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CO-SPEECH GESTURES IN ENHANCING ENGINEERING PROPOSAL PRESENTATIONS: A MULTIMODAL ANALYSIS OF ESP SPOKEN DISCOURSE

Abstract

Though gestures can convey the meaning of the message and the thoughts of the speakers, there are limited research studies on how co-speech gestures are used in presenting engineering-related messages. This case study aims to understand how four types of gestures (beat, deictic, iconic, and metaphoric) are used in engineering proposal presentations to convey technical solutions in proposed products. This study employed a mixed-method research approach of using both multimodal discourse analysis and quantitative analysis to examine the ways two student presenters used co-speech gestures to communicate technical solutions in engineering proposal presentations. The findings showed that iconic gestures were used most frequently by one presenter to mimic the visual representations of designs and processes in engineering systems, co-occurring with spoken language to reinforce the propositional content. Deictic gestures were used most frequently by another presenter in directing the audience's attention to visual figures to facilitate the explanation of technical content. In comparison, beat and metaphoric gestures were used less frequently. This case study informs multimodal research on ESP spoken discourse and provides pedagogical implications for the application of gestures to facilitate the communication of technical content and concepts in engineering presentations.

Key words

co-speech gestures, engineering proposal presentation, ESP spoken discourse, multimodal discourse analysis, student oral presentation.

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1. INTRODUCTION

Engineering oral presentations are inherently complex, involving intricate technical concepts that can be challenging to convey through verbal language alone. Kress (2003, p. 35) claimed that "language alone cannot give us access to the meanings of the multimodally constituted messages" and emphasized the importance of utilizing semiotic resources beyond the use of language. Multimodality combines different kinds of meaning-making into "an integrated, multimodal whole" (Jewitt et al., 2016, p. 2), such as in the fusion of various communicative modes like gestures, gaze, facial expression, and head movements to enrich the meaning of the spoken discourse (Kress & van Leeuwen, 2001; Norris, 2012; van Leeuwen & Kress, 2011). According to McNeill (1992, p. 11), language in its written and spoken forms is a "linear" code, while communicative modes like gesture are "multi-dimensional". This implies that the analysis of gestures used in communicative events offers many different facets and layers of interpretations and meaning beyond the use of language.

Gestures are essential in communication (Hostetter, 2011; Kendon, 2007; McNeill, 2005) and are often combined with speech to convey the speaker's messages in a synchronized way (Kendon, 2007; McNeill, 2005). Co-speech gestures are spontaneous hand and arm movements that co-occur with verbal messages or spoken language expressions (Kelly et al., 2009; McNeill, 1992; Tieu et al., 2017). Speakers use co-speech gestures to enhance communication by portraying some aspect of the communicative situation (Tieu et al., 2017). Co-speech gestures are semantically and pragmatically coherent with speech (Kendon, 2004; McNeill, 2005) and the way gestures and words co-occur in speech can be fully or partly overlapped (McNeill, 1992).

Though speech can exist independently of gestures, the incorporation of gestures may help to enhance speech production and problem-solving (Beilock & Goldin-Meadow, 2010; Osorio et al., 2024). When conveying spatial information, adults become less fluent when the hands are not free to gesture, and such disruptions are often compensated with more repetitive verbal messages (Rauscher et al., 1996). Gestures are used more often when a verbal description is more challenging to plan or produce (Hostetter & Alibali, 2008). In situations when people think aloud in problem-solving, or when explaining their solutions, they often use gestures to highlight spatial-motoric representations to express themselves (see Beilock & Goldin-Meadow, 2010). McNeill (1992, 2005) views gesture and speech as two parts of a single system and cannot be seen as separated. In this way, gestures form part of the thinking and speaking processes (Kinsbourne, 2006; McNeill, 1992, 2005; McNeill & Duncan, 2000). In addition to facilitating communication, language production and problem-solving, co-speech gestures can also affect the speaker's cognitive processes (see Kelly & Ngo Tran, 2023; Kita et al., 2017). Goldin-Meadow (2005) explains how gestures can reduce the load on the entire cognitive system by structuring spatial information and indexing words to the surrounding context.

In science, technology, engineering and mathematics (STEM) disciplines, embodied communicative modes can help to explain complex discipline content when students do not have the linguistic competence to describe and theorize the subject content in the appropriate form (Alibali et al., 2001; Roth & Welzel, 2001). Roth (2001) demonstrated how hand gestures were used to mimic the concepts of velocity and acceleration and their relationships among Physics students. Lazaraton (2004) illustrated gestures as useful co-speech tools that enable teachers to help learners with unplanned vocabulary. Lim (2021) evaluated the image-language relationship in classroom discourse to depict how language and gestures are combined to make meaning, with the teacher who used a wider range of multimodal resources being perceived as more effective in engaging the students. However, the overuse of hand gestures can lead to distraction, as shown in a study on product presentation (Palmer-Silveira, 2015).

McNeill (1992, 2005) proposes a general taxonomy of four types of hand gestures performing various communicative functions:

1. Beat, when the same gesture is used regardless of the content showing that the word or phrase is significant, or it is used to reflect the tempo of the speech or emphasize certain aspects of the speech.
2. Deictic, which shows the gesture pointing to something concrete or abstract.
3. Iconic, which shows the gesture resembling its referent, directly depicting concrete objects and actions.
4. Metaphoric, which represents a pictorial relationship through the gestures to demonstrate abstract ideas.

Each type of gesture can serve to (1) represent an aspect of the content, such as referring to something concrete or abstract (referential function), (2) regulate interaction among interlocutors (interpersonal function), such as signalling turn-taking in spoken conversations, (3) link parts of the discourse (cohesive function), such as gesturing to highlight the different parts of a narrative, or (4) pragmatically show attitude or perlocutionary meaning, such as using gestures to enact speech acts like making a request, giving a command, and expressing gratitude (Kendon, 2004).

These functions are not clear-cut, and each gesture may signal different functions at the same time. For instance, deictic gestures can be referential when they refer to an object and be pragmatic when they indicate the speaker's attitude and intention about the object.

Recent multimodal studies in ESP/EAP that mentioned co-speech gestures can be seen in areas related to 1) research pitches and talks (e.g., Masi, 2023; Ruiz-Madrid, 2021; Valeiras-Jurado & Ruiz-Madrid, 2020), 2) conferences and lectures (e.g., Bernad-Mechó, 2022; Morell, 2015; Picciuolo, 2023; Valeiras-Jurado & Ruiz-Madrid, 2019), 3) student presentations and teaching strategies (e.g., Crawford Camiciottoli & Bonsignori, 2015; Morell & Pastor Cesteros, 2018; Wang et al., 2023), and 4) classroom practices (e.g., Lim, 2021; Morell, 2018).

However, there seems to be limited literature on the analysis of co-speech gestures used in areas related to engineering or technical spoken discourse, in particular engineering presentations. To address this gap, this study examined how gestures were integrated with verbal messages to signal communication in engineering proposal presentations. This study analysed how four different types of gestures (beat, deictic, iconic, and metaphoric) co-occurred with language in a speech to communicate technical solutions in engineering proposal presentations.

This case study employed a mixed-method research approach utilizing both qualitative and quantitative methods (see Ivankova & Greer, 2015). Specifically, multimodal discourse analysis (MDA) was employed qualitatively, while quantitative analysis was used to examine the utilization of co-speech gestures by presenters. This study used the MDA approach, which was inspired by the work of Norris (2004, p. 4) to "understand and describe what is going on in a given interaction" and to evaluate "what individuals express and react to in specific situations." The quantitative analysis provided insights into the occurrences and frequencies of co-speech gestures during the presentations. The frequency of gesture usage provided information on the presenters' communication patterns in using different types of gestures. Both sets of data were triangulated to provide a holistic understanding of how co-speech gestures were employed in engineering presentations.

The research focused on the following research questions:

RQ1: In what ways did the engineering presenters use gestures to present the proposed solution and product?

RQ2: What was the frequency of the four types of gestures used during the proposed solution presentation?

Insights from this study may inform the multimodal research in ESP spoken discourse and classroom practices.

2. LITERATURE REVIEW

Gestures have been studied in many fields, including psychology (e.g., Ekman & Friesen, 1969; Iverson & Goldin-Meadow, 2005; McNeill, 2005), anthropology (e.g., Haviland, 2004; Kendon, 1997, 2004), cognitive sciences and learning research (e.g., Congdon et al., 2017; Goldin-Meadow, 1999), visual communication (e.g., Lim, 2021; Norris, 2011), and multimodal studies in linguistics (Crawford Camiciottoli & Bonsignori, 2015; Jewitt et al., 2016). Co-speech gestures help to enhance message comprehension and memorability (e.g., Dargue et al., 2019; Holler et al., 2014; Hostetter, 2011), foster teaching and learning capabilities (e.g., Congdon et al., 2017; Madan & Singhal, 2012; Schneider et al., 2022), and guide listeners to gauge the speaker's relationships with various actions and events (e.g., Chan & Kelly, 2021).

Studies carried out by various researchers have shown that speech and gestures share a cognitive stage of processing in language understanding as they do in language production (Arbona et al., 2023; Goldin-Meadow & Alibali, 2013; Zhang et al., 2023). By sharing a common neural system in the brain with the use of speech, gestures can adapt to the human physical anatomy and become part of cognitive and language capabilities (Bouissac, 2006).

As a communicative mode, co-speech gestures offer visual signals within their linguistic structure (Ebert, 2024; Fricke, 2013; Landau, 2016; Pouw et al., 2021; Schlenker, 2018, 2020). These visual signals are organized within the language system, particularly in two main areas: reference (e.g., Fricke, 2013; Landau, 2016) and semantics (e.g., Ebert, 2024; Pouw et al., 2021; Schlenker, 2018, 2020). Co-speech gestures provide visual signals to reference specific entities and objects, allowing speakers to indicate and point to, or visually represent objects discussed (Landau, 2016). Visual signals like gestures can be employed to convey meaning at the semantic level, though gestures and semantic affiliates (or the words used in a speech) need not be in synchrony for them to be successfully merged into the discourse model (see Fritz et al., 2021; Kita et al., 2017; McNeill, 2005). However, this is so "only if the preceding context constrains the gesture's meaning" (see Fritz et al., 2021, p. 104). This implies that the meaning of the gesture is limited or determined by the specific situation or information that precedes it.

In the STEM context, various research studies have focused on the cognitive aspect of co-speech gestures that signal reference and semantic representations. Cash and Maier (2016, p. 118) explored how engineering graduates used gestures during an ideation session and observed that sequences of gestures were used "to act out design concepts, repeat and learn from sequences, and establish shared understanding." Becvar et al. (2008, p. 117) analysed how representational gestures were frequently used to "reference, modify, and embody portions of existing material structure such as models, diagrams, and graphs" and how they can contribute to the conceptualisation and communication of scientific theories. Son et al. (2018) highlighted the positive impact of teachers' gestures in supporting the coordination of ideas in the learning of mathematic concepts of mean and standard deviation in the domain of statistics among university students. For instance, a particular iconic gesture signalling the mean and variability of a distribution concept refers to real-world objects or actions rather than abstract representations.

Holler et al. (2014) argued that the enhancement effect of gestures does not just occur at the semantic level. The mere visual movements of gestures activate the attention to speech and thus strengthen the subsequent memory of the message. In their study of the impact of gestures in comprehending speakers' messages, the comprehension level increased when speeches were accompanied by gestures. In a way, gestures enhance memory recall when audiences are more likely to remember information accompanied by visual cues, aiding retention of technical details. Similarly, Hostetter (2011) has found that people remember stories more effectively when the narrator provides relevant hand gestures to accompany the story content.

Some studies also highlight that only certain gestures that map semantically to accompanying utterances will have an impact on speech memory, such as iconic and metaphoric gestures (Aydin et al., 2023; Wu & Coulson, 2007; Yap et al., 2011). Other gestures that do not relate semantically (such as beat gestures) may not have a similar effect (Holler & Wilkin, 2011; Kelly et al., 2009). Nonetheless, the ways gestures are used and interpreted can be influenced by various factors, including cultural context and norms (Matsumoto & Hwang, 2013).

In ESP contexts, training students to use embodied communicative modes can help raise their awareness and competence in multimodality (Lee, 2023). Specifically, such training is essential in the field of engineering presentations where there is "limited training for engineering students" in higher learning institutions even though oral presentations are essential skills in the workplace (Mohamed et al., 2023, p. 69). There is also a paucity of literature on multimodality in engineering presentations. Most literature on engineering presentations covers areas related to: 1) professional and curriculum development (e.g., Berjano et al., 2013; Rowley-Jolivet, 2015), 2) delivery skills and persuasion (e.g., Morton & Rosse, 2011), 3) impact of affective factors on performance (e.g., Mohamed et al., 2023). Though the study of communicative modes is useful in engineering presentations and gestures are essential visual cues to reinforce communication (Kendon, 2004), there seems to be limited research on the ways gestures are used in engineering presentations to convey engineering concepts.

Engineering concepts form the foundation for exploring the integration of gestures to enhance communication. Engineering proposals focus on providing solutions to real-life technical problems (Sales, 2006). The proposed solution often involves "an engineering design process" or "a series of steps that engineering teams use to guide them as they solve problems" (Tayal, 2013, p. 1). According to Bilén et al. (2002), the epistemological convention of engineering design and problem-solving involves four steps: (1) assessment of needs and definition of the problem; (2) generation of concepts or solutions; (3) evaluation, and selection of a concept; and (4) implementation and communication of the design. Solving a complex problem involves a diversity of expertise and views, such as how the proposed solution is designed, built, applied, used, tested, and interpreted.

This study seeks to examine how presenters use co-speech gestures to convey engineering concepts in their proposal presentations.

3. METHOD

3.1. Background of study and participants

This case study employed a mixed-method research approach to examine how two high-performing first-year students used co-speech gestures in engineering proposal presentations at a technological university in Singapore. The MDA framework was used to examine the ways presenters utilized co-speech gestures, while quantitative analysis was used to examine the types and frequency of gestures used. The data were collected by analysing the video recordings of the two presenters, whose presentations were selected for analysis because the presenters attained high scores of more than 80% in their delivery of the proposed solution during a proposal presentation assessment. An analysis of high-performing student presenters provides useful examples to model how gestures can be employed in engineering presentations to convey design systems and operational procedures.

The presentation was part of the assessment of an Engineering Communication course which required students to propose a technical solution within 5 minutes to address a given real-life problem in consumerism. They were given several themes to choose from, which ranged from refining household products like awnings to designing phone applications in the healthcare sector. The assessors were two independent and experienced communication skills lecturers, who also represented the audience. Their roles were to assess the presenters' feasibility of their solutions and the effectiveness of their delivery skills to persuade the audience to accept their proposals. Ethical considerations included obtaining informed consent from the participants, ensuring their anonymity, and obtaining the university's Institutional Review Board (IRB) permissions to conduct the study.

PRESENTER	PROPOSAL TITLE	PROBLEM	PROPOSED SOLUTION	SOLUTION PRESENTATION DURATION (MIN)	TOTAL PRESENTATION DURATION (MIN)
Dan	A smart awning system	A lack of automation in existing awning systems to detect rain.	An intelligent awning that uses sensors to detect rain to automatically extend or retract the awning component without the user's intervention.	1.48	3.26
Lex	Fitness assistance application	Lack of phone applications to synchronize various health monitoring systems and gym equipment functions.	A smartphone application using radiofrequency and signal transmitter systems to communicate between gym equipment and users, as well as sensors to measure heart rate and other vital signs.	1.96	4.58

Table 1. Summary of presentations

The presenters, Dan and Lex (not their real names) presented solutions that leveraged technology to enhance convenience, efficiency, and automation in daily lives (see Table 1). Dan proposed a smart awning that retracted in the rain, which was an IoT-based home automation solution to utilize sensors and connectivity to automate a household task (awning retraction) based on environmental conditions (rain detection). Lex proposed a smart phone application to check gym equipment availability and to track the user's vital signs when exercising. This was an IoT-based health and fitness solution to use sensors and connectivity to monitor and provide information related to health and fitness. In both cases, the common thread was the integration of sensors, connectivity, and intelligent control mechanisms to address specific problems or enhance the user experience. These solutions were part of the broader trend of incorporating smart and connected technology into everyday life to make it more efficient, convenient, and responsive to various situations and needs

3.2. Data transcription and coding

The presenters' speeches were transcribed orthographically. The video recordings were watched at least three times to identify the segments where speeches co-occurred with gestures used. The use of gestures was coded using a coding scheme (see Table 2) which was adapted from McNeill's (1992) taxonomy of gestures, which classified gestures into four types: beat, deictic, iconic, and metaphoric. Table 2 shows the definition of each gesture type, and the examples provided to ensure consistency in the coding process. This coding system enabled the identification and description of gestures used by the presenters during their presentations.

GESTURE TYPE/CODE	DESCRIPTIONS	FUNCTIONS	EXAMPLES
Beat	Rhythmic movements accompanying speech	Beat gestures involve rhythmic movements that synchronize with speech patterns, adding emphasis and rhythm to the discourse.	A downward chopping hand movement is used to emphasize keywords used in a speech.
Deictic	Pointing to referents in space or time	Deictic gestures involve pointing to specific referents (e.g., objects, locations, directions) in a physical environment or conceptual space, guiding the audience's attention to particular elements.	A hand is used to point at key information on a slide in a presentation.
Iconic	Depicting attributes of an object	Iconic gestures visually represent attributes or actions associated with an object or process, aiding in the comprehension of abstract concepts. Physical movements can directly represent or mimic objects, actions, or concepts.	A hand movement outlining a square shape in the air by visually showing its four sides and the right angles that are perpendicular to each side.
Metaphoric	Using gestures metaphorically	Metaphoric gestures convey abstract ideas symbolically, adding depth and layers of meaning to the discourse. Symbolic movements can be used to represent abstract concepts or relationships.	An upward hand movement symbolizes the concept of "rising" or "increasing" in the context of a description of growth, progress, or improvement.

Table 2. The coding scheme adapted from McNeill's (1992) gestures categorisation

Table 3 shows a coding scheme of the proposed solution that focuses on the components of 1) discourse organisation, such as the way the solution is structured or organised in the presentation, 2) product design, such as the detailed plan and specifications of a product to resolve a problem, 3) operational principles and processes, such as the workings, functionality, and implementation of the proposed product. The coding scheme was inspired by the work of mechanical and machinery engineering (e.g., Merticaru et al., 2015; Pecheikina et al., 2020; Scharfe & Wiener, 2020) that highlighted how the integration of engineering principles, methods, processes, and instruments contributes to the development of a product design and functionality to solve problems.

Parts of solution	Descriptions
Discourse organisation	The structural arrangement of the solution
Product design	The detailed plan and specifications for a product intended to address a technical problem
Operational principles and processes	The inner workings and functionality of a product, detailing how it performs its intended tasks

Table 3. A coding scheme of the proposed solution

The professional annotator software EUDICO Linguistic Annotator (ELAN) was used to facilitate the transcription of speeches and coding of data. ELAN allowed for the viewing, segmentation and synchronization of gestures with corresponding verbal utterances on the same screen, contributing to the precise analysis of multimodal discourse (Wittenburg et al., 2006; Zhang, 2015). This study adapted the research method used by Lee (2023) to annotate and code communicative modes in student oral presentations via ELAN, as well as to verify the trustworthiness of the coded data. The annotation started with uploading the videos onto ELAN to create two “tiers” or sets of annotation, such as “gestures” and “solution”, as well as one “tier” of speech transcription. Figure 1 shows a screenshot of the coding processes on ELAN.

To verify the trustworthiness of the data, the researcher randomly selected sections of the transcripts which formed about 10 per cent of the total transcript length to be coded separately and independently by a second coder (see Campbell et al., 2013; Hodson, 1999; O’Connor & Joffe, 2020). SPSS was used to calculate inter-coder reliability using Cohen’s kappa to measure the level of agreement between the two coders in coding gestures and solutions that co-occurred with the transcribed utterances. A p-value of 0.68 was obtained, indicating a substantial agreement between the coders. Instances of disagreement were resolved via discussions before joint decisions were made.

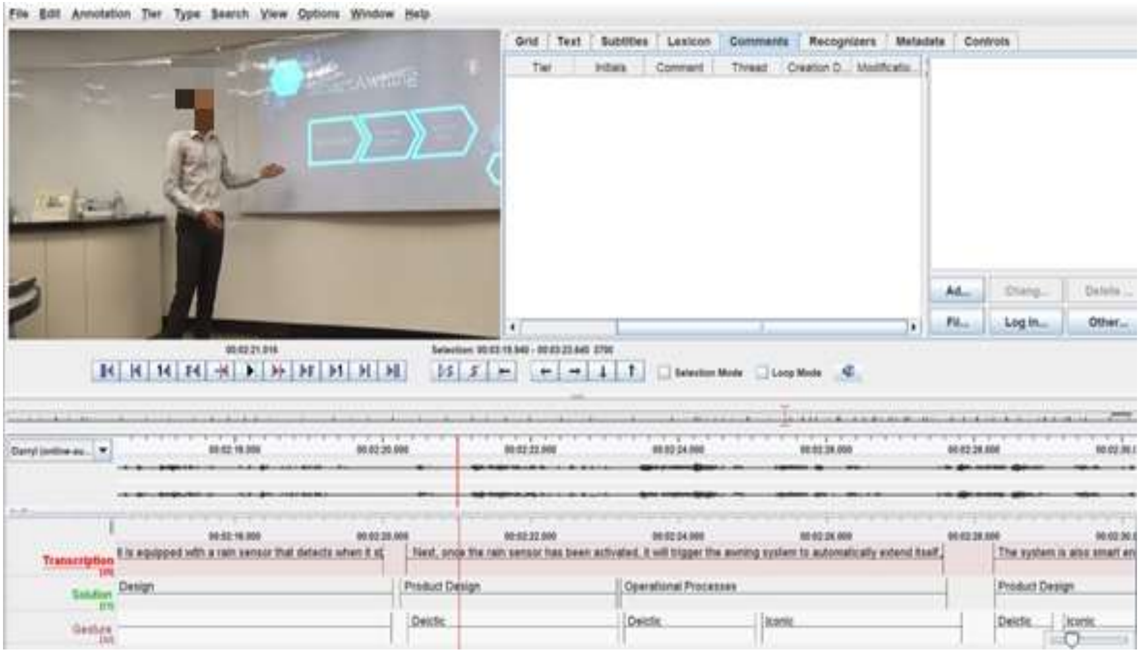


Figure 1. Screenshot of coding processes using ELAN

3.3. Coding data statistics

ELAN was used to generate the annotation statistics for the occurrences and frequency of gestures used in the presentation of the solution (see Lee, 2023) during the observation period in ELAN.

Areas of analysis	**Definitions** (adapted from ELAN manual, as cited in Lee, 2023)
Occurrence	The number of occurrences of gestures during the observation period
Frequency	The number of occurrences divided by the observation period, or the number of occurrences per second

Table 4. Areas of analysis in coded data

The observation period referred to the beginning of the first annotation of all tiers and the end of the last annotation of all tiers. Table 4 shows a summary of the areas of analysis and their definitions adapted from ELAN (see ELAN manual at https://www.mpi.nl/corpus/html/elan/).

4. FINDINGS

RQ1: In what ways did the presenters use gestures to present the proposed solution and product?

The presenters employed a variety of gestures to enhance their presentations of their proposed solutions and products: beat, deictic, iconic, and metaphoric. The four gestures performed various communicative functions related to informing the audience about the product design and explaining the operational processes. The examples below show how MDA was used to unpack the ways both presenters combined the four different types of gestures with language in speech to attain various communicative purposes when presenting technical solutions.

4.1. Beat gestures

Example 1

In Figure 2 Dan raised his left hand near his waist before moving it swiftly and rapidly in a downward vertical motion to make a beat gesture that co-occurred with the spoken words "intelligent" and "fully automatic". This example shows how a beat gesture was used to reinforce the attributes of the awning system and in doing so, helped to create a dynamic visual association for the speech uttered.

TIME FRAME	SOLUTION	VIDEO FRAME	SPEECH
02:07-02:08	Product design		Smart Awning is an intelligent,

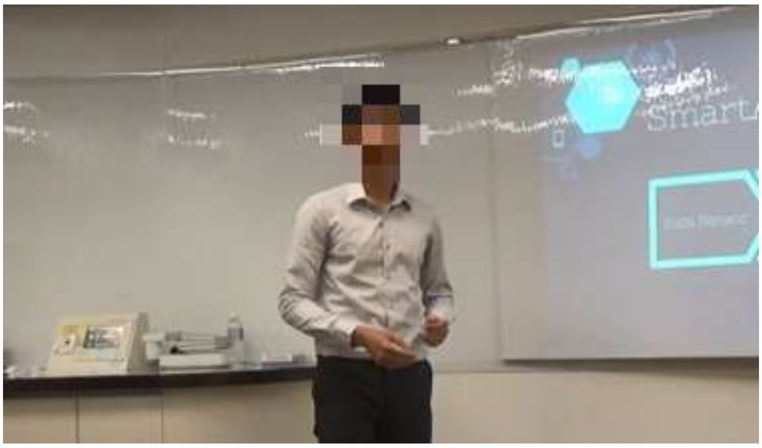
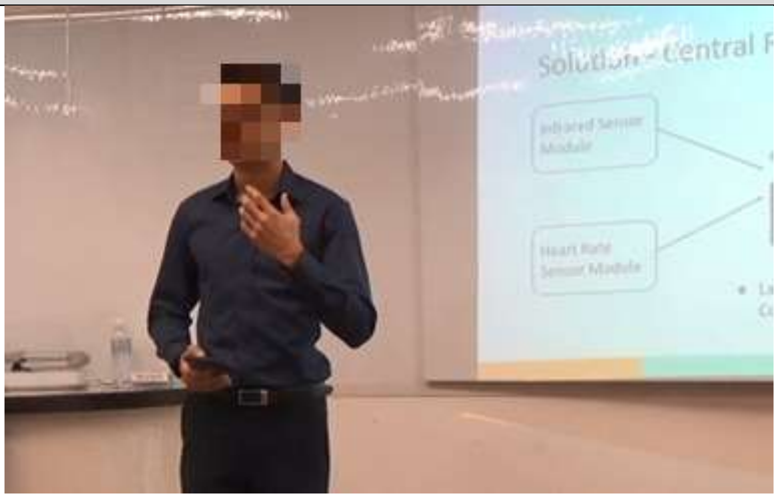
02:09- 02:11			fully automatic system that fills in the gap of the current awning system.

Figure 2. Beat gesture used by Dan

Example 2

Similarly, Lex used a beat gesture to emphasize a possible option for a central receiver of the IoT system (see Figure 3). This movement was crisp and deliberate, involving a swift downward motion of his left hand. The beat gesture co-occurred with the spoken words "laptop or desktop", aligning with the point the presenter wanted to emphasize.

Time frame	Parts of solution	Video Frame	Speech
00:42- 00:43	Product design		The central receiver comes in the form of a laptop

00:43-00:44			or desktop

Figure 3. Beat gesture used by Lex

4.2. Deictic gestures

Example 3

In Figure 4, Dan used a deictic gesture to direct the audience's attention to a flow chart on the slide that showed the operational processes of the awning system. The deictic gesture was performed with an upturned left hand that was held in mid-air, pointing to the flow chart. It co-occurred with the words "rain sensor", possibly integrating both the verbal and visual aspects of the presentation to create a synchronized experience for the audience.

TIME FRAME	SOLUTION	VIDEO FRAME	SPEECH
02:20-02:23	Operational process		Once the rain sensor has been activated, it will trigger the awning system to automatically extend itself.

Figure 4. Deictic gesture used by Dan

Example 4

Similarly, in Figure 5, Lex extended one arm and used an upturned open palm to point at the screen to direct the audience's attention to the schematic drawing of the solution. The deictic gesture co-occurred with the utterance to "look at" the solution. This gesture seemed to engage the audience's attention by inviting them to join him in viewing the schematic drawing of the product on the screen. In a way, the deictic gesture also helped to establish reference points within the discourse.

TIME FRAME	**SOLUTION**	**VIDEO FRAME**	**SPEECH**
00:18-00:20	Product design and Discourse organisation		Let's look at the first part of our solution with the infrared sensor.

Figure 5. Deictic gesture used by Lex

4.3. Iconic gestures

Example 5

TIME FRAME	SOLUTION	VIDEO FRAME	SPEECH
02:46-02:47	Product design	(A) 	The app will allow users to track the status of the awning, like whether it's extended,
02:47-02:48		(B) 	or retracted.

Figure 6. Iconic gesture used by Dan

In Figure 6, Dan used an iconic gesture to emphasize the verbal message of extending and retracting the mechanical arms of an awning system using sensor technology. To mimic the movement of extension, Dan stretched his left arm horizontally away from his body, as well as away from his right hand, which was held close to the centre of his body at waist level. The iconic gesture of extension co-occurred with the utterance of the verb "extended" (see Figure 6A). To represent the movement of retraction, he reversed the motion, bringing his arm back to be close to his body and towards his right hand. The movement that represented retraction co-occurred with the utterance of the verb "retracted" (see Figure 6B).

This example shows how an iconic gesture mimicked the physical actions of extending and retracting the awning. By doing so, the iconic gesture may visually illustrate the operational procedure to enhance the audience's understanding of how the mechanical system worked. Additionally, the iconic gesture may also depict the attributes of the awning system by harnessing physical movements to convey mechanical characteristics and functions.

Example 6

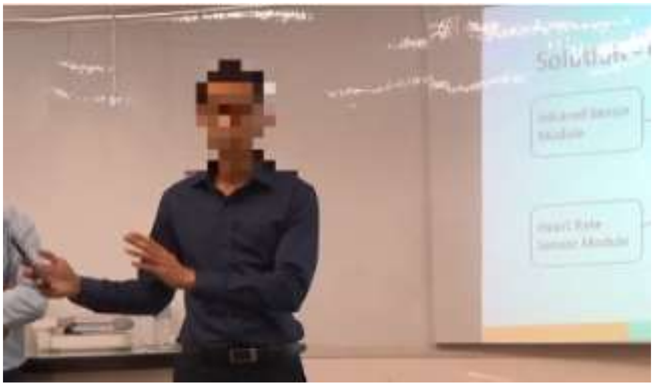
TIME FRAME	SOLUTION	VIDEO FRAME	SPEECH
00:56 - 00:57	Operational process	(A) 	So it's RF signals in
00:57- 00:59	Operational process	(B) 	and it's sending it to your smartphone application.

Figure 7. Iconic gesture used by Lex

In Figure 7, Lex used an iconic gesture to represent actions and concepts. Both his hands were used to make horizontal movements sweeping from the left (see Figure 7A) to the right (see Figure 7B) part of his body to visually imitate the idea of RF signals moving in a similar direction. The iconic gesture was used simultaneously with the verbal description of the way the RF signals were being sent. The RF signals that were "in" (to reach the infrared sensor module) are shown by the hands starting from the left side of Lex's body. The verbal meaning of "sending" of the RF signals was captured by a horizontal sweeping motion of both hands moving towards the right side of his body. The hand movement from left to right was slow and deliberate, representing a controlled and regulated operational process. The continuous and flowing motion of the hands may help to indicate the smooth transition of signals and provide a visual representation of Lex's speech.

This example shows how iconic gestures aided comprehension of technical concepts by creating concrete visual representations to depict movements and reinforce verbal language.

4.4. Metaphoric gestures

Example 7

Figure 8 shows how Dan created a metaphoric gesture using extended palms facing each other and fingers touching one another to represent the verbal speech "all the parts will work hand-in-hand". The joining of both hands represented the action of the union of separate entities. The spherical shape formed by the touching of his fingers on both hands visually portrayed the image of a completed whole, signalling unity and cooperation.

TIME FRAME	SOLUTION	VIDEO FRAME	SPEECH
03:12-03:14	Operational process		Now, these three parts will work hand-in-hand so as to work to protect your clothes from the rain.

Figure 8. Metaphoric gesture used by Dan

The metaphoric gesture symbolized the idea of collaboration and cooperation among different parts of the awning system that worked both independently and in synchrony to perform the operational processes of receiving the signals and activating the mechanical arms of the awning system.

Example 8

TIME FRAME	SOLUTION	VIDEO FRAME	SPEECH
03:16-03:17	Operational process	(A) 	We'll be combining
03:18-03:23	Operational process	(B) 	the infrared sensor and the heart rate sensor with the wireless transmitter.

Figure 9. Metaphoric gesture used by Lex

In Figure 9A, Lex raised his hands separately to represent the two different parts of the IoT system: the infrared sensor and the heart rate sensor. When describing how the two parts of the system were used, he moved both hands close to each other (as shown in 9B) to represent the meaning of "combining". In this example, a metaphoric gesture was used to visually represent the act of merging two separate components. The movement of the hands did not physically merge two objects but symbolized the abstract idea of integration in their operational processes. In this way, the metaphoric gesture may leverage visual symbolism to convey the abstract concept of combining two entities.

RQ2: What was the frequency distribution of the four types of gestures used during the proposed solution presentation?

Table 5 shows the occurrences of the gestures, with Dan using a total of 32 compared to Lex's 50 during the observation period. The observation period refers to the beginning of the first annotation of all tiers and the end of the last annotation of all tiers (see subsection 3.3).

PRESENTER	OCCURRENCE OF GESTURES				FREQUENCY OF GESTURES			
	Beat	Deictic	Iconic	Metaphoric	Beat	Deictic	Iconic	Metaphoric
Dan	5	17	9	1	0.024	0.083	0.044	0.0049
Lex	9	11	29	1	0.029	0.036	0.095	0.0033

Table 5. Annotation statistics of gestures occurrences and frequency during the observation period

As shown in Figure 10 below, the deictic and iconic gestures were used more frequently by the presenters.

Dan used deictic gestures more frequently, with an average frequency of 0.083 gestures per second compared to Lex (0.036). Dan used the deictic gesture very frequently to physically refer to the visual aids of the flow chart and schematics on the screen to describe the proposed solution design. He also used deictic gestures to engage the audience's attention by guiding them to locate the components and systemic processes on the screen (see Example 3). Similarly, Lex also used the deictic gesture to draw the audience's attention to the visual aids that were provided to structure his presentation flow (see Example 4).

Lex used iconic gestures more frequently (0.095) compared to Dan (0.044). Lex used hand movements frequently to depict physical objects, such as the screen of his system and the movements of physical signals when describing the components of the IoT system of the fitness application (see Example 6). The high frequency of both deictic and iconic gestures being used indicates that both presenters focused heavily on using visual representations to bring the audience's attention to the visual aspect of their proposed solution, with Dan directing their attention to the visual aids, and Lex depicting the physical components of the product system and its signal low via hand movements.

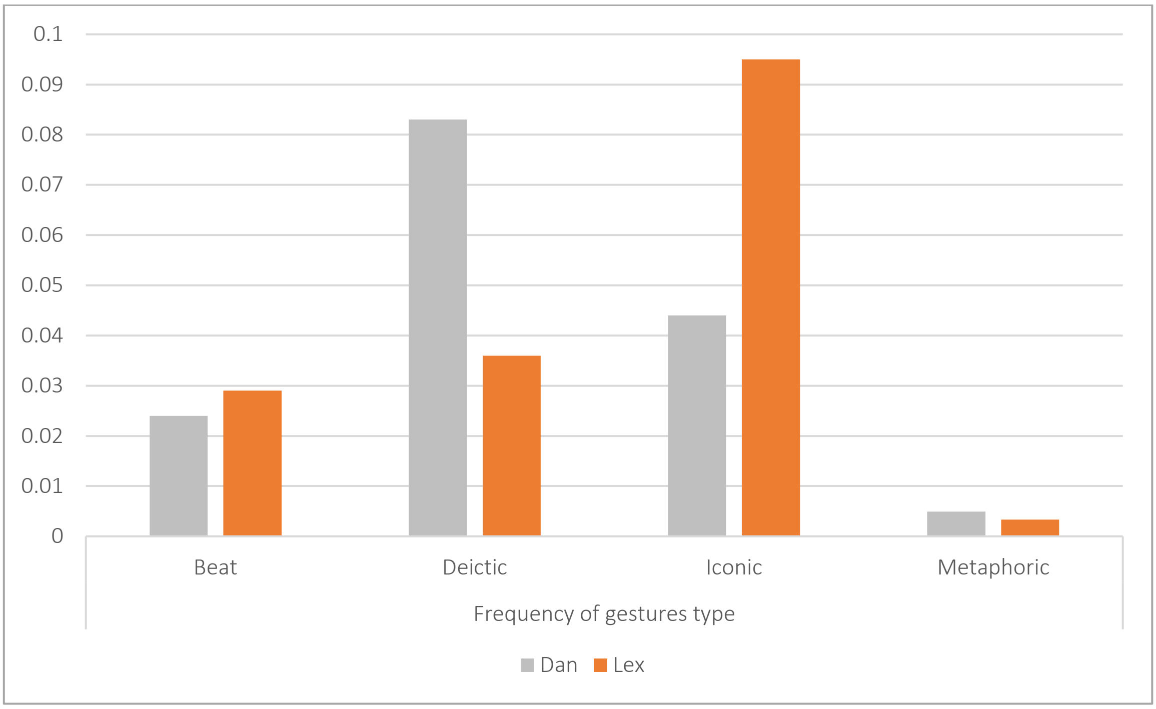


Figure 10. Frequency of gestures used by two high-performing presenters

Both presenters used metaphorical gestures minimally in their solution presentation, with Dan scoring 0.0049, and Lex 0.0033, indicating very few representations of abstraction. Similarly, beat gestures are used less frequently than deictic and iconic gestures for both presenters, with Dan scoring 0.024, and Lex 0.029. This suggests that both presenters have chosen to focus more on using co-speech gestures to illustrate real-life objects, actions, and movements more than others.

5. DISCUSSION

This case study examines two high-performing presenters using co-speech gestures to deliver engineering solutions and their frequency in using them. The co-occurrences of gesture and language in speech in this study support previous studies that indicated the integration of gesture and speech to reinforce each other's meaning in output (McNeill, 1992; McNeill & Duncan, 2000).

Both presenters used beat, deictic, iconic, and metaphoric gestures together with speech to perform various communicative functions. Some functions include 1) emphasizing semantic meaning and content with beat gestures, 2) directing the audience's attention to the solution and sequencing the discourse structure with deictic gestures, 3) illustrating actions and technical concepts with iconic gestures, and 4) signalling thinking processes with metaphoric gestures. In this way, the findings align with previous studies on how co-speech gestures can offer both communicative and cognitive functions when at work (see Congdon et al., 2017; Fritz et al., 2021; Goldin-Meadow, 2005; Kita et al., 2017; Kita & Özyürek, 2003; Osorio et al., 2024).

Co-speech gestures which are representational of the message content (e.g., iconic and deictic) can enhance the engineering presentations by reducing the cognitive load of processing them. Kita et al. (2017, p. 258) suggested that representational gestures can affect cognitive processes by "schematization", or the process of reducing or simplifying a complex idea or image into a more "lightweight, less complex, more stripped-down representation." As a result, less working memory is required to manipulate or convey such an idea or image (see Koedinger et al., 2008). In this way, using representational co-speech gestures can enhance the cognitive processing of propositional content and help presenters convey engineering ideas to aid the communication of content meaning. This reinforces the role of co-speech gestures as a communicative mode that enhances the creation of meaning beyond the use of language (see Kress, 2010), as well as integrating with speech and other different kinds of meaning-making modes such as slides to develop a cohesive, multidimensional ensemble (Jewitt et al., 2016, p. 2).

Deictic gestures support the presentation of proposed solutions by directing the audience to view physical representations on the screen such as schematic diagrams of engineering systems and flow charts. Diagrams, pictures, and photographs are commonly used to depict and explain the mechanisms and workings of engineering devices, processes, and systems. Visual representations can be persuasive if used appropriately because they are often highly valued in the engineering community (Silyn-Roberts, 2000; Vincler & Vincler, 1996). Thus, an awareness of the multimodality of the presentation allows presenters to make use of modalities other than spoken language to convey meaning (see Kress & van Leeuwen, 2001; O'Halloran, 2008). Understanding the affordances of multimodal resources (gesture types, visual diagrams, spoken language) and how they interact in meaning-making enhances multimodal literacy and empowers the presenters with the knowledge and skills to use such resources on their own or as an ensemble.

Both iconic and deictic gestures are used more frequently by the presenters than the rest of the gestures, signalling their relevance and usefulness in communicating product design and operational processes. The usefulness and functionality of these gestures are reinforced in studies that highlight how they operate as essential spatial-dynamic information that extends beyond the use of language or graphical representations to shape "theoretical understandings" in communicative events (see Becvar et al., 2008, p. 117).

Compared to the beat gesture, both the iconic and deictic gestures are representational of the content of speech, such as depicting a referent with the motion or shape of the hands. Their high-frequency usage in this study can be related to their functionality in conveying the propositional content of the proposed solution since the impact of gesture is often determined by the direct relationship between the propositional content and its physical embodiment (see Becvar et al., 2008). In this way, iconic and deictic gestures can better represent the content meaning of product design and operational processes to communicate the proposed solution more effectively. In contrast, beat gestures emphasize the prosody of speech without much semantic information (see McNeill, 1992, 2005).

Metaphorical gestures provide a visual representation to guide an audience's understanding of concepts, though the referents are often abstract ideas (see McNeill, 1992). Considering that both presentations focused on delivering the content of concrete products instead of abstract ideas, metaphorical gestures are not widely used in the context of this case study. Hence, exploring how gestures are used provides a glimpse into how engineers understand design concepts (Becvar et al., 2008).

The implications suggest that presenters need to understand the affordances of co-speech gestures to use them aptly to express propositional content, intentions, and thoughts. Being perceptive of how co-speech gestures interact with other communicative modes and how to combine them may empower presenters to plan actions in their presentation deliveries.

6. PEDAGOGICAL IMPLICATIONS

This study has shown that co-speech gestures are multidimensional communicative modes which facilitate verbal speech about the presentation of propositional content and visual representations. Gestures enrich speech by bypassing the need to represent visual images and ideas in words, especially when using words can become more challenging (see McNeill & Duncan, 2000).

Gesture types and their functions can also be taught explicitly to raise awareness and consciousness in use. This can include the learning of co-speech gestures that focus on the synchronization of both verbal and visual representations to convey meaning or examining the use of gestures alone without utterances. Strategies to teach the use of co-speech gestures can include: (1) categorising and developing the various hand movements to depict different technical information, such as using iconic gestures to represent spatial information related to dimensions, shapes, sizes, and specifications, and deictic gestures using fingers, hand and palms differently to signal key information, and (2) teaching specific gestures to represent different actions to depict the engineering system designs and processes, such as movements, procedures, and directions.

Explicit teaching and learning of gesture types and functions contribute to multimodal literacy among learners and help enhance awareness of engineering presentations as being multimodal and multidimensional in terms of their structure, language used and deployment of communicative modes to convey content and thoughts. Multimodal literacy will also mean empowering learners with the knowledge of a metalanguage to talk about the different types of gestures (e.g., iconic, deictic, beat, and metaphoric) and their affordances, as well as how to apply them in ESP contexts (see Hu, 2011, for a discussion on metalanguage). This will promote awareness of knowledge and skills learnt to build beyond literacy in multimodality to reach the level of competency.

7. CONCLUSION

This study analysed the ways two high-performing presenters used co-speech gestures (beat, deictic, iconic, metaphoric) in engineering proposal presentations to convey technical solutions in proposed products, as well as their frequency of use. The findings showed that iconic gestures were used more frequently to mimic visual representations of designs and processes in engineering systems, which co-occurred with words, phrases, and sentences to reinforce propositional content. Deictic gestures were used frequently to direct the audience's attention to visual diagrams to facilitate the explanation of technical content. An awareness of co-speech gestures and their affordances can enhance multimodal literacy and provide presenters with new strategies to cope with the challenges of engineering presentations in ESP contexts.

This case study is limited by its small sample size and lack of generalizability. To enhance the generalizability of the findings, future research could include a larger and more diverse sample of presenters from various engineering subdisciplines. This would allow for a more comprehensive understanding of how gestures are used in different contexts. In addition, comparative analysis can be incorporated into future studies, such as conducting a comparative analysis between high-performing and low-performing presenters to provide insights into the role of gestures in effective communication. Contrasting gesture usage across proficiency levels can also highlight best practices for engineering presentations. Future studies can also expand on the ensemble of communicative modes to be analysed, such as intonation, gaze, proxemics, head movements and so on, to offer a more realistic image of how communication occurs.

Nonetheless, this study contributes to multimodal research by providing some insights into how different gesture types are used to communicate designs and processes in engineering systems. The frequency of their use may be mostly related to contextual demands such as the propositional content and the presenters' perception of how each gesture can be tapped to enhance visual representations and the overall message meaning. Nurturing such a perception among learners will require an awareness of why and how gestures are used in different ESP/EAP spoken discourse.

Gestures play an important role in enriching speech and thinking via visual representations of mental images that may not be possible with the mere use of words. As such, the teaching and learning of ESP spoken discourse can be enriched with an increased awareness of multimodality via the use of co-speech gestures to reinforce communication in engineering presentations.

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