ABDUCTION IN THE ASSESSMENT OF SPECIAL EDUCATIONAL NEEDS - LEARNING DISABILITY

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Vida, Gergő & Sántha, Kálmán (2024): Abduction in the Assessment of Special Educational Needs - Learning Disability. *Különleges Bánásmód Interdiszciplináris folyóirat, 10(2),* 31-44. DOI 10.18458/KB.2024.2.31

Abstract

The diagnostic categories used to define learning disability are not standardized, and categorization systems are vague. This study aimed to explore the diagnostic methodology and strategies used to identify learning disabilities. The aim is to identify abductions in diagnostics in the field of special education. Interpreting diagnostics in remedial education using abduction can help identify learning disabilities more accurately. In the previous research phase, we conducted a meta-analysis of 11 expert reviews to identify abduction using fuzzy logic, fsQCA, and Boolean algebra. This study allowed for the creation of a new abductive diagnostic model. Based on these results, the reliability of the diagnostic process can be increased, and the diagnostic model can be used to detect learning disabilities or other types of problems and to identify sufficient conditions underlying a given phenomenon. Neither qualitative content analysis nor fsQCA revealed a relationship between all variables at a sufficient depth. Thus, in the present study, we moved on to Bayesian meshes, which shift and attempt to reorder previously identified variables based on conditional probability. We hypothesized that the Bayesian mesh and abduction application together may already be an efficient tool, which also anticipates the possibility of automation.

Keywords: abduction, abduction model, diagnostics, special needs pedagogy.
Disciplines: pedagogy

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Absztrakt

ABDUKCIÓ A SAJÁTOS NEVELÉSI IGÉNY – TANULÁSI ZAVAR MEGÁLLAPÍTÁSÁBAN

A tanulási zavar meghatározására használt diagnosztikai kategóriák nem egységesek, a kategóriarendszerek bizonytalanok. Jelen tanulmány középpontjában a tanulási zavarral azonosításához használt diagnosztikai módszertan, stratégia feltárása áll. A cél az abdukció azonosítása a diagnosztikában a gyógypedagógia területén. A diagnosztika értelmezése a gyógypedagógiában az abdukció segítségével elősegítheti a tanulási zavar pontosabb megállapítását. Korábbi kutatási szakaszban 11 szakértői vélemény metaanalízisét végeztük el az abdukció azonosítása érdekében, a fuzzy logika, fsQCA és a Boole-algebra eszközeinek felhasználásával. A kutatás során lehetővé vált egy új, abduktív diagnosztikai modell létrehozása. Az eredmények alapján a diagnosztikai folyamat megbízhatósága növelhető, a diagnosztikai modell alkalmas lehet a tanulási zavar vagy más típusú problémák feltárására, valamint az adott jelenség mögött álló elégséges feltételek azonosítására. Sem kvalitatív tartalomelemzés, sem pedig az fsQCA nem tárta fel kellő alapossággal valamennyi változó kapcsolatát. Így a bemutatott tanulmányban tovább léptünk a Bayes-féle háló felé, mely elmozdulással és a korábban feltárt változókat a feltételes valószínűség alapján próbáljuk újra rendezni. Feltételezésünk alapján a Bayes háló és az abdukció alkalmazás együttesen már hatékony eszköz lehet, mely az automatizálás lehetőségét is előrevetíti.

Kulcsszavak: abdukció, abdukciós modell, diagnosztika, gyógypedagógia

Diszciplina: neveléstudomány

Introduction

Diagnostics has gone through little, but very significant changes during the last decade. The discovery of the neurological background to learning impediments is useful, but it offers fewer solutions. The ICD-11 (International Classification of Diseases 11th Revision) and the DSM-5-TR (Diagnostic and Statistical Manual of Mental Disorders) focus on personal development, and interpret symptoms on a wide scale. Setting up a diagnosis can also be seen as a reflective process, which is a little-researched field from the point of view of abduction. In spite of this, specialists dominantly link diagnostic categories to the results of tests. According to the definition of specific learning impediments in DSMV, the definition of learning impediment is strongly dependent on cultural norms and the school system.

In the paper, a meta-analysis of documents made by experts is carried out to study the diagnostic process. The presence of abduction is detectable in the processes that identify learning impediments.

Abduction can be seen as a process that improves professional expertise and that is more than the use of deductive and inductive logic (Peirce, 1992). Abduction can be related to the phenomena around special needs pedagogy, because social phenomena can be described using multidisciplinary methods, they need a philosophical, logical, and psychological approach, and cannot be analysed efficiently using qualitative or quantitative strategies (Sántha et al., 2023). The use of abductive inference in special needs education can also be justified by the fact that the belief systems of special education teachers are similar to those described in general methods (Schumm, 1994).

The Relationship of Abduction, Beliefs, and Views in Diagnostics

The diagnostic process, the end product of which is an expert report coding the learning impediment, can be linked to a diagnostic set of criteria (Fletcher, 2012), such as the ICD or the DSM. Earlier, imaging methods were expected to reassert the diagnosis (Bigler et al., 1998), but even then the need for a multidimensional approach arose (Metzler, 1994). In reality, the diagnostic process cannot be seen consequently and exclusively as induction or deduction. During the research into expert reports, the main focus was the inductive and deductive elements of the diagnostic process, and a blurred theoretical background was also detected. The identification of the stages is relevant from the point of view of abduction, as abduction can be seen as a pendulum motion between induction and deduction (Sántha & Gyeszli, 2022). If the diagnostics were consciously abductive, inductive and deductive direction changes, fixed reflections would dominate the analysis (Sántha, 2011). Reflectiveness is not just a requirement concerning scientism, but its lack means loss of traceability and the process of how the diagnosis of learning impedement was established becomes incomprehensible (Vida, 2022).

Although the diagnostic protocol does not mention abduction, in some elements it refers to it, as in psychology and (special needs) pedagogy one test result or indicator in itself is usually not a sole and sufficient indicator of a specific impediment or disability (Simeonsson & Rosenthal, 2001). It can be claimed, thus, that inferences coming from pure examination results or findings solely based upon theoretical grounds are not sufficient.

The discovery of the aspects of abduction concerning special needs pedagogy can be closely linked to the way of thinking, beliefs, and reflections of professionals working in education (Kessels & Korthagen, 1996; Zeichner & Liston, 1996). The diagnosis of learning impediment is established for education professionals working in the field to facilitate the education process. Abduction can be detected behind beliefs and reflections (Sántha et al., 2023), so it can be inferred that it also exists in the diagnostic process.

Abduction is well-known in research in social sciences (Graneheim et al., 2017; Reichertz, 2003; Sántha & Gyeszli, 2022, Sántha et al., 2023; Želinský, 2019), and can be well related to the theoretical discourse on learning impediments, which can be divided into three big categories depending on which focus is primary concerning the phenomena around learning impediments. When the target of the analysis is a specific pattern of cognitive performance and school disfunctions, we speak about the cognitive (IQ) discrepancy model (Morris, 1988).

When the cognitive profile and intelligence are less dominant, but the main theory is school failure, we speak about the low achievement model (Fletcher, 2012). Due to the diverse nature of learning impediments, the latest diagnostic systems focus on efficient development, rather than the results obtained in tests. This paradigm is known as the intervention-oriented approach (Fletcher, 2012; Nelson et al., 2003; Vellutino et al., 2006). Instead of diagnostic cate-gories, this method is based on groups to be helped.

Abduction in special needs pedagogy can put an end to overemphasising the test results, and it can also offer an alternative against intuitive processes lacking reflection.

Abduction systematises the recognition process, intuitive and subjective beliefs are replaced by a more traceable inference method (Sántha et al., 2023), and rigid diagnostic barriers are softened, moreover, the notion system of learning impedements can be adapted to the complex phenomena that are present in real life. Abduction helps flexible diagnostics, because identifying the given learning problem cannot solely be based on induction or deduction. Abduction fosters the creativity and flexibility that is necessary in diagnostics in special needs pedagogy when describing learning problems: „Deduction proves that something must be; induction shows that something actually is operative; abduction merely suggests that something may be" (Peirce, 1997. 230.). Abduction is a way of inference in identifying learning impediments in which creativity and innovation can appear efficiently (Strand, 2005).

The relationship of abduction and diagnostics is not a new idea, its use has already turned up in the field of model-based diagnostics involving artificial intelligence (Boutilier & Becher, 1994). The use of abduction can be justified by the fact that the diagnosis of a learning impediment can be regarded as a set of conditions explaining the working of a given system. Consistency-based diagnosis (De Kleer et al., 1992) can also be relevant concerning abduction: it can be used in identifying learning problems, and it can explain the deviations between observations and the expected outcomes. This itself potentially is learning impediment. Pierce's approach about the relationship of beliefs and observations has been included in the discourse about special needs pedagogy. This can be well used in establishing consistency-based diagnoses, as abduction is capable of unveiling the network of semantic fields and logical relationships (Boutilier & Becher, 1994). Using abduction, one can make inferences about statements that can explain the validity of the original statement and infer the cause behind a certain phenomenon (Sántha, 2011). Using abduction is not necessarily a logical problem during diagnostics in special needs pedagogy, it is a prediction based on a certain input or a potential explanation to a differing output, which can also be represented in the form of an "aha-moment" and can be a sort of "thunderbolt" (Reichertz, 2009).

Preferences in Diagnostics

There can be several concurrent explanations for learning impediments in one given testing situation (Rosenbaum, 2009). Peirce's system and abduction make the preferences and beliefs behind the diagnosis, which determine the course of the process, visible. In special needs pedagogy, the notion system of abduction can be linked to the discovery of beliefs according to which the expert chooses the theories. Peirce thinks that beliefs are "logically" ordered sequences of theories or ideas (McCarthy, 2005; Smith et al., 2005; Strand, 2005).

Methodological Background

There can be several concurrent explanations for learning impediments in one given testing situation (Rosenbaum, 2009). Peirce's system and abduction make the preferences and beliefs behind the diagnosis, which determine the course of the process, visible. In special needs pedagogy, the notion system of abduction can be linked to the discovery of beliefs according to which the expert chooses the theories. Peirce thinks that beliefs are "logically" ordered sequences of theories or ideas (McCarthy, 2005; Smith et al., 2005; Strand, 2005).

A multidimensional interpretation framework behind the diagnosis of learning impediments is a very current need in special needs pedagogy, and it would help the creation and interpretation of reflective texts containing personal beliefs as well. Establishing a diagnosis can be aligned to the following abduction steps: generating a theory, developing a theory, and evaluation a theory (Haig, 2005; Sántha et al., 2023).

However, the INUS condition set drew out connected sets at several points, no clear exclusion or determinant conditions were found, and the myriad of connections conflated the inference paths. This is presumably because the case studies, although providing a very large and highly varied corpus of texts, resulted in a continuous loss of data, which was not anticipated. In summary, many variables and conditions emerged in the text, which were only mentioned or simply attached to expert opinions, but we did not find any indication in the texts that they were relevant at any level in establishing the diagnosis. Thus, the fsQCA carried out cannot be fully called successful, although the peculiarities of the distribution predicted that if we do not have data on semantic relations, it is worth approaching from the perspective of quantitative variables. One of the relevant findings of the analysis based on the logic of fuzzy sets was that the diagnosis condition can be interpreted as a vector of different directions and, in practice, as probabilistic factors for diagnosis, rather than omnipotent variables.

This is how we arrived at the research conducted in the present study, where we built a Bayesian network based on previously identified codes, inferring from their quantitative distribution which variable has a high probability of leading to learning disability diagnosis. We modified the sampling method and redesigned the study using a quantitative paradigm.

The text was analyzed using ATLAS.ti. software, version 7.5.18, only examining the word frequency. In the analysis of the full text, the software sorts 255 pages of text into 5500 lines, which are further filtered according to previous coding and frequency of occurrence. Thus, based on the quantitative distribution, the software distinguished 5500 codes, that were further filtered. This was justified by the fact that the 5500 lines of analysis were the result of mechanical filtering based on frequencies of words and analyzed conjunctions separately (e.g., etc.). After filtering, the words were sorted into two groups and aligned with the previous qualitative content analysis (Sántha, 2022). Although the words were sorted based on their frequency, the sets with the same meaning were further grouped into one set by meaning.

Sample

In the present research, two school districts allowed access to their archives. The documentation, expert reports, and pedagogical notes behind the special educational needs (SEN) status was studied using stratified sampling. As a case study, the texts of 11 students' expert reports, pedagogical characterisations, and written assessments were analysed. The study included the full process of diagnostic assessment. The text corpus used in the study amounted to 1127 pages of written text.

The texts of the findings were copied to a file and analyzed using ATLAS.ti software to determine the frequency of each word, which was saved as a table. The software generated a table of 5500 rows, which was first narrowed down to 2148 items, since the software mechanically analyzed the text corpus so that nouns and conjunctions were also listed by frequency. In the next step, we grouped the words according to what they referred to, analyzing the table line by line, and, with the help of ATLAS.ti, we also analyzed the context to ensure that the grouping was correct. The grouping did not require a deeper semantic analysis or qualitative methodological strategy because only the words belonging to a group were placed in a set. A true reflective analysis was not necessary (Alejandro, 2021) because in the practice under study, where the texts were produced, the range of tools that could be used in the analysis was fixed, and the order of the content units was prescribed. Our earlier attempts to use grounded theory (Reichertz, 2009).) methodology also went nowhere, partly for this reason. In qualitative content analysis (Sántha, 2023), early theoretical saturation predicted less text variety. Despite this, it is still unknown how a wide range of tests, measurements, and other materials that precede diagnosis affect the decision pathway, although this may be a relevant question.

In our study, we created a taxonomic system to which we assigned related words (e.g., we grouped all words related to literacy testing into the category "WRITING"). This may be misleading as it may seem equivalent to some of the methodologies of the qualitative paradigm (Corbin & Strauss, 2008), but here the categorization was based on a quantitative analysis of the ATLAS.ti software, which was then grouped according to the focus of the measurement to which it belonged or to other 'performance' of the child observed (e.g. With the resources available to us, a corpus of nearly one million characters, 255 pages and 5500 different words could not have been efficiently analyzed in any other way.

Considering that we want to model the decision-theoretic way of identifying learning disorders by building a Bayesian network, a quantitative distribution-based analysis may be appropriate. There was no reflection in the texts by the investigators, nor did we learn anything about the context. The frequency of words used in the description of a given test result was examined and aggregated to the extent to which the investigators wrote. Because the words occurred in different forms, the different forms with conjugation and subjunctions were filtered and not considered new words for the given form.

The Methodology: Diagnostics in Special Needs Pedagogy as a Fuzzy System

The fuzzy logic system can be traced back to L.A. Zadeh's paper and can be interpreted as a multi-value semantic system (Zadeh, 1965). This idea, linked to our research, can be seen as a fuzzy function where the learning impediment is inferred on the basis of the distribution of certain variables. Just like in reality, it is impossible to pinpoint concrete points for the detection of SEN (special educational needs) in the function, so the values can be anywhere between the two extreme points, thus adapting to the phenomenon studied (e.g. a learning impediment can be linked to an interval, rather than a concrete value regarding the results of an IQ test).

In diagnostics in special needs pedagogy, the identification of a learning impediment is a fuzzy system (Horvath et al., 1980; Manghirmalani et al., 2012; Vida, 2022), and the theory of fuzzy systems has already been used in the detection of reading impediments (Vanitha & Kasthuri, 2008), also, there were attempts to use them in the identification of various diagnostic categories in special needs pedagogy (Hernadez et al., 2009). In this paper, the novelty is that fuzzy logic is directly linked to operations performed on sets with the aim of finding out the extent to which a child belongs to a set and, if yes, on the basis of which personal characteristics. Thus, a diagnostic system nearer reality can be set up, in which abduction can be detected.

Data Analysis

Establishing the learning impediment is neither a data-, nor theory-driven process (Vida, 2022). To be able to detect it, the expert reports were subjected to qualitative comparative analysis using the fsQCA 4.0 software to delineate the structure of the opinions formulated during diagnostics and the diagnostic process itself. In the research, category boundaries were lifted, the mathematical and logical background made diagnostic assessment possible, furthermore, diagnostics based on categories can hinder the inclusion of children with learning impediments.

In the first step of the data analysis, qualitative content analysis was used deductively to reveal the categories into which children can be classified in the expert reports based on the diagnostic process. In the next step, the texts drawn up by the experts were studied as case studies, using qualitative comparative analysis. Thus, it was possible to pinpoint the necessary and sufficient conditions of a learning impediment. In further iterations, following the steps of qualitative comparative analysis (Kane et al., 2014), the diagnostic process of learning impediments was represented as code equations. In this paper, there is an attempt at justifying abduction rather than presenting the qualitative comparative analysis in detail.

The Circumstances of the Analysis

To represent abduction, the analysis theories set up in the following papers were used: Schreiber and Moss (2002), de Paor (2022), Vila-Henninger et al., (2022), as well as Sántha et al., (2023). In the course of diagnostics in special needs pedagogy, the diagnosis is seen as a reflection to test results and other documents helping diagnostics, and all of this is adapted to suit the theoretical framework for identifying abduction (Table 1).

Using this set of criteria, it is possible to find the behavioural patterns in special needs pedagogy and diagnostics that can describe the – so far unexplored – process of the identification of special educational needs, and to detect intuition and the strategies used by experts who draw up the diagnosis (de Paor, 2022; Paavola & Hakkarainen, 2005).

Results

Steps of abduction

The identification of the steps of abduction was carried out based on the research of Sántha et al., (2023), the only exception is the qualitative comparative analysis part, which focuses on identifying the necessary and sufficient conditions for a learning impediment.

Vila-Henninger et al. (2022) think that generating the inductive codes is the first step of abduction, during which group coding and continuous iteration are used to draw up a diagnostic model in special needs pedagogy. To display codes made through deduction, frequency-based analysis was carried out on the texts of the case studies, this helped the formulation of conditions for categorising (App. Table 2). Their use was founded on the fact that during an earlier study, similar contents were extracted from expert reports from the same period, and already the fifth opinion showed the theoretical saturation (Vida, 2022). When analysing the case studies, an effort was made to see the quantitative distribution of conditions for codable categories in the diagnostic and development process. On the basis of the frequency and links among the conditions, new iterations can be made to enhance the describability of the model. From this, inferences can be made about the process of identifying the special educational need. The ranking scale, place, and correlations of a given code can indicate the changes in direction in the diagnostic processes.

Table 1: Stages of Abduction and Steps in Abductive Coding (Source:Vila-Henninger et al., 2022. 11.)

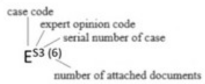
	step 1	*step 2*	*step 3*
	inductive coding	abductive data reduction *code equations*	abductive qualitative analysis
review of the phenomenon	1.a	2.a	3.a *and* 3.b
producing a code book – theoretical extension	1.b	2.b	3.a
alternative explanation – theoretical summary case comparison	—	2.a	3.a *and* 3.b

Table 2. Conditions behind detecting a learning impediment

SUMMATIVE TABLE														
CASE	**CONDITIONS BEHIND DETECTING A LEARNING IMPEDIMENT**													
$A^{5\ (5)}$	motor development^{6}	pencil grip^{5}	muscl e tone	attention^{6}	memory^{2}	thinking^{3}	speech^{5}	IQ^{4}	tempo^{2}	counting	writing	behaviour	SEN	
$B^{T\ (4)}$	motor development^{3}	pencil grip		attention^{4}	memory^{3}		speech^{1}	IQ^{4}	tempo^{3}	counting^{2}	reading^{1} - writing	behaviour ^{2} soc.	SEN	*anxiety*
$C^{5\ (4)}$	motor development	pencil grip		attention^{4}	memory^{3}		speech^{4}	IQ^{2}	tempo	counting^{4}	*eating* writing	behaviour ^{4}	SEN	*anxiety*
$D^{T3\ (3)}$	*motor development*			*attention^{3}*		*thinking^{3}*	*speech^{3}*	***IQ***	*tempo^{3}*	*counting*	*writing reading*		*SEN*	*anxiety (disadvantages / multiple disadvantages)*
$E^{S3\ (6)}$				attention^{6}	memory^{3}		speech^{6}	IQ	tempo^{6}	counting	reading writing	behaviour ^{4}	SEN	anxiety
$F^{T6\ (6)}$	motor development^{2}	pencil grip^{3}		attention^{3}	memory	thinking	speech^{6}	IQ^{5}	tempo^{6}	counting	reading writing		SEN	anxiety
$G^{S7\ (5)}$	motor development^{3}	pencil grip^{4}		attention^{4}	memory^{4}	thinking	speech	IQ^{5}	tempo^{5}	counting	reading^{3} writing^{3}	behaviour ^{5}	SEN	anxiety stuttering
$E^{T8\ (6)}$	orientation (incl. motor)	pencil grip		attention	memory		speech	IQ^{6}		counting	reading writing^{2}			anxiety
$H^{T9\ (6)}$	motor development	pencil grip		attention^{6}	memory^{6}		speech	IQ	tempo^{6}	counting^{6}	reading writing	behaviour	SEN	anxiety
$J^{S11\ (3)}$							*speech*	***IQ*** *129*				*behaviour*	*SEN aut.*	*anxiety*
$K^{T12\ (1)}$	orientation (incl. motor)	pencil grip		attention	memory	thinking	speech	IQ	tempo	counting	reading writing	behaviour	SEN	anxiety

Note:
$D^{T3\ (3)}$ $JS^{11\ (3)}$ will be presented as separate cases as in the case of $D^{T3\ (3)}$ it can be assumed that the SEN status was assigned because of disadvantages or multiple disadvantages. In the case of $JS^{11\ (3)}$, autism spectrum disorder and extreme high intelligence were detected. Grey highlighting indicates factors that are relevant in the documentation concerning the assigning of the SEN status. The number in upper index indicates the number of documents a factor was mentioned in.

Explanation:



In step 2.a of the abduction (Vila-Henninger et al., 2022. 12) further reduction was done, this was also required by the raw data amounting to more than 1000 pages. Text equations were drawn up using Boolean algebra. Keeping in mind that the diagnostics of special educational needs can only be done if assigned to a certain probability, and can only be imagined as part of a fuzzy set, the process can be justified. In relation to the Bayes proposition, earlier research has proven that the diagnosis of learning impediments and special educational needs is burdened with over-diagnosing because of the lack of proper theoretical background and lack of reflection (Vida, 2022).

Boolean functions (Czédli, 2020) can be used to create the reduction referred to in the second step of abduction. If the necessary and sufficient conditions behind the diagnosis are successfully identified, the conditions can be organised into fuzzy sets. An inevitable part of this process is the generation of truth tables.

Without a detailed treatise of Boolean algebra, the following example following Benesóczky (2004) shows the transformation of correlations into code equations. Let us see an example for identifying SEN seen as a logical task, during which deviations were found in the following test data of the child: attention (A), memory (M), IQ (Q), behaviour (B), counting (C) – see the summative table at step 1.a of the abduction process.

If attention (A) is weak, memory (M) is weak too, so IQ (Q) is also low:

- If IQ (Q) is low, behaviour (B) will also be inadequate;
- Counting (C) will be problematic if memory (M) is also problematic.

In both tests, attention and memory show weak results.

In one of the tests, however, only behaviour and counting are weak.

It has to be decided whether the weakness of attention or memory is to blame.

Logical equations based on the text:

1) If attention and memory are weak, then IQ is weak too.
   A.M.Q + /A = 1 (true statement)
2) If IQ is weak, then behaviour is also inadequate.
   Q.B + /Q = 1
3) Counting is weak exactly when memory is weak too.
   C.M + /C./M = 1
4) If any of the factors is weak in all tests.
   A + M = 1
5) In one of the tests, however, only behaviour or counting were weak.
   C./B + /C.B = 1

This corresponds to the iteration steps of the qualitative comparative analysis, on the basis of which the following can be stated:

The product of true statements is also true. Let us now multiply the samenesses in an order that lets most members fall out.

- 1, 4: (AMQ + /A)(A + M = AMQ +AMQ +/A.A + /A.M = AMQ + /AM
- 3:(AMQ + /AM)(MC + /M/C) = AMQC +/AMC
- 5:(AMQC+/AMC)(B/C+/BC)=AMQC/B + /AMC/B
- 2:(AMQC/B+/AMC/B)(QB+/Q)=/AMC/B/Q" (Vida, 2023. 51)

Thus, memory and counting are also weak.

In the next step, further text reduction can be achieved using code equations (Vila-Henninger et al., 2022. 12). The aim is to represent the text as a logical form that cannot be reduced any more. In this step, the necessary and sufficient conditions were defined.

From the focus of the case studies, inferences can be made whether the given test result, code and conditions are in correlation with the diagnosis of learning impediment. That is, if the code system based on the theory of learning impediment appears in the texts, the identification of the learning impediment has been based on theory. If there are no such codes behind the diagnostics, several questions can arise. In the case of a model based on abduction, the diagnosis does not have to be excluded, all that happens is that the description of learning problems is based on another condition compared to the current theories.

The diagnostics based on expert reports has thus been represented in a non-reducible logical form, and the necessary and sufficient conditions have been identified, too. This can be seen as step 2.b of the abduction, where the objective of creating a code book is the description and extension of the theory. After the codes and code book were reduced from the case studies, the codes were organised into a truth table by means of the correlations found, and the links among the codes were analysed by means of a software. The diagnostics of the learning impediment was thus based on the conditions found and the relationships among them (this is also a step of the qualitative comparative analysis). Tracing back the code equations to the texts can be seen as a secondary justification of the theory, it can prove that a given theory is detectable behind the process. If not, the conceptualisation starts again (Vila-Henninger et al., 2022). This way, a revision can be done concerning whether the final equation is capable of clarifying the phenomena of the diagnostic process from the point of view of tests, notes, and other documents. Using the final text equations, the codes identified during deduction can be assigned to the fuzzy sets, which are actually the content and conditions encoded in the cases themselves. In other words, it can be seen to what extent the results of a test or a document containing any data is a necessary and/or sufficient condition for identifying a learning impediment. This equals to step 3.a of the abduction, because the equation obtained through the iteration process can be traced back to the cases (Vila-Henninger et al., 2022). Thus, the code equation can be tested with the exclusion of the specificities of the case, and the validity of the model can be justified. Besides this, the coding schema can also be refined if the theory based on the code equation does not explain the phenomenon. In such cases, a revision of the equation and the repetition of the second step is necessary.

The model generated will display the steps of the diagnostic process. This is necessitated by step 3.b of the abduction, which, according to Davidson et al. (2019), can appear as "deep interpretive analysis". Although abduction is not a closed cycle, step 3.b can be seen as a final step as the rightness of the code equation and the inductive codes can be confirmed. During this deep qualitative analysis, new theoretical propositions can be made based on the previous theoretical framework (Vila-Henninger et al., 2019). Step 3.b, which closes the abduction cycle, can also be seen as a meta-analysis inside abduction (Sántha et al., 2023), which cannot be carried out with software, so diagnostics in special needs pedagogy cannot be fully automated. Wording the conclusions is a complex and reflective activity based on the theories and results used by the people making diagnoses.

On the basis of the processes and results that have been described so far, the model of the diagnostic process is the following (Figure 1):

On the basis of the cases studied, the conditions for the diagnosis of learning impediments can be visualised, and an answer can be given to the question whether there is any other relevant variable.

Taking a closer look at the relevant variables gives proof that one of the theories can be detected behind the process: whether the test results, the pedagogical characterisation, the facts told by the parents, etc. align with the variables.

If not, abduction can be used to restart the conceptualisation (Vila-Henninger et al., 2022), but, also, the process may be terminated by stating that the problem involved is not a learning impediment.

When the conceptualisation is restarted, new theories and procedures may appear in the diagnostic process that may not have been previously envisaged by the diagnostic specialist.

Steps of Bayes net

The proven abduction confirmed that learning disabilities can be treated as a probability, with variables of different strengths as factors in the diagnosis of learning disabilities. Thus, the texts were further analyzed on these grounds.

The words were grouped into three sets. One group is specific to a task, or explicitly denotes a skill. These are marked as F (F stands for a task word). This is to make the text clearer and to check that we have interpreted the meaning correctly. The other group was the set of words that collected the task performance or ability rating into a group, which was labelled J (J refers to the marker). This grouping, however, did not finally form the unit of analysis, but it may be relevant to mention it in that it can actually be considered a kind of coding, despite the quantitative methodology, or it refers to the types of nodes in the Bayesian network. The node types in the GeNIE program are ordered according to similar logic. Thus, using ATLAS.ti software, the frequency of each word in the text was analyzed, and the data were stored in two columns in an Excel spreadsheet (one column containing the words and the other the number of occurrences of the words).

In the first step, the probability of occurrence of a given word in the text compared to the other words was calculated, i.e. the relative frequency of occurrence of a given word. For each word, we determined the ratio of the frequency of that word to the number of occurrences of all the words in the text.

The relative frequency in the corpus shows the proportion of the total data in which a word occurs in the text. This can be relevant for the calculation of conditional probability, since we are interested in how relevant a variable is as a condition for the diagnosis of a learning disability, that is, how "likely" it is to diagnose a learning disability. We inferred this from the specificity of the distribution of variables. The analysis of word frequency showed that the whole text, consisting of 5500 different words, was not a complete text. This was filtered in several steps because, as indicated in the previous section, the analysis was performed mechanically by the software, which took different forms of the same word with a suffix or a prefix as a separate unit of analysis. After grouping and filtering, we were in fact able narrowed the sample down to 228 different relevant terms.

The conditional probability is ultimately a probability narrowed to a part of the entire event space. This is best illustrated by the sampling from a subset. When examining the 228-word text, word abstraction appears on average 39 times in some form. However, the average is not useful, and neither is the relative frequency necessary, since in each case, it was necessary to examine how many of the 201 expert opinions actually contained the term. This cannot be excluded, as the frequency data show that some terms appear several times in an expert opinion, while others do not appear at all. In any case, the relative frequency may be relevant confirmation that the choice of terms may be appropriate.

When merging the texts, we kept the boundaries of the expert opinions precise so that we could later filter how many expert opinions a term appears in. In this case, taking the example of "abstraction," it appeared as a condition in 53 expert opinions.

Thus, of the expert opinions, 53 are relevant for "abstraction, " and 147 are not (total sample 201 expert opinions). According to the rules of probability, if we randomly select an expert opinion from the total sample, the probability that the "abstraction" appears as a relevant condition in that opinion can be calculated using the following formula:

$$\mathrm{P(A}|B) = \mathrm{P(AB)/P(B)} = \frac{53}{201} : \frac{147}{201} = 0{,}35$$

Conclusion

A diagnostic process in special needs pedagogy – a set of models based on given theories that make an attempt using mathematical methods at interpreting human reality – is inherently destined to fail, because the world around us cannot be interpreted by the sole use of quantification. The same is true as the school success and learning of a child cannot be traced back to the result of one single test or a group of tests. To understand human reality – and the diagnostic process in special needs pedagogy –, we need to put phenomena in a context, knowing that contexts are not made up according to unambiguous rules (Sántha et al., 2023).

Keeping in mind that objective reality cannot be discovered either using induction or deduction, diagnostics in special needs pedagogy has to adapt its methods as well. Abduction, by treating phenomena – including the correlations of events – as probabilities, adopts Peirce's maxim that scientific thinking always involves some sort of doubt or uncertainty. If the success of a learner in formal schooling has to be forecast by the use of certain tests, we take uncertainty for granted, as no decision valid for a person's whole school career can be made on the basis of one single test result. So neither the thinking about the data concerning the student's performance, nor the reflection can be final, new problems may arise all the time, so it is of crucial importance that experts' reports contain the relevant steps of establishing the diagnosis, and all related reflections as well. This way, diagnostics really becomes a process.

With the huge size of the database, the construction of the Bayesian network is still in progress, as our resources make this a time-consuming task. However, based on the partial results, it can be said that the decision-theoretic model leading to the identification of the learning disorder can be explored through a series of methodological steps, as detailed above.

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