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GESTURES IN THE TEACHING AND LEARNING PROCESS: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT: Can the gestures we perform aid the teaching and learning process? The present paper summarizes the state of the art on the subject within the field of education, with a specific eye on gestural communication. Research has been found at virtually all levels of education regarding the use of gestures as a way to assist students in learning a second language, inclusive education, and science and math education. In general, there is solid evidence supporting that gestural communication helps in the evaluation and introduction of a new word in the teaching of a second language; as an additional resource for teachers and students with disabilities and as a tool to contribute to the teaching of concepts considered abstract and complex in the field of science and mathematics teaching. Of interest is the strong evidence that gesture constitutes a hidden yet powerful channel to exchange information, learn, and even as a tool to help reason.

Keywords: gestures, non-verbal communication, teaching, literature review, learning.

GESTOS NO PROCESSO DE ENSINO E APRENDIZAGEM: UMA REVISÃO SISTEMÁTICA DE LITERATURA

RESUMO: Os gestos que realizamos podem auxiliar no processo de ensino e aprendizagem? O presente artigo sintetiza o estado da arte sobre o assunto no campo da educação, com um olhar específico para a comunicação gestual. A pesquisa foi encontrada em praticamente todos os níveis de ensino sobre o uso de gestos como uma forma de ajudar os alunos a aprender uma segunda língua, educação inclusiva e educação de ciências e matemática. Em geral, existem evidências sólidas de que a comunicação gestual auxilia na avaliação e introdução de uma nova palavra no ensino de uma segunda língua; como recurso adicional para professores e alunos com deficiência e como ferramenta para contribuir para o ensino de conceitos considerados abstratos e complexos na área do ensino de ciências e matemática. Interessante é a forte evidência de que o gesto constitui um canal oculto, mas poderoso, para trocar informações, aprender e até mesmo como uma ferramenta para ajudar a raciocinar.

Palavras-chave: gestos, comunicação não-verbal, ensino, revisão de literatura, aprendizagem.

GESTOS EN EL PROCESO DE ENSEÑANZA Y APRENDIZAJE: UNA REVISIÓN DE LITERATURA SISTEMÁTICA

RESÚMEN: ¿Pueden los gestos que realizamos para ayudar en el proceso de enseñanza y aprendizaje? El presente trabajo resume el estado del arte sobre el tema dentro del campo de la educación, con una mirada específica en la comunicación gestual. Se han encontrado investigaciones en prácticamente todos los niveles educativos sobre el uso de gestos como una forma de ayudar a los estudiantes a aprender un segundo idioma, educación inclusiva y educación científica y matemática. En general, existe evidencia sólida que respalda que la comunicación gestual ayuda en la evaluación e introducción de una nueva palabra en la enseñanza de una segunda lengua; como recurso adicional para docentes y estudiantes con discapacidad y como herramienta para contribuir a la enseñanza de conceptos considerados abstractos y complejos en el campo de la enseñanza de las ciencias y las matemáticas. Es

de interés la fuerte evidencia de que el gesto constituye un canal oculto pero poderoso para intercambiar información, aprender e incluso como una herramienta para ayudar a la razón.

Palabras clave: gestos, comunicación no verbal, enseñanza, revisión de literatura, aprendizaje.

INTRODUCTION

When people speak, they naturally gesticulate and gestures often reveal information that cannot easily be found in the speech. Students are no exception. A student's gestures can index moments of conceptual instability and teachers can use them to gain access to a student's thinking. Students can also discover new ideas from the gestures they produce during a class or the gestures they see their teachers produce. Gesture, therefore, has the power not only to reflect a student's understanding of a problem but also to change their understanding (NOVACK; GOLDIN-MEADOW, 2015).

According to Walkington, Chelule, Woods, and Nathan (2019), gestures play a key role in mathematical reasoning, being an indicator that mathematical understanding is embodied - inherently linked to action, perception, and the physical body. As students collaborate and engage in mathematical discussions, they use discourse practices such as explaining, refuting, and developing each other's reasoning, often mixing speech and gesture when talking.

Developing research based on gesture analysis is promising since the use of gestures in education is still under-researched and a relatively new topic (FLOOD et al., 2014). Not only, one can infer how much gestures can help and contribute to the learning process, since it is naturally present in our daily lives, constituting - among other ways - a communication channel between the most capable tutor and the learner, a channel that is not properly discussed by most learning theories.

However, what about the role of gestures between a teacher and his student when it comes to teaching and learning? What constitutes an important communication channel for classroom teaching and learning? How can gestures help in teaching? Is there research in education in the field of gesture analysis and teaching? Imbued with these questions, a literature review was conducted bringing the most relevant aspects and research related to education on this topic. Based on these questions, the present literature review seeks to answer the following question, that generally synthetizes our goals***: What is the contribution of gestures (non-verbal communication) to the teaching and learning process?***

The objective of this article is to uncover evidence, both in the Brazilian and international educational published research, of the contribution of gestures to the teaching and learning processes, as well as how this specific field of research is evolving.

METHOD

This research aims to identify, through the literature review, research that brings contributions to how gestures can be a way to assist in the teaching and learning process of students. Therefore, to perform this research, we defined four different stages – or staples – that needed to be made to a satisfactory completion(Figure 1).

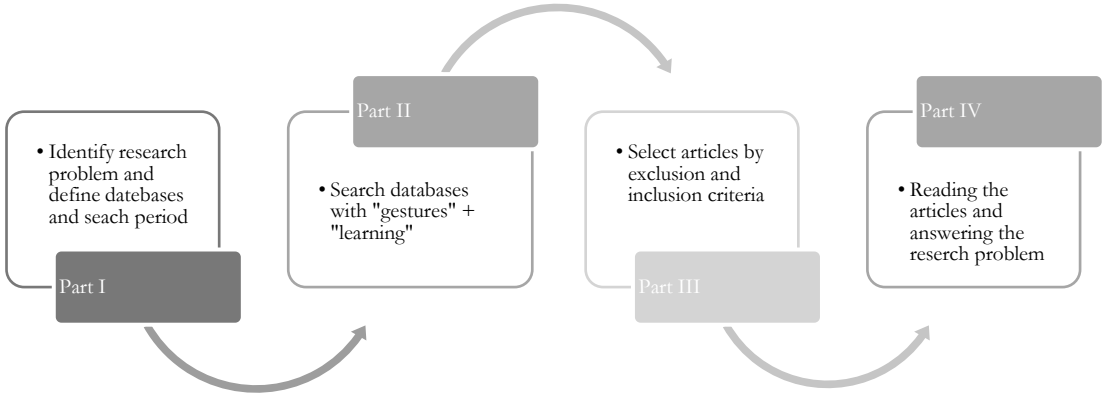
Figure 1 shows the search procedures used. The first step was, after defining the search problem (discussed above), defining which databases, the search terms (key words) and the search period. After delimiting our research, the second stage of the research consisted of the search itself for research related to our central theme.

The databases used were: *Eric, Scopus and Google School*. In these three databases, the following search terms were used: *"gestures"* + *"learning"* and, in both three search platforms, the search period between *2000 and 2019* was selected.

The third part was the moment when we selected the articles through exclusion and inclusion criteria, which will be described in Table 1. Finally, the last stage of the research was the full

reading of the articles and the elaboration of this text to find the answers to the central research problem of that article.

Figure 1 - Research Procedures



Source: Research data.

Just like Pereira et. al. (2019), we chose to perform two phases for the inclusion or exclusion of the selected articles during the literature review. The first phase consisted of reading the titles, abstracts, and keywords contained in the articles. Then, after the criteria we established, we head to the second phase. The second phase started by reading the integral paper selected in the first phase and, after reading them, classifying them according to their proximity and similarities.

Below is a table that was created to guide us in the selection of articles (Table 1). These criteria were elaborated by the authors of the present article with a focused look that would contribute to getting us closer to an answer regarding the research problem that guides this literature review.

Table 1 - Inclusion and exclusion criteria

	INCLUSION CRITERIA	**EXCLUSION CRITERIA**
CRITERIA	Be written in Portuguese, English, or Spanish	Articles not peer-reviewed
	Contain evidence of the use of gestures in the teaching and learning process in the summary	Research that did not bring collaborations on the presence of gestures in the teaching and learning process
	Preference for research that has been applied in the classroom	They did not contain the words “gestures” or “learning” or “teaching” in the keywords

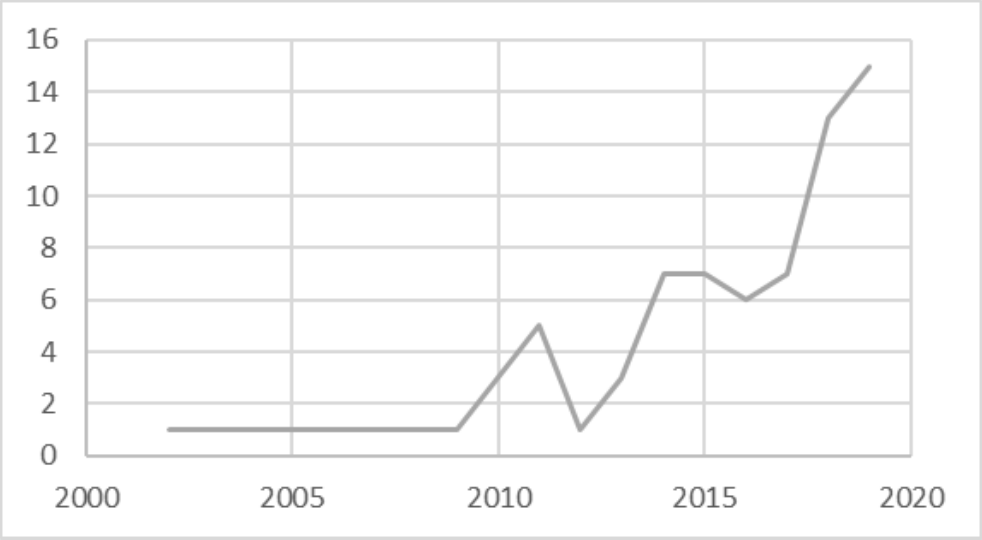
Source: Research data.

Therefore, after the selection of the 69 articles according to the established criteria, we opted to separate teaching levels at first, so that it was possible to identify at which stage of the academic trajectory there is a greater presence of research on gestures in the process of teaching and learning. We also made a historical sequence of the articles by publication date, so we could detect if there is an increase or not of publication in gestures, indicating an increase in research interest. The final grouping of the articles found in phase 1 was made after reading the content of each article, and the categories emerged from reading them naturally.

RESULTS AND DISCUSSIONS

The results indicate that production in the field of gesture as a way of teaching or learning has seen an ongoing increase since 2009 (Graph 1).

Graph 1 - Articles published from the year 2002

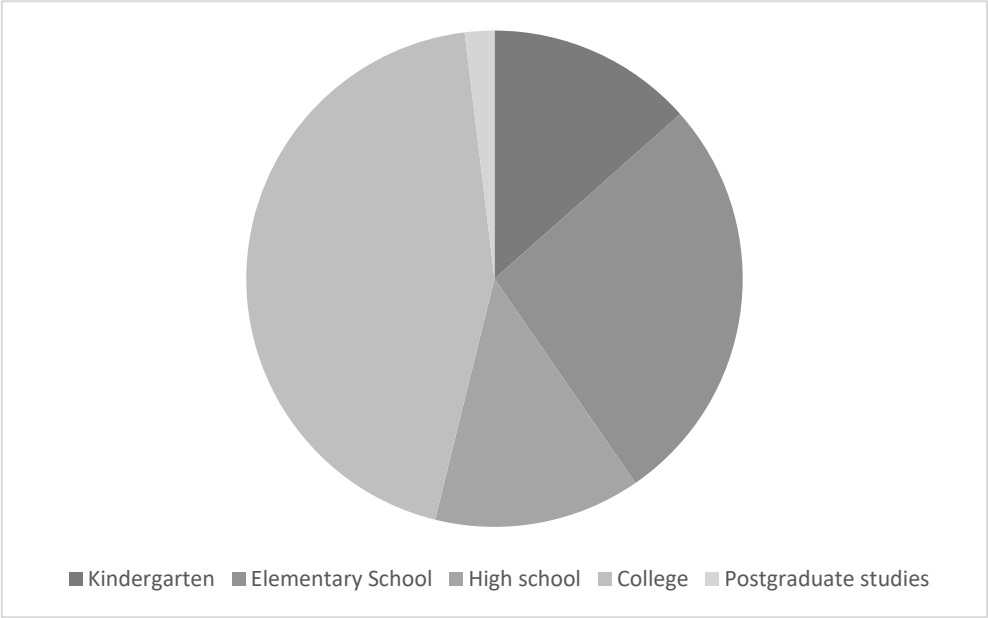


Source: Research data.

Regarding the distribution of papers according to the categories that emerged during the review, most of them (71%) are related to activities applied in classrooms; 21% relate to research that addresses the teaching of a second language through gesture and inclusive education; and finally, 8% with articles that we categorized as theoretical reflection.

From the studies done in the classroom, Elementary School and Higher Education are the levels of education that were found to be the most researched, while postgraduate classrooms have very little researches that address the subject of gestures in education (Graph 2).

Graph 2 - Division of research by level of education



Source: Research data.

After the initial, pre-defined categories of analysis were made (categorized by year, school level, etc) a second categorization was made. To understand the contribution of gestures to the teaching and learning process, we aimed to group the articles found in the literature review into categories that would be meaningful to answering our research question. These categories naturally emerged after reading the articles and considering their similarities and their contributions to the teaching and learning process.

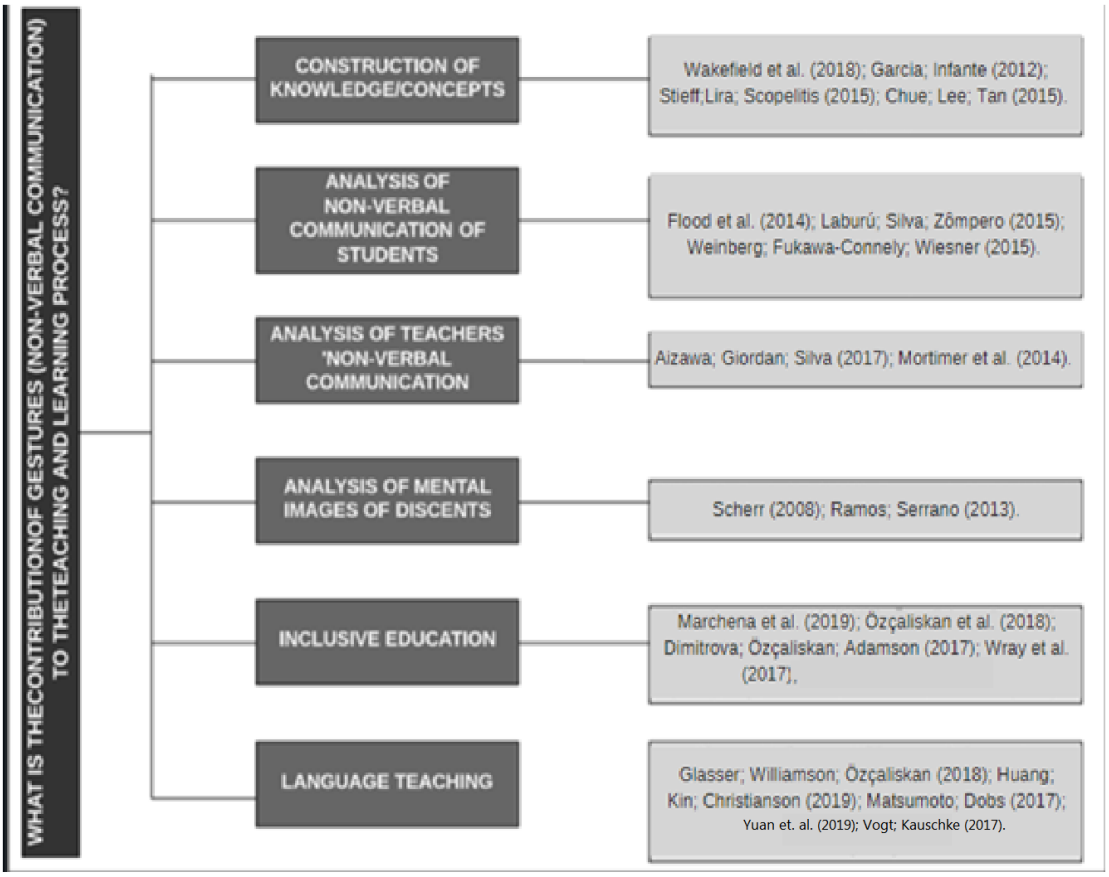
The categories are: the construction of knowledge/concepts, analysis of non-verbal communication by students, analysis of non-verbal communication by teachers, analysis of mental images of teachers, teaching for inclusive education, and, finally, the teaching of languages (Figure 2).

These categories will allow us to find possibilities and the relevance that gestures can contribute to the teaching process through research already carried out in the classroom and at different levels of education. The first category shows us how the gestures, both of teachers and students, can help students in their knowledge construction, that is, through gestures, students can express themselves and understand differently from the usual concepts that are abstract or not so close to their daily life. The second and third categories help us to see how the analysis of non-verbal communication, the gestures, of students and teachers, is relevant to the teaching and learning process. It is through analysis that it is possible to understand their questions, their understanding, and other situations to improve teaching.

The fourth category presents us with two articles that articulate and bring techniques on how gestures can provide an understanding of students' mental images. The students' mental images can be revealed through gesticulation. The gestures helped, according to these articles, to understand what went on in the students' minds when they talked among their colleagues, teachers and tried to explain and justify their answers about concepts pertinent to the discipline of Physics.

The penultimate category, inclusive education, addresses research on how gestures were relevant to the teaching of students with inclusion and, in particular, autistic students. The last category includes articles that corroborate the teaching of a second language or the mother tongue itself through gestures. Therefore, for a better understanding of the categories, the following diagram shows the research question, the categories, and the authors that corroborate the different categories.

Figure 2 - Category layout



Source: Research data.

Construction of knowledge/concepts

Do the gestures help students learn, but not just by directing their visual attention? Based on this conception, Wakefield et al. (2019) used eye-tracking to explore a frequently proposed mechanism - the gesture's ability to direct visual attention. Based on previous studies by Singer and Goldin-Meadow (2005), the authors state how it is possible to teach a new concept through gestures, in which hand movements accompany the speech. The research made it possible to verify that, using eye-tracking measures, children who attend a math class with gestures allocate their visual attention differently from children who attend a math class without gestures - they analyze more the problem being explained, look less at the instructor, and were more likely to synchronize their visual attention with the information presented in the instructor's speech.

In 2012, Garcia and Infante published an article in which they addressed the impact that gestures can have on the mathematical environment in workshops given in higher education. After the workshops, the researchers realized that there was a correlation between diagramming and gestures (dynamic and static). These two types of gestures were part of the students' constructive thinking, relating them to the problem or the construction of their diagrams. The more challenging the problems, the more students gesticulate. Some issues were influenced by gestures by their colleagues and over time they were adopted and adapted.

In the search to understand how gestures can help in teaching in STEM, Stieff, Lira, and Scopelitis (2016), from Chicago (USA), describe two studies that verified the impact on teaching when students used gestures to support their thinking in space in STEM content. In the first study, the effectiveness of watching and reproducing gestures or reading a text was compared. In the second study, the effectiveness of the gesture was compared with an instructional approach that involved the handling of concrete models, but without gestures. The results indicated that gestures can be an

effective strategy to support students' spatial thinking in STEM subjects because, with the use of gestures, students performed significantly better than without gestures.

Chue, Lee, and Tan (2015) conducted their research in higher education in the discipline of Chemistry in Singapore. Their research sought, first, to conduct a brief review of the literature on communication and education, to articulate possible contributions of iconic gestures in science education. Then, they analyzed the iconic gestures performed by a university professor when exemplifying abstract concepts, such as size, position, and movement of particles. The researchers suggest that iconic gestures may illuminate aspects of abstract scientific meaning, being a more complete version of meaning than just speech.

Therefore, these four studies show how gestures can help in the construction of knowledge. The gestures follow the speech and the more difficult and necessary a deep explanation, the presence of gestures becomes increasingly more important, becoming support for students' thinking and reasoning in the teaching and learning process.

Analysis of non-verbal communication of students

When students share about subjects that were discussed during class with other people, have you noticed that they often end up using gestures to explore and explain their ideas and concepts? According to research by Flood et al. (2014), this would be like a publicly visible space-dynamic means of expression, in which gestures and the body provide productive resources to imagine the submicroscopic, three-dimensional, and dynamic phenomena of chemistry together.

Laburú, Silva, and Zômpero (2015) researched high school students about concepts of Electrostatics through experimental activities, intending to understand the scientific concepts of students. When evaluating the students through the experimental activity, it was found that the concepts cannot be "visualized" and their incorrect domain, or the lack of it, can unduly demonstrate conceptual unintelligibility, and the difficulty of the apprentice can be located in these elements and not in the conceptual dimension, as such. Therefore, the gestures contribute, according to these researchers, as an instrument for the teacher to understand what students are learning about scientific knowledge and, besides, it ends up being fundamental for the construction of the thought of that knowledge.

In 2015, in the USA, Weinberg, Fukawa-Connelly, and Wiesner (2015) published research that sought to understand how gestures can help in thinking and communicating in the discipline of Mathematics. The research took place at a public university in an introductory abstract algebra discipline. The results indicated that the mathematical meanings - specific and general - are expressed in gestures and highlight the integrated nature of the elements of the semiotic package.

Through the analysis of their students from the research presented in this category, it was seen that gestures end up becoming an instrument for teachers to understand their students, their difficulties when expressing themselves through words and that, through gestural analysis, there is a way to capture what goes on in the minds of the students, especially when portraying abstract concepts.

Analysis of teachers' non-verbal communication

In 2017, Aizawa, Giordan, and Silva published their research with graduate students in their mandatory undergraduate internships. Using the technique of Video-Stimulated Remembrance, the students were filmed when they taught their classes, and, afterward, they analyzed their gestures through the categories of Kendon (2004). The results of this research point out that the undergraduates "developed both a gestural and multimodal perception, that is, they became aware of what was said, of the positioning of the body and hands so that in the future they can modify their actions with the main objective of producing meanings. " (Aizawa, Giordan, & Silva, 2017).

In Brazil, in 2014, Mortimer et al. investigated how two university teachers mobilized different semiotic modes and promoted interaction between them for the construction of meanings in Chemistry class. After the teachers were recorded while teaching their classes, they were analyzed. The analysis showed that each teacher uses and articulates different semiotic modes, such as speech,

gestures, drawings on the board, being these means to communicate with students. The research identified that these semiotic modes and, in particular, gestures, contribute to the construction of meanings in the classroom.

Both Brazilian researchers were able to find in their research how the gestural analysis of teachers can find new paths for teaching, in addition to assisting teachers during their classes. These researches show how relevant it is for teachers to be aware of their gestures when teaching their classes. Through gestures, they can facilitate students' understanding, as well as pass on distorted or erroneous concepts.

Analysis of mental images of students

Scherr (2008) goes beyond the other researches mentioned so far on gestures in higher education. His research seeks evidence that students' gesticulation can not only fill in gaps in students' verbal expressions but offer valuable information about what is going on in students' minds, that is, to better understand what the student is thinking about Physics at that particular moment. "Physics education is a rich field to further explore these issues, and researchers in physics education can benefit and contribute to ongoing investigations into the importance of gesture in thinking and learning." (Scherr, 2008).

Like the research made by Garcia and Infante (2012), Ramos and Serrano (2013) also carried out their investigation through a workshop (extension course) for undergraduates. The researchers interviewed undergraduate chemistry students after carrying out activities using molecular modeling software. Analogous to the considerations of Scherr (2008), the researchers in the interviews tried to find out what was going on in the students' minds when answering the questions, that is, it was possible to identify a link with the gestures and what they imagined at that moment to answer the questions.

This category gives us indications that gestures can reveal what is going on in students' minds when explaining to someone about certain content or when explaining their responses. Gestural analysis using techniques, such as Think Aloud, provides an understanding of the articulation between students' gestures and mental images.

Inclusive education

Marchena et al. (2019) conducted research in which they observed adults and how they used gestures. Twenty-one verbally fluent autistic adults and another twenty-one typically developing controls involved in a controlled conversational task.

Autistic adults were more likely to gesture unilaterally than bilaterally, a motor characteristic of the individual gesture associated with symptoms of autism. According to the researchers, co-speech gestures can provide a link between symptoms of non-verbal communication and known differences in motor performance in autism.

Özçalışkan, Adamson, Dimitrova, and Baumann (2018) showed in their research that children and parents produce similar types of gestures and gesture-speech combinations. That is, when researching children with autism spectrum disorder (ASD) or Down syndrome (DS), they observed the specific differences in diagnosis concerning children with typical development (TD) in the production of gestures. However, only the children - but not the parents - showed specific variability of the diagnosis in the frequency with which they produced each type of gesture and gesture-speech combination.

Gestural understanding remains poorly studied, according to Dimitrova, Özçalışkan, and Adamson (2017), from Sweden, especially with children with autism spectrum and who have difficulty in producing gestures. Following the studies by McNeill (2005), these groups of researchers examined children aged 2 to 4 years old, to understand the types of gestures and the combinations between gesture and speech. The results obtained suggest that children understand deictic gestures and reinforcement gestures - better speech combinations than iconic/conventional gestures and

supplementary combinations - a pattern that remains robust at different ages in children with autism spectrum.

The study by Wray et al. (2017) sought to determine whether children with language disorders use gestures to compensate for their language difficulties. From the research, it was possible to detect that the gesture and language form a communication system closely linked, in which the deficits of gestures are seen alongside difficulties with spoken communication.

Language teaching

Do children understand iconic gestures about events as early as iconic gestures about entities? From this question, Glasser et al. (2018) aim to understand whether children understand iconic gestures that characterize events as early as possible and, if so, whether their understanding is influenced by gesture production patterns in their native language. The research found that native patterns of gesture production influenced the understanding of the gestures of children that characterize these events, with a better understanding of gestures that follow specific language patterns compared to those that do not follow these patterns, especially in the way of movement of gestures.

Recently, in 2019, Huang, Kim, and Christianson, from the University of Illinois at Urbana-Champaign presented that gestures are useful if they are not to be confused with other words to be learned and if the number of words presented was limited. This research showed that introducing new words in a second language and presenting the word with simultaneous gestures can facilitate the recall of new words by students. The researchers address the theory of double coding, in which it predicts that students can learn better by having the articulation between gestures and new words.

In 2017, at the University of Pennsylvania, researchers Matsumoto and Dobs conducted a study in which they investigated the functions of gesture in teaching and learning grammar in the context of classroom interactions in a second language, as did Huang, Kin, and Christianson (2019), but now in higher education. The research consisted of the analysis of the gestures used by the teachers to explain temporal concepts of the English language and the students when they answered. The analysis reached the considerations that teachers and students repeatedly used abstract and metaphorical lithic gestures in the classroom, which can become important resources for instruction and assessment of student learning.

Eighty-nine students from the University of International Studies in Xi'an, China, participated in research that aimed to understand whether tuning gestures can improve the learning of prosody (part of the traditional grammar that is dedicated to the characteristics of the emission of the speech sounds, such as accent and intonation). The authors Yuan, González-Fuente, Baills, and Prieto (2019) carried out their research in which they divided students into two identical groups, the first group (control group) received intonation training without the use of tuning gestures. The second group, experimental, received the same training, but with more tuning gestures, representing contours of nuclear intonation. The results of the research provide evidence that the experimental group has improved significantly and that even though individuals who have stronger skills have obtained a better result, those who had weaker musical skills have benefited even more by observing the gestures.

Vogt and Kauschke (2017), from Germany, observed how iconic gestures can help developing children to learn new words. According to the researchers, iconic gestures promote richer coding and lead to more efficient word learning in children who are at the beginning of speech development or with language problems.

Consequences of gestures in the teaching and learning process

The main purpose of gestures is to assist communication. But, in addition to being important to communication, gestures also have important consequences for thinking and learning, to understanding language. More than just clarifying or improving the message of a lesson, it can lead students to understand and promote conceptual development, which is the primary focus of this research (Chu & Kita, 2016).

In the classroom, when a student swings his arm wildly when the teacher asks a question; or another tries not to make eye contact with the teacher, both are using their bodies to tell the teacher that they want to answer the question. These body movements constitute what is normally called non-verbal communication (Goldin-Meadow, 2017).

According to Goldin-Meadow (2018), gesture has the potential to boost learning in all children and perhaps reduce inequalities in performance in language and mathematics. Also, it can be a tool that helps teachers understand what is going on in the students' minds, as well as understand how much they learned from the content through their speeches articulated with their gestures.

The gesture can be well used in educational environments and, according to Goldin-Meadow (2017), it can exist in at least three ways. The first would be for teachers to examine their gestures to ensure that they are not conveying ideas that might mislead students. Teachers can even think about how the ideas they want to teach can be displayed in their hands and then consciously produce these gestures during classes.

Students can be encouraged to gesture when they explain a problem. The gestures that students produce will probably demonstrate their understanding of the evolution of the problem, which is not yet evident in their speech. These gestures can then serve as a diagnosis that teachers can use to find out what their students know and what they are ready to learn.

Finally, being encouraged to gesture about a problem can help students activate any implicit ideas they have about that problem. This activation, in turn, can make them more open to new instructions (Goldin-Meadow, 2017). Therefore, gestures not only reflect thinking but also have the potential to change thinking in listeners and speakers. The gesture is a tool that students, teachers, and researchers can use to make discoveries about the mind.

According to Chu and Kita (2016), there is evidence that the gestures of co-judgment and co-speech share several properties, suggesting that they are generated by a common mechanism. According to the researchers, people produce more co-production gestures when speech production is more difficult than when it is less difficult. They produce more judgmental gestures when a quiet problem-solving task is more difficult than when it is less difficult.

Finally, a gesture not only reflects our thoughts but also our role in changing those thoughts. We know gestures that can transmit substantive information so that it is not difficult to imagine that we could learn by seeing the gestures that other people produce. But to be sure, we need to manipulate the gesture and explore the impact of that manipulation on learning (Goldin-Meadow, 2017).

CONCLUSION

The evolution of published research on the use of gestures in classrooms clearly shows how this theme is growing over the years, and readily becoming increasingly more fascinating. Since 2009, there has been an increase in the publication of articles concerning nonverbal communication in journals, with classroom applications or even more theoretical discussions, allowing readers to wonder the importance of this - old and at the same time new – communication channel with results reporting as gestures can assist in the teaching of a second language, in the area of inclusive education and specially in the teaching of science and mathematics, which many students find difficult.

Gestures in the teaching of a second language can contribute to the way a new word is presented, the way an assessment is performed, and even provide greater articulation between the gestures and the new words. In inclusive education, the use of gestures may provide new avenues for research in this area, perhaps a new resource that contributes and assists teachers and students with disabilities or disorders. And in science and mathematics teaching, gestures emerge as a tool to contribute to the teaching of concepts considered abstract and complex.

During the normal speech, when we detail our thinking or try to explain a concept or specially a scientific model to a teacher or classmate, we end up using gestures to express ourselves.

Those gestures are acutely important, as it is possible through them to find out student's mental images and often there is an opportunity to understand gaps in the student's speech. Therefore, we also conclude our literature review assessing the important role that gestures can play in the teaching-learning process, bringing new perspectives and paths for education, as well as new resources that aim to contribute to the students' academic formation.

Of special notice is that gesture can be viewed as an "external device" that aids humans when reasoning about different subjects, including aiding in visuospatial thinking. Gestures are used to express ideas between subjects (external function) and most likely also internalized as images (internal function), much like how Vygotsky (1986) describes the relation between thought and language, a conclusion that the authors would like to offer with this review.

To conclude, returning to the research question of this paper, "What is the contribution of gestures (non-verbal communication) in the teaching and learning process?" we can definitively say that gestures present themselves as a very important factor that contributes to the teaching and learning process, that they can't be overlooked and its analysis should be integrated into the teacher training curriculum. Therefore, not only the field of research in Education, but also the practice of education both in formal and non-formal spaces, should consider non-verbal communication, and specially gestures – that try to depict a certain thought in the minds of teachers or apprentices – as important and relevant as speech and new research should be done to set the limits and possibilities of addressing this important channel of communication between humans.

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Author 1 – Active participation in data collection and analysis, such as writing the article.
Author 2 – Data analysis and writing and review of the article.

DECLARATION OF CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with this article.

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