

ARTICLE

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

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ABSTRACT: Can our gestures aid the teaching and learning process? This paper summarizes the state-of-the-art on the subject within the educational field, focusing on gestural communication. There have been studies at virtually all levels of education regarding the use of gestures 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. We highlight the strong evidence that gesture constitutes a hidden yet powerful channel to exchange information, learn, and 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 be easily seen in the speech. Students are no exception. A student's gestures can index moments of conceptual instability, and teachers can use them to access students' thinking. Students can also discover new ideas from their gestures during class or from teachers' gestures. Therefore, gestures can reflect students' understanding of a problem and change their understanding (NOVACK; GOLDIN-MEADOW, 2015).

According to Walkington, Chelule, Woods, and Nathan (2019), gestures play a crucial 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 as gestures in education are still under-researched and a relatively new topic (FLOOD et al., 2014). Not only that, but we can infer how gestures can help and contribute to the learning process since they are naturally present in our daily lives, constituting - among other things - a communication channel between the tutor and the learner. Most learning theories do not adequately discuss this channel.

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

In the research, we will address the gestures naturally and spontaneously performed by the students to explain concepts and words. We aim to uncover evidence of the contribution of gestures to teaching and learning and how this specific field of research is evolving in Brazilian and international educational published research.

METHOD

This literature review aims to identify research that contributes to understanding how gestures can assist in students' teaching and learning process. Therefore, we defined four stages – or staples – that needed to be completed satisfactorily (Zawacki-Richter et al. 2020) (Figure 1).

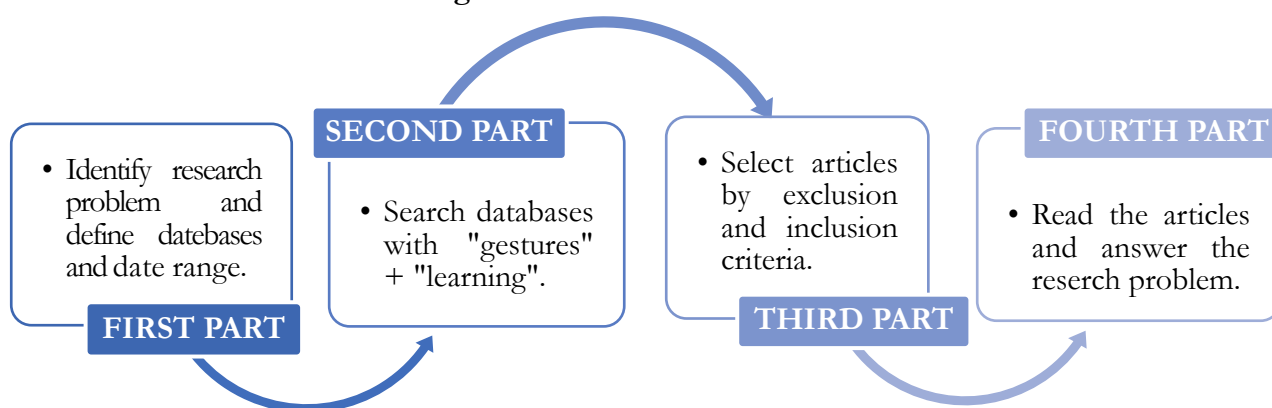
We used the databases *Eric*, *Scopus*, and *Google School*. In these three databases, we used the following search terms: “*gestures*” + “*learning*”, and selected the search period between 2000 and 2019. We chose these databases because all three allow the analysis of citation metrics by author, and to define the publication date of articles.

Figure 1 shows the search procedures used. After defining the search problem (discussed above), the first step was defining the search terms (keywords) and the search period.

After delimiting our research, the second part was the search itself. Thus, we used the terms “*gestures*” + “*learning*” in the databases.

In the third part, we selected the articles through exclusion and inclusion criteria, described in Table 1. Finally, the last research stage was thoroughly reading the articles to build this systematic literature review.

Figure 1 - Research Procedures



Source: Research data.

Just like Pereira et. al. (2019), we performed two inclusion or exclusion phases for the selected articles during the literature review.

The first part consisted of identifying the objective of our research, then defining our research problem - which would guide us throughout the research process - and later defining the databases and period that we would research to achieve the objective.

The second part consisted of searching the previously selected databases - Eric, Scopus, and Google Scholar - using the following terms: “*gestures*” + “*learning*”, as these two terms would lead us to find the searches related to our objective, resulting in 69 papers.

In the third part, we select the articles by exclusion and inclusion criteria defined by us. Table 1 shows these criteria. All 69 papers were read entirely and judged according to the criteria mentioned above. We highlight the second exclusion criterion of judging whether or not the paper brought a significant contribution to answer our research question (Did the paper contribute to the investigation of spontaneous usage of gestures in the teaching and learning process?). Albeit analyzing the production of gestures, many of those 69 papers did not necessarily address spontaneous gestures when explaining concepts or spatial relationships¹

The last part was to make a thorough discussion of the 19 articles – those that contributed to answering our research question. We also indicated the means, challenges, and new didactic proposals for using gestures in the teaching-learning process.

¹We stress that our work addresses a specific kind of gesture. For teaching, the crucial gesture when explaining concepts or spatial relationships is what Stephens and Clement (2010) called depictive gestures – not indicative, static, and dynamic gestures. The production of depictive gestures during internal visualization processes has already been documented. These gestures are crucial to conceptualization, mainly in science and mathematics.

We created the table below to guide us in selecting the articles (Chart 1). We formulated these criteria to get closer to an answer regarding the research problem that guides this literature review.

Chart 1 - Inclusion and exclusion criteria

	INCLUSION CRITERIA	EXCLUSION CRITERIA
CRITERIA	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 contributions to the investigation of spontaneous usage of gestures in the teaching and learning process
	Preference for research applied in the classroom.	They did not contain the words "gestures", "learning", or "teaching" in the keywords.

Source: Research data.

After selecting the 69 articles, following the established criteria, we first opted to separate educational levels (Childhood Education, Elementary and Middle School, High School and Undergraduate) to identify which level has more research on gestures in teaching and learning.

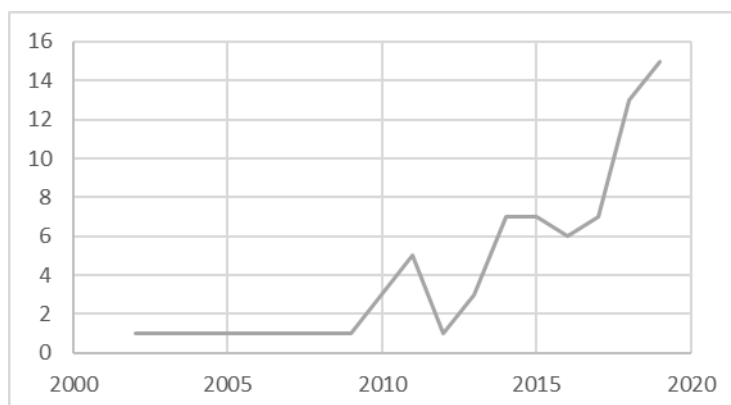
The categories emerged naturally after reading the 19 final papers. For instance, "construction of knowledge/concepts" groups the papers discussing the role of gestures in students' construction of knowledge or concepts. "Analysis of non-verbal communication of students" focuses on the analysis of gestures and not construction concepts. One category deals with inclusive education due to the specificities of students with special needs. Another is language teaching dealing with mathematics or science education. However, those papers are interested in how depictive gestures are used when learning a second language to communicate the meaning of words and spatial relations by using gestures.

We also made a historical sequence of the articles by publication date to detect if there is an increase in the publications about 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 studies about gestures as a way of teaching or learning have increased since 2009 (Graph 1). This data indicates that there is an increasing interest in the topic and its relevance in teaching.

Graphic 1 - Articles published since 2002

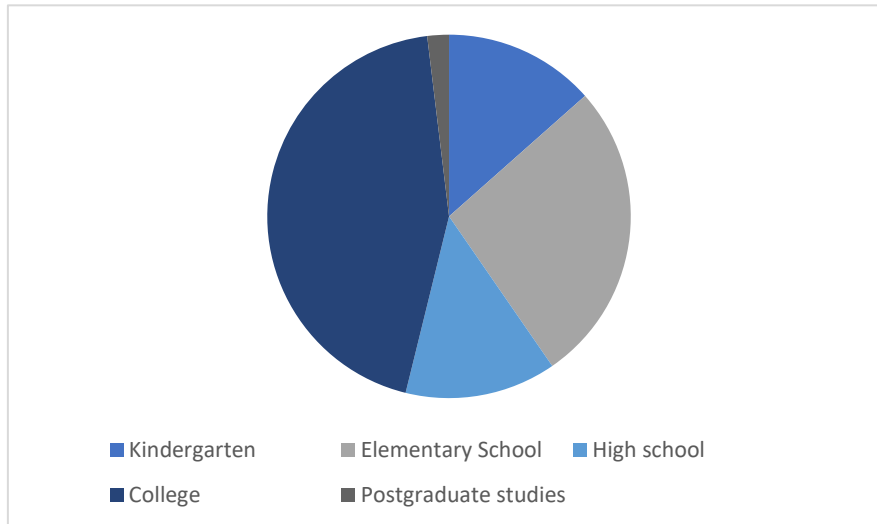


Source: Research data.

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 teaching a second language through gesture, and inclusive education outside the classroom. Finally, we categorized 8% of the articles as theoretical reflections.

From the studies done in the classroom, Elementary and Middle School and Higher Education are the most researched education levels. Postgraduate classrooms are the least explored (Graph 2).

Graphic 2 - Research by education level

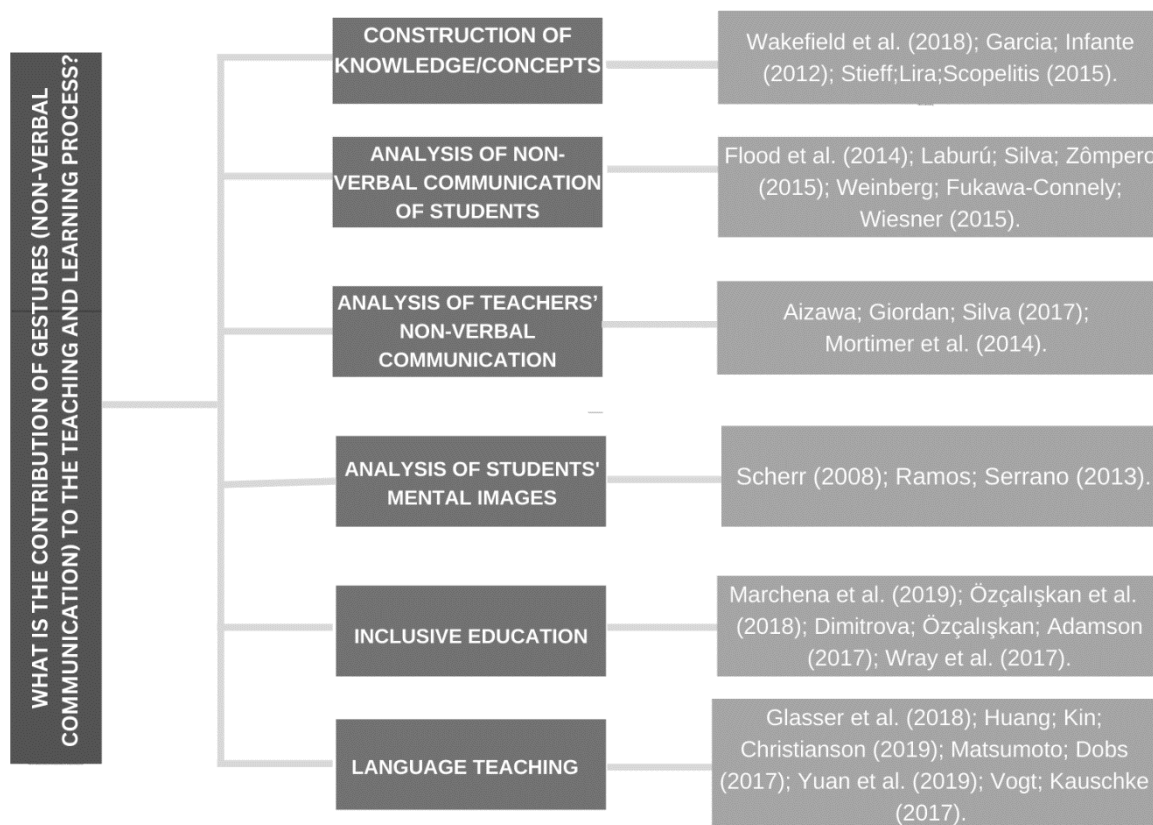


Source: Research data.

After the initial pre-defined categories of analysis, we did a second categorization. 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 contributions to the teaching and learning process. Figure 2 below presents the nineteen articles that comprise this systematic literature review. These articles were selected based on the established criteria, which helped us with the research (presented in the methodology section).

To better understand the categories, the figure below shows the research question, the categories, and the authors in the different categories. The categories are the construction of knowledge/concepts, analysis of students' non-verbal communication, analysis of teachers' non-verbal communication, analysis of teachers' mental images, teaching for inclusive education, and, finally, language teaching (Figure 2).

The fourth category has two articles (cited in figure 2) that articulate and bring techniques on how gestures can provide an understanding of students' mental images. Students' mental images can be revealed through gesticulation. According to the articles in figure 2, which will be exposed throughout this article, the gestures helped to understand what went on students' minds when talking with their classmates and teachers. The students also tried to explain and justify their answers about concepts of Physics.

Figure 2 - Analytical categories

Source: Research data.

The penultimate category, inclusive education, addresses research on how gestures were relevant to teaching students with disabilities or learning challenges, particularly autistic students. The last category includes articles that corroborate the teaching of a second language or the mother tongue through gestures.

Construction of knowledge/concepts

Do gestures help students learn, but not only, by directing their visual attention? Based on this question, 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 when hand movements follow the speech. Using eye-tracking measures, the research found that children who attend a math class taught with gestures allocate their visual attention differently from those in 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 addressing the impact of gestures on the mathematical environment in workshops given in higher education. After the workshops, the researchers perceived 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. Their colleagues' gestures influenced some issues and, over time, they were adopted and adapted.

Seeking to understand how gestures can help in teaching in STEM - Science, Technology, Engineering and Mathematics - Stieff, Lira, and Scopelitis (2016), from Chicago (USA), describe two studies that verified the teaching impact when students used gestures to support their spatial thinking in STEM content. In the first study, the effectiveness of watching and reproducing gestures was compared

to only reading a text. In the second study, the effectiveness of the gesture was compared with an instructional approach involving the handling of concrete models but without gestures. The results indicated that gestures can effectively support students' spatial thinking in STEM subjects because they performed significantly better with gestures than without.

Therefore, these four studies show how gestures can help construct knowledge. The gestures follow the speech and the more complex and deeper an explanation, the more important the use of gestures, which support students' thinking and reasoning in the teaching and learning process.

Analysis of non-verbal communication of students

When students share with other people about subjects discussed during class, do they often use gestures to explore and explain their ideas and concepts? According to Flood et al.'s (2014) research, this would be 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 Electrostatics concepts through experimental activities, intending to understand their scientific concepts. When evaluating the students through the experimental activity, the authors found out that the concepts cannot be "visualized", and their incorrect understanding, or the lack of it, can unduly demonstrate conceptual unintelligibility. This is because electrostatics concepts (e.g. electrical charges and electrons) are abstract, and invisible to the naked eye. The behavior of electrical charges at rest can only be explained with the help of simulation and illustrative images.

Students' difficulties can be located in these elements rather than the conceptual dimension. Therefore, according to these researchers, the gestures contribute as a teaching instrument to understand what students are learning about scientific knowledge. Besides this, they end up being fundamental for the construction of the thought of that knowledge.

In 2015, in the USA, Weinberg, Fukawa-Connelly, and Wiesner (2015) sought to understand how gestures can help Mathematics thinking and communicating. The research took place at a public university in an introductory abstract algebra discipline. The results indicated that when mathematical meanings - specific and general - are expressed in gestures, the combined gestural and speech languages 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 there is a way to capture what goes on in the minds of the students, through gestural analysis, especially when portraying abstract concepts.

Analysis of teachers' non-verbal communication

In 2017, Aizawa, Giordan, and Silva published their research with undergraduate students in their mandatory supervised internships. Using the Video-Stimulated Remembrance technique, the students were filmed when they were teaching. Afterwards, they analyzed their gestures through Kendon's (2004) categories. The results 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 to construct meanings in Chemistry classes. The teachers were analyzed after they were recorded teaching. The analysis showed that each teacher uses and articulates different semiotic modes, such as speech, gestures, and drawings on the board. Thus, these were means to communicate with students. The research identified that these semiotic modes, in particular, gestures, contribute to constructing meanings in the classroom.

Both Brazilian studies show how teachers' gestural analysis can find new paths for teaching and assisting teachers during their classes. These works show how relevant it is for teachers to be aware of their gestures when teaching. They can facilitate students' understanding or pass on distorted, erroneous concepts through gestures.

Analysis of students' mental images

Scherr (2008) goes beyond the other researchers on gestures in higher education. Her 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 understand better what students are thinking about Physics at that particular moment. "Physics education is a rich field for exploring these issues further, and physics education researchers may both benefit from and contribute to continuing investigations of the significance of gesture in thinking and learning." (Scherr, 2008, p.14).

Like Garcia and Infante's (2012) research, Ramos and Serrano (2013) also carried out their investigation through a workshop (outreach course) for undergraduates aiming to understand the role of different mediations - social, psychophysical, cultural or hyper cultural interaction - in chemistry teaching.

The researchers interviewed undergraduate chemistry students after carrying out activities using molecular modeling software. Similar to Scherr (2008), during the interviews, the researchers tried to find out what was going on in the students' minds when answering the questions. Hence, they could identify a link between the gestures and what they imagined when answering the questions.

This category indicates that gestures can reveal students' thoughts when explaining certain content or when explaining their responses to someone. 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) 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 autism symptoms. According to the researchers, co-speech gestures can link symptoms of non-verbal communication and known differences in motor performance in autism.

Özçalışkan, Adamson, Dimitrova, and Baumann (2018) showed 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 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 in the autism spectrum and who have difficulty producing gestures. Following McNeill's (2005) studies, these groups of researchers examined two to four-year-old children to understand the types of gestures and the combinations between gestures and speech. The results 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.

Wray et al. (2017) study 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 gesture and language form a closely-linked communication system, 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 gesture production patterns influence their understanding in their native language. The research found that native patterns of gesture production influenced children's understanding of gestures that characterize these events, with a better understanding of gestures that follow specific language patterns than 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 helpful if they are not confused with other words to be learned and if the number of words presented is limited. This research showed that introducing new words in a second language and presenting the word with simultaneous gestures can facilitate students' recall of new words. The researchers address the theory of double coding, which predicts that students can learn better by having the articulation between gestures and new words (Huang, Kim & Christianson, 2019).

In 2017, at the University of Pennsylvania, researchers Matsumoto and Dobs investigated the functions of gesture in teaching and learning grammar in the context of classroom interactions in a second language, as did Huang, Kim, and Christianson (2019), but now in higher education. The research analyzed the gestures used by the teachers to explain temporal concepts of the English language and those used by students when answering. The analysis showed 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 the research to understand whether tuning gestures can improve the learning of prosody (part of the traditional grammar dedicated to the speech-sound emission characteristics, such as accent and intonation). The authors Yuan, González-Fuente, Baills, and Prieto (2019) carried out the research in which they divided students into two identical groups. The first group (control group) received intonation training without tuning gestures. The second group (experimental) received the same training but with more tuning gestures, representing the contours of nuclear intonation. The research results provide evidence that the experimental group has improved significantly and that even though individuals with stronger skills have obtained a better result, those with 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 learn new words. According to the researchers, iconic gestures promote richer coding and lead to more efficient word learning in children at the beginning of speech development or with language problems.

Significance of gestures to the teaching and learning process

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 they are not conveying ideas that might mislead students. Teachers can even think about how the ideas they want to teach can be displayed with their hands and then consciously produce these gestures during classes.

The primary purpose of gestures is to assist communication. However, in addition to being essential to communication, gestures also have significant consequences for thinking, learning, and understanding language. More than just clarifying or improving the message of a lesson, they 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 usually called non-verbal communication (Goldin-Meadow, 2017).

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

Students can be encouraged to gesture when explaining a problem. Students' gestures will probably demonstrate their understanding of the problem's evolution, which is not yet evident in their speech. These gestures can then serve as a diagnosis that teachers can use to determine what their students know and are ready to learn (Goldin-Meadow, 2017).

Finally, being encouraged to gesture about a problem can help students activate any implicit ideas they have about it. In turn, this activation can make them more open to new instructions (Goldin-Meadow, 2017). Therefore, gestures can reflect the thought and change listeners' and speakers' thinking. 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 a common mechanism generates them. According to the researchers, people produce more co-production gestures when speech production is more complicated than when it is less complex. Similarly, they produce more judgmental gestures when a quiet problem-solving task is more complicated than when it is less complex.

Ultimately, a gesture reflects our thoughts and our role in changing those thoughts. We know gestures that can transmit substantive information, so it is not difficult to imagine that we could learn by seeing other people's gestures. Indeed, 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 gestures in classrooms (images 1 and 2) shows that this theme is growing and 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. These articles allow readers to wonder about the importance of this - old and, at the same time, new – communication channel. The results show how gestures can assist in teaching a second language, in inclusive education, and mainly in teaching science and mathematics, areas many students find difficult.

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

During the everyday speech, we use gestures to express ourselves when we detail our thinking or try to explain a concept, especially a scientific model, to a teacher or classmate. Those gestures are essential, as it is possible through them to unveil students' mental images and, often, there is an opportunity to understand gaps in the student's speech. Therefore, we also conclude our literature review by assessing the critical role gestures can play in the teaching-learning process, bringing new perspectives and paths for education and new resources to contribute to students' academic formation.

We highlight that gestures can be seen 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, we can say that gestures present themselves as a crucial factor that contributes to the teaching and learning process. They must be noticed, and their analysis should be integrated into the teacher training curriculum. Therefore, the field of

Education research and Education practice, in formal and non-formal spaces, should consider non-verbal communication, and especially gestures – which try to depict a particular thought in students' and teachers' minds – as vital as speech. New studies should be conducted to set the limits and possibilities of addressing this critical communication channel between humans. (Flood et al., 2014; Goldin-Meadow, 2017; Goldin-Meadow, 2018).

From the review we carried out and, particularly, from the nineteen articles presented and discussed here, we suggest further research on the role of teachers' gestures and their influence (as a semiotic set) in students' thinking, mainly on what we could call a "gestural heritage" between teachers and students.

REFERENCES

- AIZAWA, A., GIORDAN, M., SILVA, A. B. A. Lembrança Estimulada por Vídeo como ferramenta de análise dos modos gestuais de licenciandos de Química. In: Anais do XI Encontro Nacional de Pesquisa em Educação em Ciências, Florianópolis, SC. **Anais do XI Encontro Nacional de Pesquisa em Educação em Ciências**, Florianópolis, SC, 2017.
- CHU, M.; KITA, S. Co-thought and co-speech gestures are generated by the same action generation process. **Journal of Experimental Psychology: Learning, Memory, and Cognition**, v. 42, n. 2, p. 257-270, 2016.
- DIMITROVA, N.; ÖZÇALIŞKAN, S.; ADAMSON, L. B. Do verbal children with autism comprehend gesture as readily as typically developing children? **Journal of autism and developmental disorders**, v. 47, n. 10, p. 3267-3280, 2017.
- FLOOD, V. J. et al. Paying attention to gesture when students talk chemistry: Interactional resources for responsive teaching. **Journal of Chemical Education**, v. 92, n. 1, p. 11-22, 2014.
- GARCIA, N.; INFANTE, N. E. Gestures as Facilitators to Proficient Mental Modelers. **North American Chapter of the International Group for the Psychology of Mathematics Education**, 2012.
- GLASSER, M.L.; WILLIAMSON, R. A.; ÖZÇALIŞKAN, S. Do Children Understand Iconic Gestures About Events as Early as Iconic Gestures About Entities? **Journal of psycholinguistic research**, v. 47, n. 3, p. 741-754, 2018.
- GOLDIN-MEADOW, S. Taking a Hands-on Approach to Learning. **Policy Insights from the Behavioral and Brain Sciences**, v. 5, n. 2, p. 163-170, 2018.
- GOLDIN-MEADOW, S. Using our hands to change our minds. **Wiley Interdisciplinary Reviews: Cognitive Science**, v. 8, n. 1-2, p. 1-6, 2017.
- HUANG, X.; KIM, N.; CHRISTIANSON, K. Gesture and vocabulary learning in a second language. **Language Learning**, v. 69, n. 1, p. 177-197, 2019.
- KENDON, A. **Gesture: Visible action as utterance**. Cambridge University Press, 2004.
- LABURÚ, C.E.; SILVA, O.H.M.; ZÔMPERO, A.F. Significados de eletrostática interpretados por meio da gesticulação de estudantes. **Ciência & Educação (Bauru)**, v. 21, n. 4, p. 851-867, 2015.
- MARCHENA, A. et al. Atypicalities of gesture form and function in autistic adults. **Journal of autism and developmental disorders**, v. 49, n. 4, p. 1438-1454, 2019.
- MATSUMOTO, Y.; DOBS, A.M. Pedagogical gestures as interactional resources for teaching and learning tense and aspect in the ESL grammar classroom. **Language Learning**, v. 67, n. 1, p. 7-42, 2017.
- MCNEILL, D. **Gesture and Thought**. Chicago: University of Chicago Press, 2005.

- MORTIMER, E. et al. Interações entre modos semióticos e a construção de significados em aulas de ensino superior. **Ensaio Pesquisa em Educação em Ciências** (Belo Horizonte), v. 16, n. 3, p. 121-146, 2014.
- NOVACK, M.; GOLDIN-MEADOW, S. Learning from gesture: How our hands change our minds. **Educational psychology review**, v. 27, n. 3, p. 405-412, 2015.
- ÖZÇALIŞKAN, S. et al. Do parents model gestures differently when children's gestures differ? **Journal of autism and developmental disorders**, v. 48, n. 5, p. 1492-1507, 2018.
- PEREIRA, N. L. et al. Boas práticas em ambientes virtuais de ensino e de aprendizagem: uma revisão de forma sistemática na literatura. **Educação em Revista**, v. 35, 2019.
- RAMOS, A.; SERRANO, A. Como são internalizadas as competências adquiridas quando um aluno utiliza computadores? Um exemplo de mediação cognitiva em rede durante a utilização de software de modelagem molecular. In: Anais do IX Encontro Nacional de Pesquisa em Educação em Ciências, Águas de Lindóia, SP. **Anais do IX Encontro Nacional de Pesquisa em Educação em Ciências**, Águas de Lindóia, SP, 2013.
- SCHERR, R. E. Gesture analysis for physics education researchers. **Physical Review Special Topics-Physics Education Research**, v. 4, n. 1, p. 010101-1-010101-9, 2008.
- SINGER, M. A.; GOLDIN-MEADOW, S. Children learn when their teacher's gestures and speech differ. **Psychological Science**, v. 16, n. 2, p. 85-89, 2005.
- STEPHENS, A. L.; CLEMENT, J. J. Documenting the use of expert scientific reasoning processes by high school physics students. **Physical Review Special Topics: physics education research**, College Park, v. 6, n. 2, p. 20122/1-20122/15, 2010.
- STIEFF, M.; LIRA, M. E.; SCOPELITIS, S. A. Gesture supports spatial thinking in STEM. **Cognition and Instruction**, v. 34, n. 2, p. 80-99, 2016.
- VYGOTSKY, L. S. **Thought and language-Revised edition**. Cambridge, MA: Massachusetts Institute of Technology, 1986.
- VOGT, S.; KAUSCHKE, C. Observing iconic gestures enhances word learning in typically developing children and children with specific language impairment. **Journal of child language**, v. 44, n. 6, p. 1458-1484, 2017.
- ZAWACKI-RICHTER, Olaf et al. Systematic reviews in educational research: Methodology, perspectives and application. **Springer Nature**, 2020.
- WAKEFIELD, E. M. et al. Breaking down gesture and action in mental rotation: Understanding the components of movement that promote learning. **Developmental Psychology**, v.55, n. 5, p.981-993, 2019.
- WALKINGTON, C. et al. Collaborative gesture as a case of extended mathematical cognition. **The Journal of Mathematical Behavior**, v. 55, p. 1-20, 2019.
- WEINBERG, A.; FUKAWA-CONNELLY, T.; WIESNER, E. Characterizing instructor gestures in a lecture in a proof-based mathematics class. **Educational Studies in Mathematics**, v. 90, n. 3, p. 233-258, 2015.
- WRAY, C. et al. Gesture production in language impairment: it's quality, not quantity, that matters. **Journal of Speech, Language, and Hearing Research**, v. 60, n. 4, p. 969-982, 2017.
- YUAN, C. et al. Observing pitch gestures favours the learning of Spanish intonation by Mandarin speakers. **Studies in Second Language Acquisition**, v. 41, n. 1, p. 5-3, 2019.

Submitted: 11/05/2022

Approved: 10/11/2022

AUTHORS' CONTRIBUTION

Author 1 – Active participation in data collection and analysis; writing the article.

Author 2 – Data analysis and writing and reviewing the article.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest in this article.

The translation of this article into English was funded by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES/Brasil.

Editora-Chefe: Suzana dos Santos Gomes