		THEORETICAL		PRAGMATIC	
3		10	X	2	X	1	X
5	X	16	X	4	X	8	X
7		18	X	6		12	X
9	X	19	X	11		14	X
13	X	28	X	15	X	22	X
20	X	31	X	17	X	24	X
26		32	X	21	X	30	X
27		34	X	23	X	38	X
35		36	X	25	X	40	X
37		39	X	29	X	47	X
41	X	42	X	33	X	52	X
43		44	X	45	X	53	X
46	X	49	X	50	X	56	X
48		55	X	54	X	57	X
51		58	X	60	X	59	X
61	X	63	X	64	X	62	
67		65	X	66	X	68	X
74		69	X	71	X	72	X
75		70		78	X	73	X
77		79		80	X	76	X
Total	7	Total	18	Total	18	Total	19

Abstract	Score
ACTIVE	7
REFLEXIVE	18
THEORETICAL	18
PRAGMATIC	19

My preference in Learning Styles is:	
ACTIVE	
REFLEXIVE	
THEORETICAL	
PRAGMATIC	X

PARTICIPANT
SAMUEL MAURICIO
HUERTAS MUÑOZ

YOUR PARTICIPATION IS APPRECIATED

Figure 2. Test CHAEA (Alonso & Gallego, 2000)

the different types of learning styles, it has 80 questions, and the learning style is determined according to the student's previous experience. In this model, the student is characterized as active, reflective, theoretical, or pragmatic one. Through this test, researchers can determine the learning style of the person who takes/filled out it.

Following the test results, the students are given eight sequential working guides. Once the students complete the test, they need to capture the screen with the results and upload it to the LMS platform. You can see an example of this in **Figure 2**.

The test shows the scores obtained in each style and with an x marks the preferred one without forgetting that the second option may be very close in score.

The eight sequential working guides created have a procedure, teaching resources, a challenge or activity to measure progress, and a submission deadline (**Figure 3**).

- Design of the measuring instrument: A Likert scale is designed to analyze the five aspects that support inclusion, where 1 corresponds to never, 2 to almost never, 3 to occasionally, 4 to almost always, and 5 to always. The tool used to measure the level of inclusion consists of 25 questions or items, with 5 dedicated to measuring each objective's aspect or dimension. Our team developed

INSTRUCTIONAL DESIGN EDUCATIONAL ROBOTICS COURSE
Subject: Technology and Computer Science Tenth Grade

GUIDE №	NAME OF THE GUIDE	LEARNING ACTIVITY	TERM	DELIVERY TIME	CHALLENGE
0	Assembly of the robot structure.	Assemble the structure according to a plan and instructions.	five hours	Seven days.	Assemble the structure of the robotic car and upload the evidence to the platform.
1	Robotic kit materials.	Identify the elements that make up the robotic kit.	Three hours	Seven days.	Design an interactive playful activity that involves all the elements of the robotic kit and that is applicable to all groups.
2	LED handling.	Correctly install leds on a breadboard.	Two hours	Seven days.	Assemble a minimum of four LEDs on the protoboard of the robotic cart and upload the evidence to the platform. (Images and video).
3	Play of light	Properly install a potentiometer and a photoresistor.	Three hours	Seven days.	Assemble at least four LEDs on the breadboard of the robotic car controlled by a potentiometer and a photoresistor.
4	H bridge for motors.	Install two motors using an H-bridge.	Three hours	Seven days.	Move the car forward and backward.
5	Follow line.	Recognize and install the necessary components for a line follower.	Five hours	Seven days.	Design a route that the robotic car must follow.
6	Arduino UNO.	Recognize the parts and basic code of Arduino UNO.	Six hours	Seven days.	Design a program in Arduino that turns its internal led on and off every 20 seconds.
7	Control of a circuit with Arduino UNO.	Recognize the inputs and outputs of an Arduino card and program them.	Six hours	Seven days.	Design an Arduino program that controls a circuit of leds mounted on a protoboard.

Figure 3. Instructional design for each working guide (Source: Authors)

this tool by combining various instruments used in previous national and international research. We submitted the instrument to eight professionals trained in psychology, psychopedagogy, and pedagogy to review its validity and structure.

- Selection of a learning management system according to the needs and possibilities: The Moodle platform (Uribe-Tirado et al., 2007),was chosen for its ability to handle multiple formats for uploading resources, provide both synchronous and asynchronous tools, and enable individual and group follow-ups. These are all essential elements required to manage both the pedagogical materials and the training and evaluation processes of students, while accommodating the various learning rhythms and styles. Diversity is prioritized in all aspects considered. The configuration was applied to eight sessions, with resources and activities tailored to each student through face-to face or virtual meeting format.

In the following image corresponding to **Figure 4**, the structure of the created course is evident.

- Robotic kits: The kits contain all the necessary elements to develop the eight working guides' tasks. The first component is the structure or chassis part, which was designed in AutoCAD with clear specifications to refer to the plans in case new quantities are needed for more students, and then laser-cut. It also includes a series of electronic elements according to the proposed guides (from guide #0 to #7).
- Development of classroom experience as a pedagogical methodology: The pedagogical process involves the use of Blended-learning methodology or hybrid model (Viñas, 2021). This model allows teachers to combine face-to-face training with virtual training to provide a comprehensive learning experience. During face-to-face training, teachers use a structured approach based on five moments:

1. Reading the working guide.
2. Asking a series of questions to verify the students' understanding of the guide's objectives.
3. Demonstrating the practical application of the specific guide through a systematic process using Tinkercad simulator and other interactive video/visual resources.

Figure 4. Educational robotics course, general structure (Source: Authors)

Table 1. CHAEA test results

Learning style	Number of students
Active	6
Reflexive	10
Theoretical	8
Pragmatic	8
Total	32

4. Providing students with the opportunity to practice and familiarize themselves with the materials and resources.
5. Presenting a challenge or problem for the students to be solved or overcome.

This approach ensures that the students have a clear understanding of the guide's objectives and are able to apply the concepts learned in a practical setting.

Phase II: Development

In the first class, students will enter the platform through the link https://sistemavirtu.milaulas.com/. Each student will register and enter the ER course. They will recognize the course interface and analyze its operation together with the teacher. After that, they will individually develop the CHAEA test and finally upload the results to the site indicated on the platform. The obtained results will be analyzed, and **Table 1** will be generated.

In order to create teams that incorporate diverse learning styles (theoretical, reflective, active, or pragmatic), we implemented a cooperative approach, selecting a student with a higher score in each style. This approach allowed us to analyze two students' cases with a reflective preference although whose second option was very close to the active style. By balancing the students groups in this way, we were able to configurated up to eight strong teams that encompassed all of the styles we were analyzing.

In the second class, the teacher introduces the groups that were formed based on the results of a prior assessment. The teacher begins with the working guide #0 and emphasizes that the other next sessions are also important. For the next class, the students are expected to have read the corresponding working guide in advance, so that they can bring questions and clear up any doubts about the flipped learning methodology

Table 2. Reliability statistics: Cronbach's alpha

Cronbach's alpha	Number of elements
0.929	25

Table 3. Reliability statistic Cronbach's alpha for each question

	Total element statistics			
	Scale mean if item has been deleted	Scale variance if item has been deleted	Total element correlation corrected	Cronbach's alpha if the item has been deleted
I1	84.5455	59.818	0.769	0.922
I2	84.8788	59.860	0.674	0.925
I3	84.4545	64.256	0.653	0.925
I4	84.3636	68.614	0.153	0.930
I5	84.6061	62.371	0.717	0.923
M1	84.6970	66.030	0.351	0.929
M2	85.5152	61.883	0.681	0.924
M3	84.9394	64.059	0.551	0.926
M4	84.1818	65.903	0.424	0.928
M5	84.2424	65.252	0.590	0.926
CS1	84.8485	61.383	0.751	0.923
CS2	85.2424	62.502	0.764	0.923
CS3	84.8485	63.570	0.726	0.924
CS4	84.4848	65.133	0.604	0.926
CS5	84.5152	64.508	0.668	0.925
C1	85.1515	62.008	0.721	0.923
C2	85.2121	64.797	0.526	0.927
C3	84.7273	65.767	0.430	0.928
C4	84.5152	66.758	0.352	0.929
C5	84.7576	63.939	0.661	0.925
SP1	84.9697	65.093	0.585	0.926
SP2	84.6970	64.468	0.435	0.929
SP3	84.4545	65.506	0.578	0.926
SP4	84.3636	68.614	0.153	0.930
SP5	84.6061	65.434	0.492	0.927

or the topics planned for the class. The subsequent classes are conducted in the same manner until the last guide (#7).

In this activity, each group selects a theme based on their interests and preferences. For instance, one group can choose to explore the *world of dinosaurs* or to create another customized scenario, wherein a robot character will be the protagonist who faces weekly challenges proposed by the working guide.

Each working guides are explained and analyzed in the classroom, and the teaching material is reviewed to support the learning process and to ensure that no one feels excluded for any reason. The times and spaces for the activity are clarified to avoid overwhelming people who learn at different paces.

The experimental group consisted of thirty-two students, comprising of 7 girls and 25 boys from the tenth grade of secondary education. Their ages ranged between 14 to 16 years with varying learning rates. Out of these, three students had special educational needs – one of them due to low vision, one due to cognitive deficit and another due to motor problems.

Finally, in each class session, a member of the school psychoorientation group apply/administers a Likert scale measurement instrument for each student and to records the results.

Data Collection and Processing

SPSS statistics 28.0.1.0 was used for statistical reliability, consistency of measurements, and absence of errors:

Cronbach's alpha was calculated to be 0.929 (**Table 2**), which is higher than the recommended threshold of 0.7 (Nunally & Bernstein, 1978). Cronbach's alpha was calculated in general (**Table 2**) and for each question (**Table 3**), giving the average result of the study 0.929, and similar results for each question (25) included in the measurement instrument and that was designed to analyze the five key aspects when using ER

Table 4. Reliability statistic Two Guttman halves

Reliability statistic Two Guttman halves		Value
Correlation between forms		.893
Spearman's coefficient-Brown	Equal length	.943
	Uneven length	.943
Gutman coefficient of two halves		.908

Table 5. "Interest" across eight working guides

	Interest											
	Guide0	Guide1	Guide2	Guide3	Guide4	Guide5	Guide6	Guide7	Average	Deviation	Max	Min
Never	0%	0%	0%	0%	0%	0%	0%	0%				
Rarely	4%	3%	2%	5%	1%	1%	0%	0%				
Sometimes	32%	39%	43%	41%	39%	19%	9%	15%				
Usually	58%	58%	53%	52%	56%	75%	79%	71%	62%	0.1052	73%	52%
Always	7%	1%	2%	2%	4%	6%	12%	14%				

Table 6. "Motivation" across eight working guides

	Motivation											
	Guide0	Guide1	Guide2	Guide3	Guide4	Guide5	Guide6	Guide7	Average	Deviation	Max	Min
Never	0%	0%	0%	0%	0%	0%	0%	0%				
Rarely	9%	10%	2%	5%	1%	1%	1%	0%				
Sometimes	35%	39%	40%	46%	32%	12%	10%	11%				
Usually	51%	50%	55%	47%	64%	81%	75%	70%	62%	0.1253	74%	49%
Always	5%	0%	2%	2%	3%	7%	15%	19%				

Table 7. "Social competences" across eight working guides

	Social competences											
	Guide0	Guide1	Guide2	Guide3	Guide4	Guide5	Guide6	Guide7	Average	Deviation	Max	Min
Never	0%	0%	0%	0%	0%	0%	0%	0%				
Rarely	5%	7%	4%	1%	0%	0%	0%	0%				
Sometimes	45%	50%	45%	47%	27%	15%	6%	8%				
Usually	50%	44%	49%	51%	70%	81%	83%	79%	63%	0.1648	80%	47%
Always	0%	0%	2%	1%	3%	4%	11%	13%				

(**Appendix B**), results that are at a level higher than the recommended threshold of 0.7 (Nunally & Bernstein, 1978). The analyzed results maintain a parameter greater than 0.7, ensuring reliable and consistent data. **Table 4** confirms that the instrument is reliable as the two Guttman halves produced a result of 0.908.

RESULTS

Analyzing each of the study aspects proposed in the objectives in the eight working guides, the results are showing in **Table 5**.

The study carried out in **Table 5** revealed that the most frequent element was "usually", and when analyzing the results shown in the eight guides, an average of 62% was obtained, which indicates its effectiveness in capturing the attention of the diverse range of students participating in the course. The deviation was only 0.1052, indicating that the information presented was consistent and reliable with low changes.

According to **Table 6**, the most common factor that influenced students in the study was "motivation", with an average frequency of 62%. This suggests that it serves as a strong incentive for students to take initiative and engage in activities that cater to the diverse needs of all participants in the course.

The standard deviation for motivation was 0.1253, which is two points higher than interest but still statistically significant.

In the study, it was found that the social competence that occurred most frequently was assertive communication and emotional management, which allowed students to work together effectively in their respective roles. This was observed in 63% of the cases, as shown in **Table 7**. Despite the diverse student population in the course, there were no issues in teamwork due to this competency. The deviation was found to be 0.1648, indicating a slight increase in information changes compared to previous data, but still reliable.

Table 8. "Creativity" across eight working guides

	Creativity											
	Guide0	Guide1	Guide2	Guide3	Guide4	Guide5	Guide6	Guide7	Average	Deviation	Max	Min
Never	0%	0%	0%	0%	0%	0%	0%	0%				
Rarely	5%	5%	2%	3%	0%	0%	0%	0%				
Sometimes	52%	49%	43%	44%	33%	21%	18%	12%				
Usually	42%	46%	54%	52%	65%	76%	76%	79%	61%	0.1465	76%	47%
Always	0%	0%	1%	1%	2%	2%	6%	9%				

Table 9. "Problem-solving" across eight working guides

	Problem-solving											
	Guide0	Guide1	Guide2	Guide3	Guide4	Guide5	Guide6	Guide7	Average	Deviation	Max	Min
Never	0%	0%	0%	0%	0%	0%	0%	0%				
Rarely	0%	2%	3%	2%	1%	1%	0%	0%				
Sometimes	39%	45%	45%	47%	42%	19%	17%	11%				
Usually	59%	52%	49%	49%	54%	75%	72%	77%	61%	0.1191	73%	49%
Always	2%	2%	3%	2%	3%	5%	12%	12%				

Table 10. Results in the five aspects analyzed for students with special educational needs

Aspect	Average	Deviation
Interest	63%	0.1333
Motivation	63%	0.1671
Social competences	67%	0.1285
Creativity	67%	0.1851
Problem-solving	60%	0.0846

Throughout the study, the element of creativity had the highest frequency, averaging 61% and appearing almost always (**Table 8**). This indicates a high level of acceptance for the methodology and instruments used to propose ideas of quality and fluency. All students enrolled in the study course participated in this process. The deviation was 0.1465, which is reliable as changes in the information were only two points lower than the previous ones.

According to **Table 9**, the most commonly used problem-solving technique throughout the study was "almost-always," with an average frequency of 61%. This indicates that participants found the methodology and tools used to be effective in building and enhancing their pre-existing knowledge to reach the best possible solution for the given challenge. The deviation was 0.1191, meaning that information changes were very similar to the information of interest, making it reliable.

After conducting a thorough analysis of students with special educational needs (**Table 10**) and their behavior in each work session, it was found that their average scores in aspects such as interest, motivation, creativity, and social skills were similar to those of other students. However, there was a slight drop in their average score in the problem-solving aspect from 61 to 60. Furthermore, the standard deviation (**Table 7**) remained stable, indicating that the results obtained are reliable for research purposes.

Table 11 shows the five aspects under analysis for each learning style (CHAEA test) and their behavior throughout the study. The maximum score reached by each aspect is 20 (**Appendix C**).

ANALYZING THE RESULTS

From **Table 10**, the Interest aspect is the highest average in the entire study is for the pragmatic style with 19.29. The next one is the reflexive style with 19.28, in the motivation aspect the pragmatic style with 19.23. *Subsequently* the reflexive style with 18.90, in the social competences aspect the pragmatic style with 19.23. Following, the reflexive style with 18.93, in the creativity aspect the pragmatic style with 19.87. The next one, the reflexive style with 18.76, and finally, in the problem-solving aspect the style pragmatic with 19.15, followed by the reflexive style with 18.80.

Observing the emotional component (interest and motivation) both aspects increased in score in the almost-always and always options as the course progressed, evidencing that the course managed to capture their attention, attract them, encourage their initiative, curiosity and manifested in a greater commitment to develop the challenges posed by each of the members of the course.

Table 11. Results in the five aspects analyzed in relation to learning styles (CHAEA test)

	Guide0	Guide1	Guide2	Guide3	Guide4	Guide5	Guide6	Guide7	Average	Deviation	Max	Min
Active style												
Interest	18.17	16.83	16.83	15.83	16.33	17.83	19.33	19	17.52	1.27	18.78	16.25
Motivation	17	16.5	17.5	16.17	17.33	18.67	19.17	19.67	17.75	1.28	19.03	16.47
Social competences	17.33	16.5	17	16.83	18	18.83	19.33	19.5	17.92	1.18	19.09	16.74
Creativity	16.5	16.33	17.33	17.17	18	18.67	19	19.17	17.77	1.11	18.88	16.66
Problem-solving	18.5	17.17	17.17	16.33	16.83	18.33	18.83	19.67	17.85	1.15	19.00	16.71
Reflexive style												
Interest	19.1	18.4	18.2	18.4	18.9	20	20.7	20.5	19.28	0.99	20.27	18.28
Motivation	17.6	17	17.8	18.03	19.1	20.2	20.6	20.9	18.90	1.51	20.41	17.40
Social competences	18	17.2	17.8	18	19.2	19.9	20.7	20.6	18.93	1.36	20.28	17.57
Creativity	17.4	17.6	18	18.1	19	19.6	20	20.4	18.76	1.15	19.91	17.62
Problem-solving	18.3	18.1	17.9	17.9	18.1	19.5	20.1	20.5	18.80	1.06	19.86	17.74
Theoretical style												
Interest	16	16.17	16.83	16.5	17.33	18.5	19.5	18.67	17.44	1.30	18.74	16.14
Motivation	16.5	16.17	17.33	16.17	17.3	18.83	19.17	19.17	17.58	1.30	18.88	16.28
Social competences	14.33	14.67	15.33	16.33	18	18.83	19.33	19.17	17.00	2.08	19.08	14.92
Creativity	14.5	15.5	15.83	15.67	17	17.83	18.17	18.67	16.65	1.49	18.13	15.16
Problem-solving	16.83	16.5	16.5	17	17.33	18.33	18.5	18.5	17.44	0.88	18.31	16.56
Pragmatic style												
Interest	19.09	18.64	18.45	18.09	18.82	19.91	20.64	20.64	19.29	0.99	20.27	18.30
Motivation	18.6	17.73	18.4	17.91	19.18	20.2	20.82	21	19.23	1.29	20.52	17.94
Social competences	18.18	17.91	18.5	18.36	19.27	19.82	20.82	21	19.23	1.20	20.44	18.03
Creativity	17.82	17.82	18.46	18.27	19	19.45	19.81	20.36	18.87	0.94	19.81	17.93
Problem-solving	18.45	18.18	18.18	18.36	18.82	19.91	20.55	20.73	19.15	1.08	20.23	18.07

Likewise, the cognitive component (creativity and problem-solving) in both cases was above 80% in the almost-always and always options, evidencing imaginative quality, fluidity of ideas, connection with their pre-knowledge and choice of the most appropriate solution according to the context.

The communication and social skills in the latest guides adding the options are almost-always and always above 90%, observing a management of emotions among all the members of the course, a better and more efficient communication, participation and harmony in the work groups.

Results Comparison versus Previous Studies

Regarding the study cited as Flores et al. (2020), the authors analyzed the impact of the use of robotics and active methodologies on aspects such as interest, motivation, supported by the social relationships of students. They concluded that students' motivation and social skills improved significantly. Our research also supports their findings, but our study is more specific in terms of statistics and learning styles, as classified by the CHAEA test (Alonso & Gallego, 2000). The methodology and learning environment used in the course have been effective and well received by students of diverse backgrounds.

In a study by Nemiro et al. (2017), it was found that a free or low-cost learning platform is ideal for institutions with limited budgets. They developed their own learning environment on a Moodle platform for a course offered free on Milaulas. This platform includes study guides, course complements, space for uploading evidence, and other resources that contribute to continuous and comprehensive evaluation of students. This allows instructors to adapt their teaching methods to the individual learning styles and rhythms of each student. In our case, we were able to provide practical support to our students with robotic kits. Higher-grade level students donated those designed kids, resulting in minimal cost for our public school,

The investigation cited in this text (Álamo et al., 2019) combines robotics with active PBL methodologies and collaborative learning. The aim of this study is to consolidate emerging pedagogies of the future, and it concludes that students have a positive acceptance of this approach. These methodologies are used to support inclusion and are vital to improve communication between students and teachers, as well as improving social skills. In this research, students with pragmatic and reflective learning styles, according to the CHAEA test, showed a higher average when applying the instruments designed to measure the five aspects under study to support educational inclusion.

The relationship that exists between the research (Chaidi et al., 2021), which analyzes the impact of robotics in inclusive institutions, highlighting in its results the active participation of students and the integration of children with special educational needs. This cited research is the one that coincides with that of this study, in the levels of participation of all the students. Nevertheless, in our case, an analysis from the distinctive emotional and cognitive components to support ER-inclusive learning, are also highlighted through statistical analysis the progress obtained by students as well as the progress during the development of the course.

CONCLUSIONS

The course designed for ER has allowed us to measure several inclusion aspects or components. Among these, the most favorable for positive students' attitude was the topic **interest**, which was reflected when they managed to capture the attention of the entire group in the last activities. The second prominent component was **motivation**, where curiosity and enthusiasm during each meeting and when taking on challenges received a rating of 74% at the "almost always" level of the measuring instrument. The third component that stood out in the research was **social skills**, which were reflected in communication and understanding, respecting the students' roles and assuming their responsibilities within their working team. **Creativity** was the component that achieved the greatest results. At the beginning of the course, the students presented flat ideas, little elaborated and without logical analysis. However, during the course's progress, the proposals reached higher levels. Finally, **problem-solving** also received high acceptance. The challenges were always focused on their interests and experiences, managing to crosscut with other grade subjects and with their pre-knowledge.

The learning methodology used was a combination of active methodologies such as PBL and CBL. PBL involved creating groups, assigning activities, investigating and implementing, whereas CBL involved connecting pre-existing knowledge, investigating, challenging, implementing and publishing. The approach also utilized collaborative learning, which promoted the joint construction of knowledge, cooperative learning to foster a common goal through interaction, and facilitated roles according to learning styles. Finally, design-based learning was used to propose a significant approach based on the interests and experiences of each participant, to convert into a prototype that would allow them to evaluate the results. All of these methods led the students to feel motivated and assume proactive roles in a team that needed everyone to achieve their set goals.

The Moodle-Milaulas adapted a technological learning environment that allowed users to combine virtual and face-to-face meetings according to their needs and possibilities during the COVID-19 pandemic.

We have created a measurement tool to evaluate students' participation in a course and record research outcomes, including key components of significant learning. The designed instrument was purposefully and validated by experts, achieving statistical reliability. This was tested through both Cronbach's alpha and Guttman's two halves tests, which produced positive results.

It was found that the performance of SEN students who have been taught using robotics was better than the general average. This suggests that robotics, when taught using appropriate methodologies, can be a valuable tool for promoting inclusive education in classrooms. These results provide evidence for the effectiveness of using robotics in education.

Throughout the course, all the students were able to improve their average scores in various aspects related to inclusion. This highlights the effectiveness of the activities and work environment provided. It's worth noting that the students classified as pragmatic and reflective in the CHAEA test showed a slightly stronger improvement, as demonstrated in **Table 7**.

The results show that aspects such as interest, motivation, social skills, creativity, and problem-solving are attributes of ER that are related to learning and facilitate educational inclusion in the classroom.

Author contributions: SACR: design of the research structure, application in work environments, and analysis in general; **HCMG:** pedagogical advisor and reviewer of methodology in general; **RJGH:** reviewer of the general structure of the research and global contents. All authors have significantly contributed to the development of the manuscript and are responsible for its content. Each author has reviewed and approved the final manuscript and has given consent for its publication.

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Data availability: Data generated or analyzed during this study are available from the authors on request.

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APPENDIX A: LEARNING STYLES (CHAEA TEST)

Instructions: Answer with a check mark (√) depending on your answer. If you agree more than disagree with the item, mark 'More (+)'. If, on the other hand, you disagree more than agree, mark 'Less (-)'. There are no right or wrong answers, it will be useful as long as you are sincere in your answers.

Table A1. Learning styles (CHAEA test)

Item	More (+)	Less (-)
1. I have a reputation for saying what I think clearly and bluntly.		
2. I am sure what is good and what is bad, what is right and what is wrong.		
3. Many times I act without looking at the consequences.		
4. I usually try to solve problems methodically and step by step.		
5. I believe that formalisms restrict and limit people's free action.		
6. I am interested in knowing what other people's value systems are and what criteria they act with.		
7. I think that acting intuitively can always be as valid as acting reflectively.		
8. I think the most important thing is that things work.		
9. I try to stay aware of what is happening here and now.		
10. I enjoy when I have time to prepare my work and do it conscientiously.		
11. I am comfortable following an order, at meals, in study, exercising regularly.		
12. When I hear a new idea I immediately start thinking about how to put it into practice.		
13. I prefer original and innovative ideas even if they are not practical.		
14. I admit and conform to rules only if they help me achieve my goals.		
15. I normally fit in well with thoughtful, analytical people and it is difficult for me to tune in with people who are too spontaneous, unpredictable.		
16. I listen more often than I speak.		
17. I prefer structured things to messy ones.		
18. When I have any information, I try to interpret it well before expressing any conclusion.		
19. Before making a decision, carefully study its advantages and disadvantages.		
20. I thrive on the challenge of doing something new and different.		
21. I almost always try to be consistent with my criteria and value systems. I have principles and I follow them.		
22. When there is an argument I don't like to beat around the bush.		
23. I dislike getting emotionally involved in my work environment. I prefer to maintain distant relationships.		
24. I like realistic and concrete people more than theoretical ones.		
25. It is difficult for me to be creative, to break structures.		
26. I feel comfortable with spontaneous and fun people.		
27. Most of the time I openly express how I feel.		
28. I like to analyze and think about things.		
29. It bothers me that people don't take things seriously.		
30. I am attracted to experimenting and practicing the latest techniques and innovations.		
31. I am cautious when drawing conclusions.		
32. I prefer to have as many sources of information as possible. The more data you gather to reflect on, the better.		
33. I tend to be a perfectionist.		
34. I prefer to hear the opinions of others before expressing my own.		
35. I like to face life spontaneously and not have to plan everything in advance.		
36. In discussions I like to observe how the other participants act.		
37. I feel uncomfortable with quiet and overly analytical people.		
38. I frequently judge the ideas of others by their practical value.		
39. I get overwhelmed if I am forced to speed up work too much to meet a deadline.		
40. In meetings I support practical and realistic ideas.		
41. It is better to enjoy the present moment than to delight in thinking about the past or the future.		
42. I get annoyed by people who always want to rush things.		
43. I contribute new and spontaneous ideas in discussion groups.		
44. I think that decisions based on careful analysis are more consistent than those based on intuition.		
45. I frequently detect inconsistency and weaknesses in the arguments of others.		
46. I think it is necessary to break the rules many more times than to comply with them.		
47. I often realize other, better, more practical ways of doing things.		
48. On the whole I talk more than I listen.		
49. I prefer to distance myself from the facts and observe them from other perspectives.		

Table A1 (continued).

Item	More (+)	Less (-)
50. I am convinced that logic and reasoning must prevail.		
51. I like to seek new experiences.		
52. I like to experiment and apply things.		
53. I think we should get to the point quickly, to the heart of the issues.		
54. I always try to get clear conclusions and ideas.		
55. I prefer to discuss specific issues and not waste time with empty talk.		
56. I get impatient with irrelevant and incoherent arguments in meetings.		
57. I check beforehand if things really work.		
58. I make several drafts before final writing a work.		
59. I am aware that in discussions I help others stay focused on the topic, avoiding digressions.		
60. I notice that I am often one of the most objective and dispassionate in discussions.		
61. When something goes wrong, I downplay it and try to do better.		
62. I reject original and spontaneous ideas if I do not see them as practical.		
63. I like to weigh various alternatives before making a decision.		
64. I often look ahead to foresee the future.		
65. In debates I prefer to play a supporting role rather than being the leader or the one who participates the most.		
66. I get annoyed by people who don't follow a logical approach.		
67. It is uncomfortable for me to have to plan and foresee things.		
68. I believe that the end justifies the means in many cases.		
69. I usually reflect on issues and problems.		
70. Working conscientiously fills me with satisfaction and pride.		
71. When faced with events I try to discover the principles and theories on which they are based.		
72. In order to achieve the goal I intend, I am capable of hurting other people's feelings.		
73. I don't mind doing everything necessary for my work to be effective.		
74. I am often one of the people who cheers up the most at parties.		
75. I quickly get bored with methodical and meticulous work.		
76. People often think that I am insensitive to their feelings.		
77. I usually let myself be carried away by my intuitions.		
78. If I work in a group I try to follow a method and order.		
79. I am often interested in finding out what people think.		
80. I avoid subjective, ambiguous and unclear topics.		

APPENDIX B: LIKERT-TYPE SCALE TO MEASURE FIVE KEY ASPECTS WHEN USING EDUCATIONAL ROBOTICS THROUGH PRACTICAL LABORATORIES

The instrument for measuring levels of inclusion in total has 25 items or questions, 5 to measure each aspect or dimension raised in the objectives, it is self-developed based on various instruments found in previous national and international research, for its validity and structure. It was submitted to the review of eight professionals from psychology, psychopedagogy and pedagogy.

Table B1. Likert-type scale to measure five key aspects when using educational robotics through practical laboratories

Interest	1	2	3	4	5
Read your work guide carefully, understanding the stated objective.					
Actively participate by answering the questions asked by the teacher and asking if you have any questions.					
His attitude is favorable when receiving instructions.					
Shows willingness to manipulate material and resources necessary to develop the experience.					
Actively participates, assuming its role in formulating ideas to strengthen the quality of the project to be developed within the proposed challenge.					
Motivation	1	2	3	4	5
Express curiosity when observing the graphic objects in the guide.					
Proposes ideas generated from your environment for the development of the guide.					
Observe and express your conclusions in writing, verbally, graphically, etc....					
Manifests initiative by assuming the activities of his role.					
Show enthusiasm to achieve the proposed challenge.					
Creativity	1	2	3	4	5
It proposes various ideas for the development of the challenge posed in the guide.					
Express feelings looking for possible solutions to the proposed challenge.					
State alternative solutions for the explained process.					
Provides ideas for manipulating available resources.					
He brings novel ideas that come from his imagination to reality, solving the challenge.					
Social skills	1	2	3	4	5
Listen to your colleagues in the interpretation of the guide and give your opinions if necessary.					
Express your concerns and proposals clearly.					
Interprets the instructions given and reaches agreements with his colleagues.					
Assume their role, respecting and fulfilling the activities agreed upon with their work team.					
Demonstrate collaborative work by generously contributing your skills to the success of the set objective.					
Troubleshooting	1	2	3	4	5
Relate the information contained in the guide with your pre-knowledge by socializing it with your work group.					
Describe the challenge posed, looking for suitable alternatives to achieve the goal.					
Relates the process developed in class with their needs aimed at solving the challenge.					
Identify various ways to solve the proposed challenge.					
Select the most appropriate solution by visualizing the possible results of the challenge.					

APPENDIX C: LEARNING PROFILE RESULTS

Instructions: Circle with a line each of the numbers that you have indicated only in the box with the plus sign (+). Add up the number of circles in each column and finally place these totals in the boxes below.

Table C1. Learning profile results

I Active	II Reflexive	III Theoretical	IV Pragmatic
3	10	2	1
5	16	4	8
7	18	6	12
9	19	11	14
13	28	15	22
20	31	17	24
26	32	21	30
27	34	23	38
35	36	25	40
37	39	29	47
41	42	33	52
43	44	45	53
46	49	50	56
48	55	54	57
51	58	60	59
61	63	64	62
67	65	66	68
74	69	71	72
75	70	78	73
77	79	80	76