# Using Heuristics and 'TEACCH' Material in Problem-Solving with Students with Autism-Asperger Syndrome

# El uso del Heurísticos y material TEACCH en la Resolución de Problemas con Estudiantes con Autismo-Síndrome de Asperger*

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**Abstract**: This study reports on the use of heuristics and TEACCH materials by students with Asperger syndrome for problem-solving tasks in a workshop. Taking visual representation as an organising principle, the use of heuristics such as trial and error, seeking regularities, and going backwards helped students overcome the difficulties associated with literal thinking and cognitive inflexibility, and poor shared and sustained attention related to deficits in central coherence and executive functioning. The interaction between, on the one hand, these heuristics, the visual material and manipulatives, and on the other, the characteristics of Asperger syndrome which they aim to mitigate is also considered.
**Keywords:** Autism Spectrum Disorder; Problem-solving; Heuristics; Inclusion; TEACCH material

**Resumen**: Este estudio expone el uso de heurísticos y material TEACCH por alumnado con síndrome de Asperger al abordar tareas de resolución de problemas en un taller. Tomando la

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representación visual como principio organizador, los heurísticos como el ensayo y error, la búsqueda de regularidades y la marcha atrás ayudaron a los alumnos a superar las dificultades asociadas al pensamiento literal, la rigidez cognitiva, y la atención sostenida, relacionadas con las limitaciones de la coherencia central y funcionamiento ejecutivo. Se consideran la interacción entre estos heurísticos, el material visual y los manipulativos, así como las características del síndrome de Asperger que pretenden mitigar.
**Palabras clave:** Trastorno del Espectro Autista; Resolución de Problemas; Heurísticos; Inclusión; material TEACCH

## INTRODUCTION

Mathematics is characterised by a higher level of abstraction, which might be incompatible to some abilities of students with Special Educational and Support Needs. The Spanish curriculum establishes inclusive education principles, but its transfer to the classroom still follows the deficit model (Echeita, 2017). In this sense, we claim for inclusive education, based on the presence, participation and succeed of students (Ainscow, 2024), specifically working on problem solving (PS) with students diagnosed Asperger Syndrome (AS).

This study draws on a doctoral thesis (Chico-Gómez, 2024), and reports on the implementation of heuristics for PS tasks in a workshop developed with children from an Asperger Syndrome Association (AOSA). It involved the use of heuristics (Carrillo, 1998) along with visual and manipulative TEACCH material (Treatment and Education of Autistic and Related Communication Handicapped Children; Schopler et al., 1995) in the problem-solving process following the principles of Universal Design for Learning (UDL) and the "Solve it!" method. The research questions are: What heuristics do they use and how do Asperger Syndrome students solve problems with TEACCH material? How are their solving strategies related to the general features of the syndrome? Three teachers' interview complement this research to clarify educators' perspective when working PS with children with Asperger in the ordinary classroom.

## 1. THEORETICAL FRAMEWORK

Asperger Syndrome is a functional neurodiversity on the autism spectrum (level 1, without cognitive affection, according to DSM-V; APA, 2013) that present characteristics associated to executive functions and the

Central Coherence and the Mind Theory (see Table 1). This affects social interaction and communication and reduces flexibility in terms of behaviour and routines (de Giambattista et al., 2019). Research on autism and PS (Root et al., 2021) underlines the role of cognitive strategies and representation. This review highlights the advantages of strategies considering PS stages (foregrounding the stages of comprehension and execution), especially in terms of the representation of the information, emphasising the visual channel for mitigating the problems derived from understanding written texts (Kribbs & Rogowsky, 2016; Delisio et al., 2018). Significant advances have been also noted in AS students by sequencing the problem statement and the solution procedure, attending to the difficulty with verbal understanding and identification of structures (Klaren et al., 2017).

In this regard, the heuristics described by Polya (1945) represent an appropriate starting point for tackling PS in relation to the characteristics of Asperger, since these strategies can be described as supportive methods that provide students with planning reasons, steps, and criteria for developing a particular process (Goldin & Shteingold, 2001).

Table 1. Asperger Syndrome associated features

| EXECUTIVE FUNCTIONS | | ABILITIES |
|---|---|---|
| Difficulties in making predictions<br>Difficulties in shared and sustained attention<br>Difficulties in organising/planning<br>Self-regulation difficulties<br>Working memory difficulties<br>Reduced mental flexibility | | Preference for sequence learning<br>Visual ability<br>High level of visual and rote memory<br>Auditory perception<br>Ability to perceive/focus on detail<br>Pattern recognition |
| CENTRAL COHERENCE AND MIND THEORY | | |
| Difficulties to infer the larger meaning inherent in a communicative situation<br>Difficulties with understanding non-verbal messages<br>Literal Thinking | | |

*Note*: adapted from Bae et al., 2015 & de Giambattista et al., 2019.

Heuristics such as the use of drawings or constructions provide the solving process with visual representation, which associated with other strategies during the solution phase (see Table 2) facilitates the handling of the data (Novotná et al., 2014), experimentation and simplification of the problem statement, in terms of presentation rather than content. Research into heuristics and staged methods (e.g. SOLVED, DISC and Solve it!) have shown the effectiveness of schematic and visuospatial instruction with students with specific learning needs (Kribbs & Rogowsky, 2016). Also, situating visual representation at the problem-solving heart, allows alternative methods of communication to be embodied, such as pictograms and graphics (Polo-Blanco et al., 2018). In this sense, the inclusion of TEACCH materials following the UDL principles facilitate sequencing through visual cues, in terms of both understanding and solving the problem (presence and progress), which promotes orderly sequencing and increases student autonomy (Rose & Gravel, 2010) and emotional engagement (participation). These ideas are integrated into the inclusive perspective contemplated in the Spanish education law, which since 2006 advocates the creation and adaptation of the teaching context to cater for diversity, rather than the needs of the students (Chico-Gómez, 2024). Moreover, UDL is recognised and included in the new Spanish educational law.

Most of studies in the field of PS with students diagnosed with AS are focused on arithmetic word problems (Root et al., 2021). By contrast, this research reports on the appliance of heuristic problems, which require the appliance of going backwards, trial and error, and seeking regularities (Table 2). These heuristics seem to be connected to the most frequent AS features and therefore influence on the PS process: The rigidity of thinking and weak self-regulation when moving onwards and backwards; the difficulty to predict when (more or less) systematically checking the PS process and the ability to focus on details in order to seek for regularities (Delisio et al., 2018).

Table 2. Solving phases and heuristics

| Identification and comprehension | | Planification and execution | | Verification |
|---|---|---|---|---|
| Representing<br>Exemplifying<br>Organising the information<br>Use a list<br>Making an analogy | | Seeking regularities<br>Exploding only one variable<br>Systematic or random trial and error<br>Going Backwards | | Generalising<br>Analysing consistency: process/solution |

*Note:* Elaborated from Carrillo (1998) & Novotná et al. (2014)

## 2. METHODOLOGY

This case study is thriven through a two-day workshop in collaboration with AOSA and INCLUREC (a project from the University of Huelva, which creates teaching resources for students with special educational needs). The 16 participants (6-18 years old), who had never worked together, were chosen and grouped by the AOSA psychologists according to age, abilities and cognitive development (Figure 1).

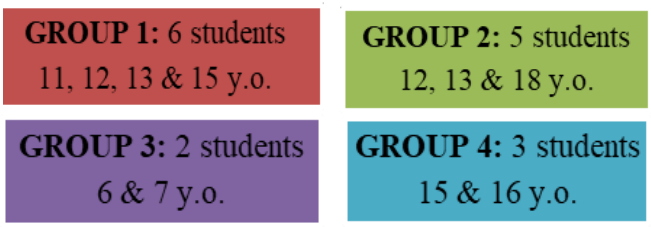


Figure 1. Workshop Groups

The problems (see Table 3) were selected in terms of applicability of the heuristics, and they were contextualised in situations of interest to the students (animals and construction games). Manipulatives (depressors, fractions with Velcro, coloured dot stickers), pictomaterial and visual organisers, were implemented for helping them progress through the problem. After individual reading and paraphrasing the statement, materials were provided, as well as teacher support, following Solve it! Phases and UDL principles and guidelines (different forms of presenting

and expressing the information and different manner of involving children to participate through discussion and feedback). The teachers intended to orientate children's ideas attending to their needs, aiming to reduce the influence on the solving result to a minimum. Problems were also organised keeping in mind participants' level diversity, so every group were assigned a set of problems according to the expected difficulties and heuristics requirements. Both the materials and the problems were adapted, after being tested with students not diagnosed with AS and same aged as the sample, in terms of reduction in the amount of information and easier numerical relationships. The research data was gathered through observation, audio-visual recordings, and participants' productions. Following a qualitative methodology, a content analysis of the transcriptions and participants' work was conducted (McMillan et al., 2005), from which units of information were obtained and then categorised according to the heuristic employed and the involved Asperger features (Table 1, 2). As an example, the figure 6 (see Results) shows the implementation of the heuristic (tabular) representation. Also, as the student applies a strategy used in a previous problem and does not modify it after observing that it is not successful, we associate with it inflexibility of thinking and organising difficulties.

Table 3. Record of problems and material used in the workshop

| | |
|---|---|
| **Problem 1:** These figures have been made from identical sticks. How many sticks are needed to make 4 figures? And for 7? | 1A (Groups 1,2,3,4)  <br>1B (Groups 1,2, 4)  |
| **Problem 2** (Groups 1, 2, 3 and one member of group 4): Juan lives on a farm which has hens and rabbits. Counting all the animals on the farm, there are 10 heads and 28 legs. How many hens and how many rabbits are there? | |
| **Problem 3** (2 members of group 4): Carmen leaves home with a bag full of nuts. She meets Martina and gives her half of the nuts. Then she sees Julia and gives her half of the remaining nuts. Finally, she eats two of the nuts she has left and gives the last one to a squirrel. How many nuts did she have at the beginning? | |

To approach PS in the classroom context, four semi-structured interviews were thriven. Some information about teachers have been

included. The interviewees are primary level teachers from public and private schools, who have Asperger Syndrome students as part of their class diversity. The questions revolve around three topics: methodologies applied when solving problems with a child with Asperger, the difficulties teachers must cope with and the teacher training needs when dealing with inclusive Mathematics in the classroom.

## 3. RESULTS

Visually representing was the most frequently used heuristic at all PS stages. The participants referred to the schematic representations in order to tackle fractions (problem 3), recognise algebraic variables (problem 2), and to make structures in search of a pattern (problems 1A and 1B), giving priority to visualisation of the information, and linking the syntax and the semantics. In this way, they approached other heuristics which take support in representation transversally.

### 3.1 Representation and seeking regularities

The joint use of the visual organiser (Figure 4) and the tongue depressors (Figure 2) facilitated the development of a personal strategy because of the possibility of transposing the annotations needed to find the pattern underlying problem 1. The coloured depressors also enabled participants add new figures to their constructions, especially when recognising the shared stick (1B, Table 3) (see figure 2). However, the illustration given in the problem statement generated an obstacle due to the literal interpretation, since the width of the 'shared' stick was greater than the others. Despite this added difficulty, the students were successful in developing generalisation. The visual support incorporated in the material was evident at several levels, from simply counting the number of sticks needed for 9 and 10 figures – an arithmetic generalisation (Radford, 2001) observed in group 3 (see Figure 3) – to the contextual generalisation (ibid., 2001) by establishing a relationship between the number of shared sticks and the number of figures (n), multiplied by 10 (10n-(n-1)), as we can see in the following dialogue with Mar, fictitious name of a student who belongs to the group 1. The joint use of the visual organiser (Figure 4) and the tongue depressors (Figure 2) facilitated the development of a personal strategy because of the possibility of transposing the annotations needed to find the pattern underlying problem 1. The coloured depressors also

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| | |
|---|---|
| Mar (G1): | For each figure you add 9 sticks to the others because they share this stick (indicating the stick in the Velcroed picture). |
| Teacher: | And so how do you know how many sticks you need for 7 figures? |
| Mar: | I count the number of figures (x10) and subtract the shared sticks. |

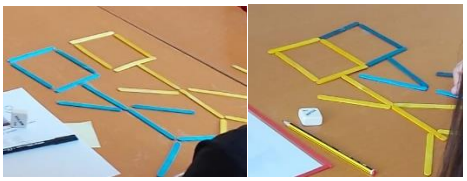

Figure 2. Transition to the shared stick

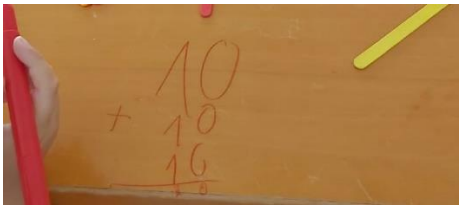


Figure 3. Counting sticks on the left part of the table: "10+10+10"

On the other hand, some students replaced the visual representation using the organiser as a means of recording the information (Figure 4),

which allowed them to discover their own strategy (David, group 4 and, Isaac, group 3).

David (G4): It's like it was the 9 times table. You calculate it regarding the figures. You add ten for the first one which is the odd one out and doesn't fit the pattern.

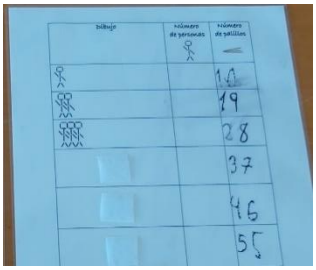


Figure 4. Seeking regularities without support of the pictomaterial

Isaac (G3): I'm changing the numbers in the table. I take away one from this one (units' column) and give it to other (tens column).

Teacher: What if you don't know the one before? 9 figures, for example?

Isaac: Then I take 2 away and give them to the other one.

### 3.2 Representation and trial and error

The trial-and-error heuristic aims to find a correlation between two variables, requiring various attempts to fit the data until a solution can be found. The need to go back and reformulate the initial hypothesis requires mental flexibility and an understanding of the big picture, something which appears to be incompatible with the deficit in executive functioning associated with AS (Bae et al., 2015: Polo-Blanco et al., 2024). Representing the number of animals (problem 2) through malleable material (stickers or drawings) enabled the participants to tackle the problem in a pre-algebraic manner by extracting from the problem statement the heads and legs, thus mitigating the difficulty of organising the information while at the same time keeping focused on the two data elements of the problem. Nevertheless, the literality of thought and mental rigidity characteristic of AS constrained the students' representation, tending to focus on the drawing and its execution rather than on what it

represented. Thus, Sergio (group 2) refused to carry on with the problem because the stickers did not match with his mental image of hens and rabbits. He originally drew the legs of hens with three toes (Figure 5), so when substituting them for rabbits, he added four more legs, ending up with an odd six-legged beast, which caused him to give up the attempt (showing the strong influence of emotions on AS students solving problems). Javi (Group 1, Figure 6) used the stickers indistinctly as both legs and heads in a table. However, the remaining participants were able to carry out the trial-and-error strategy, with attempts varying between random attempts (Figure 7) and a more sequenced and regulated procedure based on the counting of legs (Figure 8).

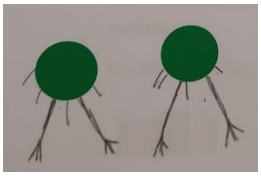

Figure 5. 6-legged animals

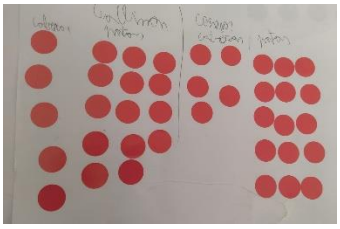

Figure 6. ‘Hens’ heads’, ‘hens’ legs’, ‘rabbits heads’ and ‘rabbits legs’ columns

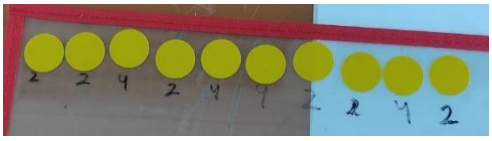

Figure 7. Random assigning legs to the stickers

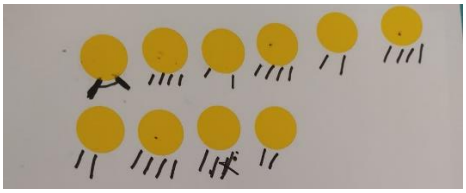

Figure 8. Alternating 2 and 4 legs

### 3.3 Representation and going backwards

The going backwards heuristic introduces a different perspective for PS, presenting the problem with an initial unknown quantity. The TEACCH material enabled students to associate the meaning of half to the number of nuts remaining after several sharing steps. It especially supported the understanding of fraction meaning as being part of a whole. Using the table allowed to organise the data corresponding to each sharing episode according to known information on the one hand, that is the nuts which were shared, and derived information (Mulligan et al., 2006) on the other – a key element for working out how many nuts remained after each encounter. During the problem 3 solving process, both participants broke the problem down into its constituent events and used the detachable fraction markers to tackle the problem from an arithmetic perspective connecting nuts and fractions (Figure 9) or visual perspective (Figure 10).

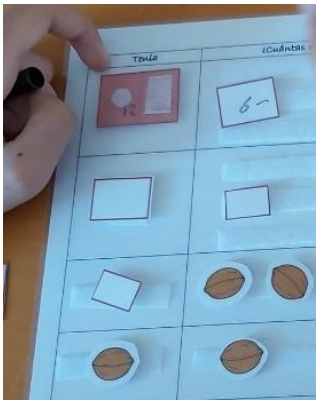


Figure 9. The nuts are associated with the meaning part of a whole

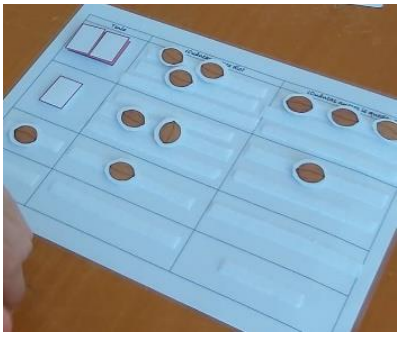

Figure 10. Doubling the number of nuts from the endpoint

### 3.4 Association of heuristics, TEACCH material and Asperger characteristics

Regarding previous ideas, the Table 4 relates TEACCH material and heuristics (see Table 2) as a support for characteristics typically associated with AS (see Table 1).

Table 4. Heuristics, TEACCH material and Asperger Syndrome characteristics

| Seeking regularities | |
|---|---|
| **Heuristics** | **Characteristic of Asperger and the use of TEACCH material** |
| Representing | **Visuospatial abilities and focus on details:** Observing and counting sticks which vary from one figure to other (Figure 2).<br>**Difficulties in making predictions:** Representations can be numerically associated (Figure 3, 4). |
| Organising information | **Difficulties in shared and sustained attention:** Various complementary resources are used (Figures 2, 4).<br>**Difficulties in organising, planning and working memory:** Notes include pictorial elements (Figures 3, 4). |
| Generalising | **Working memory, perception of details and difficulty in seeing the big picture:** Seeking a pattern in a drawing, construction or the data summarised in the organiser (Figure 4). |
| Trial and error | |
| Representing<br>Exemplifying | **Difficulty in verbal understanding:** Use of images or drawings to extract data and reproduce them using material (Figure 7).<br>**Reduced mental flexibility and difficulties in making predictions, organising and working memory:** Rabbits |

| | |
|---|---|
| Exploding only one condition | and hens can be drawn indiscriminately, employing a schematic representation and modifying the number of each one, fixing the total number of animals. Drawing and constructing help break down the examples' properties into smaller units (Figures 7, 8). |
| Going backwards | |
| Analysing consistency: process/solution | **Difficulty in self-regulation:** Visual support from drawings and tables allows nuts to be counted at all times, with bi-directional reading of starting and end data (Figure 9). |
| Organising information<br>Representing | **Predominance of sequential learning**<br>**Difficulties in organising, planning and working memory:** The story is told throughout the pictures, creating associations between the number of nuts and fractions (Figure 9, 10) |

### 3.5 Problem solving and Asperger Syndrome in the real classroom

The interviewed teachers implement strategies more or less close to inclusion in terms of presence, participation or progress principles (Rose & Gravel, 2010): from applying a timer and organiser to the entire group, to individual work outside the classroom (Roos, 2023). They all agreed the greatest difficulty in PS lies in the comprehension and execution phases. The frequently affected executive functions translate into the predominance of the mechanic and sequenced arithmetic, skipping the solving process or even misreading the statement. The teachers claim to follow solving phases; to bring the problem closer to the student's daily life; to include other means of communication such as the appliance of UDL through projects and visual cues; and to establish rules regarding organising or planning needs. However, the lack of human resources, time, and ratio might restrict teachers' work. Teacher-training is described as paramount to approach inclusive methods (Klaren et al., 2017). This might provide them with tools and knowledge, though trial-and-error prevails as

a method to discover benefits and difficulties when applying pedagogic strategies.

## 4. CONCLUSIONS

The representation heuristic linked to the organisers and TEACCH material following the UDL principles enabled students to sequence the comprehension and solution stages (problem 3) as they overcome the restrictions associated with limited mental flexibility, shifting the tendency to dwell on the specific towards a more global understanding of the situation (de Giambattista et al., 2019; Delisio et al., 2018). Order and sequencing were worked on through the going backwards and generalisation heuristics, as necessary dynamics for finding a solution. Regarding difficulties, literal thinking and mental rigidity represent obstacles to learning, and hence the importance of substituting pictorial representations to more schematic ones (Polo-Blanco et al., 2018; Kribbs & Rogowsky, 2016). Also, difficulties related to focus on the original objective during the execution stage, linked to poor working memory, sustained attention and planning (Klaren et al., 2017), were evident when dissociating animals from the legs and heads counting process (problem 2). Nevertheless, we would underline the involvement of the trial-and-error heuristic in this problem since, being a priori incompatible with the rigid thinking and absence of intuition associated with people with AS (de Giambattista et al., 2019), it was spontaneously adopted systematically by 85% of the problem-solvers.

Through the heuristics and TEACCH materials we pay attention to the cognitive but also the emotional state (Gourdou, 2019): children were emotionally engaged in the problems as challenging activities (participation), though the way the material is presented might also trigger negative emotions, as consequence of children expectations and rigid thoughts (e.g. Sergio); strategies were not fixed and impressions could be exchanged at the discussion time (progress), and the materials provide students with the autonomy to continue and organise their responses, visually supported, considering errors as solving process (presence). Long-term PS workshops with four AOSA children will delve into heuristics reflecting on these UDL principles and therefore thrive teacher training regarding inclusive Mathematics, to work on heuristics on the base of understanding the usual Asperger Syndrome features and classroom methodological needs.

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