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The Benefits of Cooperative Teaching Applied Through Projects to Improve Learning for Students with Autism Spectrum Disorder

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ABSTRACT: People with autism spectrum disorder (ASD) are characterised by severe limitations in nodal connectivity of information, which can involve some or several levels of the neuropsychological information processing system to various degrees. For this reason, in besides treating behaviours formally expressed by international classifications, it´s necessary to apply programmes to facilitate functional connectivity and fluidity over knowledge processing, in this sense, the cooperative project-based method can help neural networks interact and support the perception and subsequent processing of information.
A total of 10 participants took part in this study, divided into two groups of 5 students each. One of the groups included a student with level 1 ASD (n: 5). All students belong to the same class and are studying all subjects corresponding to first grade of secondary education. Results confirmed the hypothesis that project-based work in small cooperative groups is effective, with all students showing improvement compared to the other two didactic methods implemented: practical and expository. Moreover, it was also observed that the group in which the student with ASD participates has not impaired the knowledge process, but, on the contrary, provides benefits that exceed the second group of exclusively neurotypical students (n: 5) in the statistics applied.

KEY WORDS: Autism spectrum disorder, genetics and nodal relationships, perceptual-cognitive processing, cooperative learning, project work.

INTRODUCTION

Persons with ASD, in its three levels of intensity, are defined by a developmental disorder, which is symptomatically observable regarding to three symptomatic categories, related to deficits in social interaction, social communication, and restrictive and stereotyped behaviours, within three levels of intensity, being 1 the lowest level and 3 highest specificities (American Psychiatric Association, 2013; National Autism Center, 2015). These specificities usually co-occur with other associated comorbidities to greater or lesser severity, such as epilepsy, attention deficit hyperactivity disorder or intellectual disability (Baghdadli et al., 2018; Franchini et al., 2018; Mahoney, 2023; Sparrow, Cicchetti & Saulnier, 2016). However, these behaviours aren't always observed so formally during the diagnostic process, and some of them may even appear with a certain intensity while others show no apparent signs, and in some cases, none of them may be observed; nevertheless, a structural rigidity specific to this disorder is observed, which may lead to diagnostic errors, currently estimated at approximately 70%–80%.
For this reason, Patriquin et al. (2016) and Ojea (2025) in-depth analysis of perceptual-cognitive relational processing in people with ASD concludes that neural activity, which links information through the process of informational connectivity on a brain level, presents relational-nodal deficits in new information regarding to previously learned knowledge, which affects the nodal of neurotransmission processes in the gamma-aminobutyric acid or GABAergic system, which is fundamentally genetic, limiting the self-perceived relationship in the new context with previously acquired information, so that, at an individual level, they cannot find the connections between the two pieces of information that would allow them to make a decision and solve a problem with any certainty.
Indeed, this neurotransmitter system for relational information is not included in current diagnostic tests, yet it could be used to diagnose the disorder in people who exhibit very few or none of the behaviours observed in current classifications, as attempted in Ojea´s specific complementary diagnostic test (2023), which aims to analyse not only the observable behaviours of currently classifications, but also to determine the perception, coding, cognition and information retrieval levels, with the aim of analysing possible deficits in the functioning of neuropsychological information processing as a whole.

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Therefore, in order to improve the quality of educational services, it´s advisable to update the diagnostic processes and, above all, to improve the educational intervention, since doing it just as an individual adaptation is still further hindering the development of these cognitive nodal relationships for the teaching-learning processing, as it does not enable him to gather these relationships from the environment or context, something he is unable to do by himself.

Of course, students with ASD might need specific individual support, but always within the group activity, on which they could activate the nodal relationships and inductive and deductive developments observed in their peers and make them their own, justly then and not before, will students be able to develop complex cognitive activities on a self-directed basis, which gradually develop as they progress through the characteristics of the academic subjects themselves (Fransen, Weinberger & Kirschner, 2013; Weinberger & Fischer, 2006). The assignments thus form a set of interactive sub-tasks among the students who participated in developing them, which contribute to the cognitive enrichment of everyone, but especially the students with ASD, whose limitations necessarily require this complementary contribution, the intensity of which will logically depend on the cognitive abilities associated the students with ASD (Janssen, Erkens, Kanselaar & Jaspers, 2007).

In fact, collaborative learning generates bipartite networks, which facilitate the automatic creation of information networks between contents, provided that the content is a coherent development project (Hadwin & Oshige, 2011; Järvelä & Hadwin, 2013), which influenced the creation of all metacognitive factors essential for the effective processing of information, not just for students with ASD, but also all students within the group (Freyn, Sedaghatjou & Rodney, 2021; Magen-Nagar & Shonfeld, 2018; Newman, 2018). Consequently, this intervention is highly mediated, either by a teacher-tutor or by a student-tutor assigned to support the student with ASD (Kulichyova, Jooss & Garavan, 2024; Odom & Strain, 1984; 1986), that improves the information processing in most complex components, including the ability to induct and deduce regarding to the contents previously studied (Green, Hernandez, Bookheimer & Dapretto, 2016).

Obviously, these methodologies, when properly applied, require ongoing training for teachers on the aims of collaborative learning, as well as for the students themselves, in order to achieve the planned aims (Busby, Ingram, Bowron, Downing & Peckham-Hardin, 2007; Carter & Hughes, 2006; Downing & Peckham-Hardin, 2007; Oliver & Lyons, 2012; Foreman, Arthur-Kelly, Pascoe & King, 2004; Kim & Park, 2018; Siu & Ho, 2010; Morrier, Hess & Heflin, 2011). Maybe it´s this lack of teacher training that keeps us going with basically individual intervention processes, through curriculum adaptation and differentiated environments.

Obviously, this intervention way must go beyond the school itself and extend to the peer group and, above all, to the family and/or specific external associations or services where they might complete their training, forming a constant inclusive process, in which everyone works to the standards of the training needed based on the specific needs of this disorder (Goodman & Williams, 2007; McCabe, 2008; Salisbury, 2006).

GENERAL AIMS

The general objectives of this study are essentially threefold: 1) to analyse whether cooperative learning through project work significantly improves the teaching and learning of students with ASD in relation to other learning methodologies, 2) analyze the resulting longitudinal data compared at all three assessment times of student learning with ASD throughout all subjects, and 3) verify whether the participation of students with ASD in one group impairs overall results, compared to control group, where all students are neurotypical.

METHOD

Research design

The design is based on the analysis of assessment results found in the three types of teaching-learning corresponding to the 1st year of secondary education, Regarding cooperative learning, practical learning, and the expository teaching process, throughout an academic year.

The teaching and learning methods weren´t created on the ad hoc basis, but that´s how the educational process is organized in this particular course at this educational centre. The differential data from three methodologies applied were analyzed by means of Kolmogorov-Smirnov Z Test for 1 sample; while the differential data between the two groups of students (the group with a student with ASD and the neuropypical group) were studied by means of the Mann-Whitney U and Wilcoxon W tests.

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Participants

A total of 10 first-year secondary school students participated in this study, distributed into two groups. One group consisted of five participants, including one student with ASD´ level 1 of highly intellectual ability. The other group was made up of five exclusively neurotypical students.

Variables

The variables are the subjects themselves of first year of secondary education, regarding to the average result obtained over the three trimestres of the course. Logically, though, all subjects have theoretical and practical content, the subject categories have, in addition, been subdivided according to the prevailing teaching methodology applied:

I) COOPERATIVE: 1) mathematics (math), 2) biology, y 3) technology (tech).
II) PRACTICAL: 4) citiz (citizenship education), 5) music, y 6) physical education (motor).
III) EXPOSITIVE: 7) language and literature (language), 8) geogragpy, 9) 1ª foreign language (foreign), y 10) language specific to the community (langua2).

Data analysis

Data has been operationalised in a database of the SPSS statistical package, being operationalised as follows: 0 (0-2 points), 1 (3-4 points), 2 (5-6 points), 3 (7-8 points) and 4 (9-10 points). Results were obtained through the tests specified in the research design section and are analyzed in the results section.

Procedure

All students belonging the two groups study all subjects corresponding to the three types of teaching-learning, into which the 10 subjects are classified throughout one school year. And, although any teaching method might utilize some of the characteristics corresponding to three academic methodologies, in this study, it´s been classified in regards to the intensity the use of one teaching methodology or another applied to the whole sample (N:10): 1) cooperative, 2) practical , and 3) expository methodology, whose most general features are outlined below.

Cooperative methodology

The academic interaction of this method has involved a cooperative methodology between 4-5 students, who develop their own project in according with the aims and content facilitated by the teacher, thereafter enabling students to work independently themselves. Throughout this process, students with ASD build a stronger connection between theoretical concepts and their practical application, which he sometimes gathering directly from his classmates, and other times getting from his own directly input.

In this approach, it´s essential to get help from a partner tutor within the team to support the student with ASD and keep them focused on the main goal and important aspects of the key concept, so they don't get sidetracked by secondary issues (Council for Exceptional Children, 1988; Schneider, Dowell & Thompson, 2021). In this study, the peer tutor is the student wearing a T-shirt marked with an M (mediator) (see Figure 1), but without failing to provide any individual attention that might be necessary from the support teacher or tutor (van Aalst, 2013).

The cooperative teaching method has been applied in the subjects of mathematics (math), biology (biology) and technology (tech). E.g., in the topic of 'proportions' in the subject of Mathematics, the project proposes an economic exchange, which the students, then try to work out their answers and conclusions independently, using the necessary material ssupplied.

Lastly, they present their findings to the whole class, a small extract of which is shown above:

> "The cost of 12 photocopies is €0.50, how much will it cost to make 30 photocopies?: One girl immediately said that it´s very easy, as we could use a 3-step rule, i.e.:
> If 12 photocopies – €0.50
> 30 photocopies – X
> Therefore, X = (30/0.50)/12 = €1.25.
> In conclusion, 30 photocopies would cost €1.25.
> The other five members of the group had fully understood the functional process, allowing the student with ASD to add to the problem situation:
> And if there were 40 photocopies, then they would cost €1.66 (...)"

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Figure 1: cooperative learning.

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Practical methodology

This teaching method has been carried out in the subjects of citizenship education (citiz), music (music) and physical education (motor), which, themselves, are highly practical classes, However, they could be more individual or collaborative depending on activity way. This means that a running race is an individual justly sport (see Figure 2a); but a team game, like football or basketball, that require a methodology of cooperation between the members of each team, but it doesn't mean it fits the characteristics of an independent academic project of a cooperative design (see Figure 2b)

E.g., In physical education (motor), some activities are based justly on each student's individual skills, while others need the group to work together, but also, some skills are individual.

However, in any case, the basic programme must be adapted to the general characteristics of the students who make up the group as a whole or, when least, conform to the specific characteristics that the programme should include in accordance with the most significant specific needs of a particular group (Loiacano & Valenti, 2010).

Figure 2a: Individual functional teaching.

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Figure 2b: Group functional teaching.

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Metodología expositiva

The subjects with the most intensive lecture-style content were language (language and literature), geography, foreign language (first foreign language), and langua2 (the language of the Community). In these subjects, which are taught in a lecture-style format, as the results also show, not justly students with ASD had more difficulty keeping up with the class, but it also adversely affects all students in general.

E. g., while discussing the theme of the Geography and History subject, 'the movement of the Earth,' the teacher is saying:

> "The translation of the Earth describes the movements it makes as the Earth revolves around the Sun, which takes 365 days and 6 hours, corresponding to one year to complete this journey. This movement occurs in the Earth´s orbit and reaches a distance of approximately 930 million kilometres. (…)"

After about 10 minutes, the brain of a student with ASD begins to deflect attention towards their own thoughts, which might be related to the topic being explained or simply be a new and completely unrelated creation.

However, with greater or lesser difference, the majority of neurotypical students also disconnect after a certain length of time, which could cause them to miss the main points of the teacher's basic discourse (see Figure 3).

Figure 3: expository teaching.

Source: copyright rights have been acquired from the Canva-Pro software (ABN- 80 158 929 938). Canva-Pro: **iAGtaW-84Ck.**

Ethical considerations

This study has ensured absolute confidentiality, both in terms of locations and participants, who have consented to its performance justly for the purpose of scientific divulgation of data in an anonymous way.

RESULTS

Data resulting were classified into three sections: 1) differential data found regarding the methodology way used, 2) specific following of student with ASD throughout different subjects, and 3) comparative data of the group ASD, compared to a neurotypical group.

Firstly, the general statistical descriptions are indicated for the non-parametric comparative Kolmogorov-Smirnov Test for one sample (S-K) for the three teaching-learning approaches applied, in the aim of observing whether there´re differences between the methods regarding to the means (μ), standard deviations (σ) and averages found the subjects that students are studying grouped according to methodologies (see Table 1).

Table 1: General descriptive statistics (N: 10).

subjects		μ	σ	min.	max.
COOPERATIVE	math	3.70	.48	3.00	4.00
	biology	3.30	.48	3.00	4.00
	tech	3.30	.48	3.00	4.00
PRACTICAL	citiz	2.50	.52	2.00	3.00
	music	3.00	.47	2.00	4.00

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	motor	3.10	.56	2.00	4.00
EXPOSITORY	language	1.80	.63	1.00	3.00
	geography	1.40	.69	.00	2.00
	foreign	2.40	.69	1.00	3.00
	langua2	1.80	.42	1.00	2.00

Data show that highest statistical average is found in cooperative teaching matters (COOPERATIVE) (μ: 3.43), while in the activities corresponding to the PRACTICAL section, the arithmetic means are slightly lower than in the previously cooperative section (μ: 2.87). Finally, the scores for subjects delivered through expository teaching method (EXPOSITIVE) were the lowest in this study (μ: 1.85).
The previously descriptive statistical data were also confirmed with the S-K Test (see Table 2).

Table 2: Kolmogorov-Smirnov Test for one sample (N=10).

		COOPERATIVE			PRACTICAL			EXPOSITIVE			
		math	biology	tech	citiz	music	motor	language	geography	foreign	langua2
parameters (a,b)	μ	3.70	3.30	3.30	2.50	3.00	3.10	1.80	1.40	2.40	1.60
	σ	.48	.48	.48	.52	.47	.56	.63	.59	.69	.51
≠ extremes	absolute	.43	.43	.43	.32	.40	.37	.32	.30	.30	.38
	positive	.26	.43	.43	.32	.40	.37	.27	.21	.21	.27
	negative	-.43	-.26	-.26	-.32	-.40	-.30	-.32	-.30	-.30	-.38
Kolmogorov-Smirnov Z		1.36	1.36	1.36	1.03	1.26	1.17	1.02	.96	.96	1.20
asymptotic sig. (bilateral)		.04	.04	.04	.23	.08	.13	.24	.31	.14	.11

a) Contrast distribution is normal.
b) Calculated based on data.

In effect, the critical level of significance of the three subject categories that make up the cooperative methodology found significantly positive differential levels (sig.: .04) in the three subjects that making up it (math, biology, and tech).
Although, there´re no significant differences observed in the subjects that make up the practical section, such as citiz (sig: .23), music (sig: .08) and motor (sig: .13).
Lastly, no significant differences were found in any of the subjects taught mainly through expository and magistery classes regarding to third expositive cathegory analyzed: language (sig: .24), geography (sig: .31), foreign (sig: .14) and language2 (sig: .11).
As a whole, the subjects that were taught cooperatively based on work projects proposed by the teacher, in which students collaborated with each other to solve the problems posed, have been the most academically successful compared to the other two methodological categories.
Regarding the personal academic development of students with ASD, as can be seen in Figure 4, the same downward trend is observed. Nevertheless, two exceptions have been observed regarding to practical subjects, since while students with ASD show excellent skills in music, in which they have achieved high scores, Nevertheless, he´s very inflexible and has particular difficulties in physical education, which is why his qualification in this subject was significantly lower.

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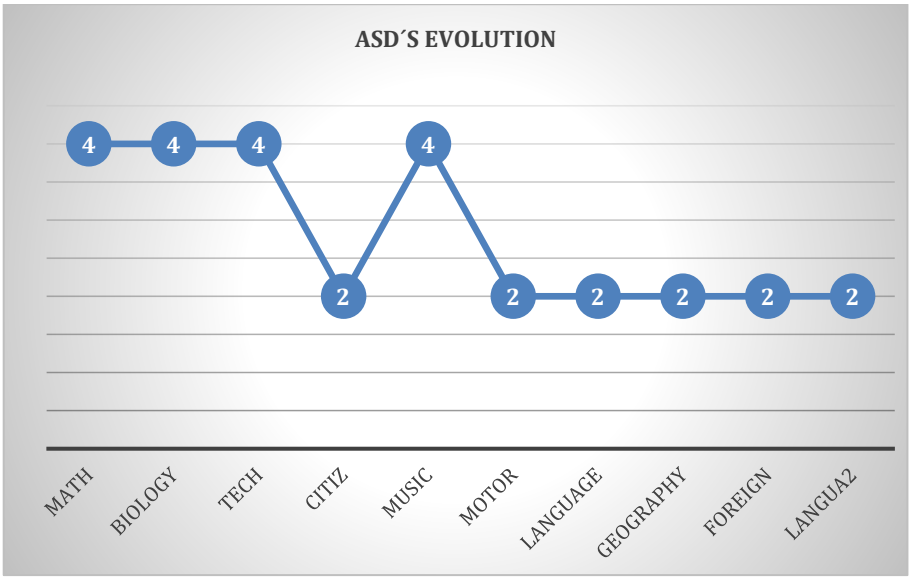

Figure 4: ASD´s academic evolution.

As can be seen, therefore, the student with ASD progressed similarly to the other students in both groups, even contributing positively to the average scores in the subjects that made up the cooperative group, as well as in the practical subjects group, specifically in music, as well as in the category of practical subjects, specifically in music, in which he particularly stands out.

Regarding the third and last study aim, which set out to determine whether the participation of student with ASD in (ASD group) affecting in some way the average scores found, in relation to group exclusively composed of neurotypical students (typical), according to three methodological categories applied.

To get this question, it used the Mann-Whitney U Test for two groups.

Firstly, it´s possible to observe the set of rank statistics and the average score for each group, which indicated very insignificant differences in all subjects, corresponding to the three teaching methodology categories, which, as previously mentioned, were applied to both groups of participants, both the group that included the student with ASD and the group made up exclusively of typical students (see Table 3).

Table 3: Ranks by group way.

categories	subjects	group	N	μ rank	Σ
COOPERATIVE	math	ASD	5	6.00	30.00
		typical	5	5.00	25.00
	biology	ASD	5	6.00	30.00
		typical	5	5.00	25.00
	tech	ASD	5	6.00	30.00
		typical	5	5.00	25.00
PRACTICAL	citiz	ASD	5	5.00	25.00
		typical	5	6.00	30.00
	music	ASD	5	5.50	27.50
		typical	5	5.50	27.50
	motor	ASD	5	5.10	25.50
		typical	5	5.90	29.50
EXPOSITIVE	language	ASD	5	5.60	28.00
		typical	5	5.40	27.00

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	geography	ASD	5	6.20	31.00
		typical	5	4.80	24.00
	foreign	ASD	5	6.20	31.00
		typical	5	4.80	24.00
	langua2	ASD	5	6.50	27.50
		typical	5	4.50	27.50

In essence, the Mann-Whitney U Test and its relative correspondence to the Wilcoxon Test highlighted that all critical levels or significance values were clearly insignificant in any of the subjects analyzed, regarding the educational categories applied to both groups (see Table 4).

Table 4: Mann-Whitney U to group variable (b).

tests	math	biology	tech	citiz	music	motor	language	geography	foreign	Langua2
Mann-Whitney U	10.00	10.00	10.00	10.00	12.50	10.50	12.00	9.00	9.00	12.50
Wilcoxon W	25.00	25.00	25.00	25.00	27.50	25.50	27.00	24.00	24.00	27.50
Z	-.65	-.65	-.65	-.60	.00	-.51	-.12	-.80	-.80	.00
asymptotic sig. (bilateral)	.51	.51	.51	.54	1.00	.60	.90	.41	.41	1.00
exact sig. [2]	.69(a	.69(a)	.69(a)	.69(a)	1.00(a)	.69(a)	1.00(a)	.54(a)	.54(a)	1.00(a)

a) Unadjusted for ties.
b) Grouping variable to group (ASD & typical).

These latest data allowed us to deduce that the participation of students with disabilities, specifically in regard to students with autism, in the mainstream setting doesn´t worsen data for the group he belonging; rather, as can be seen in Table 3, which shown the ranks of the two groups compared, in some subjects, the student with ASD helped the group to improve the overall average results in some subjects, as was the case in project-based subjects and in the practical category subject of music.

CONCLUSIONS

In this study, it has been proven that when students collaborate in small groups to carried out an autonomous academic action project cooperatively, the results of all studentsimproved, including to students with ASD, in comparison with other more common teaching methods, both practical learning, which relied more on individual skills, and expository-lecture-style activities, where the teacher explained the content and the students listening passively.

This is because the cognitive-active activity required by the cooperative process, starting with perception and continuing through to the retrieval of other information stored in long-term memory in relation to new knowledge, involves a continuous, highly active and dynamic process of learning that requires an environment facilitating its development.

In such a sense, regardless of which student has presented an idea or performed an action, all others observed the process and connected it their own way of thinking, which has been proposed by any of its members, making it the team's own. You will then be able to compare your proposal with those of your colleagues and introduce learning through a dynamic and constantly active process own it.

That way, it would be possible to do activities that might be a bit complex cognitively, like cognitive induction and deduction, which would let students improve their metacognitive awareness of their own contributions and strengthen their regulated behaviour at different levels of neuropsychological information processing. (Banihashem, Noroozi, van Ginkel, Macfadyen & Biemans, 2022; Joksimović, Eagan & Shaffer, 2019).

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However, the practical elements worked on were more individual in the sense they depended on personal characteristics and abilities. In this case, the student with ASD performed particularly highly in music but had greater needs in the motor skills area of physical education, where their scores were significantly lower.

Lastly, the teaching activity based on the expository process, although it could also be complemented by practical exercises, greatly depends on the primary perceptual-attentional ability However, above all, it will depend on the ability to immediately link the new information presented with previously learned material existing in long-term memory and semantic memory, which is precisely where students with ASD show the greatest neural connection needs. Although, many other neurotypical students also got lost during the most immediate attentional process, as this depends not justly on immediate attentional capacity, but also on the quickness in making connections with previous information with the previous information with the new content has been presented, that facilitates medium-high understanding.

In this sense, the system that shapes information processing, from sensory register, perception, the process of information encoding and, most importantly, the elaboration of relationships between the information being received and the information previously stored in permanent memory and, on the basis of these assumptions, facilitate their retrieval in context. Therefore, the process as a whole must function continuously throughout the exhibition, and any alteration in any phase of the process limits or impairs the educational process when it is just one-way And, even though some of the information could subsequently be recovered through the practical actions planning for the activity and reduce the widespread failure it could involve, particularly for higher-level students, but not so much for medium or medium-low level students who persisted in their lack of understanding.

However, this study justly showed that categorical cooperative methodology applied through the development of project-based curricula, which is a highly positive educational option for achieving a level of success in academic activities among the student group as a whole, whether or not they have specific educational support needs, and, as shown in this study, is highly positive in the case of students with ASD included in cooperative group on.

Nevertheless, applying a cooperative academic methodology doesn´t ensure a psychosocial process that is fully inclusive in education. It´s just a methodological and didactic device that facilitates learning for all students, specifically for students with ASD, contrary they affirm different authors (Cross, Traub, Hutter-Pishgahi & Shelton, 2004; Mazurek, Gorska, Korzynski & Silva, 2022; Monje-Amor, Vázquez & Faíña, 2020).

Instead, socio-educational inclusion is a way more comprehensive process that involves both curricular and non-academic activities, such as free time, family, peers, and many other activities inside and outside of school, To get this done, we'd need to set up shared info and training networks for all professionals involved in the educational process in the social and family environment as a whole.

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