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Silent learning: a multimodal approach to examining non-verbal communication in secondary school computer-based music lessons

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ABSTRACT

In a UK secondary school context, this article examines how two Year 9 pupils' (ages14–15) non-verbal 'silent' communication evidenced their learning during computer-based music composition. Operationalising multimodal social semiotic theory of communication and learning and the principles of recontextualization [Bezemer, Jeff, and Gunther Kress. 2016. *Multimodality, Learning and Communication: A Social Semiotic Frame*. London: Routledge], the video-based observations enabled the generation and framing of data. The first stage filtered out speech, mapped pupils' semiotic work and highlighted all instances of non-verbal communication for further analysis. The second stage involved a micro-analysis of 16 selected instances. These methods legitimised pupils' non-verbal communications during compositional activities. The analysis revealed complex signs of learning, such as engagement and interest, control and agency and negotiation, that materialised through the process of transformation of resources. The findings highlight the significant role of non-verbal communication in pupils' learning during computer-based music composition. Understanding and valuing non-verbal communication can enhance teaching practices and provide deeper insights into pupils' learning experiences.

Introduction

Past studies in music education have yielded some important insights into how the concept of transformation of resources shows change in pupils' learning (Breeze 2008; 2011; Gall and Breeze 2008; Nijs and Bremmer 2019; Pramling and Wallerstedt 2009). Their research was not solely framed by a multimodal perspective; however, their findings consistently identified two themes. First, learning in music education often drew on sociocultural theories of social interaction and mediation. Second, multimodal principles of transformation, transduction (or the process of enactment) identified the importance of capturing data at the point of change.

This article reports on how selected concepts of Kress (2010) and Bezemer and Kress (2016) multimodal social semiotic theory of communication and learning move towards methodological development of examining pupils' non-verbal communication during their instances of 'silence'. From this perspective, learning is a continuous process of sign-making in which different signs

of learning come together, through transformation of resources, in complex ways to evidence the pupils' ongoing processes of meaning-making, communication and learning (Bezemer and Kress 2016; Kress et al. 2021). Throughout, 'silence' has been defined as the absence of the mode of speech, and recognises other modes of communication beyond language, such as gaze, facial expressions, gesture, action, computer-generated sound and body movement or positioning. Examining how pupils' signs of learning can impact their musical knowledge and learning in teacher-designed computer-based compositional activities can enhance teaching practices and provide valuable insights into pupils' experiences during their instances of silence.

A central aim considered in this article is how a multimodal social semiotic approach can be operationalised to examine pupils' non-verbal communication in computer-based music composition.

Bridging sociocultural learning and multimodality in music composition

Sociocultural views of learning have strongly influenced research methods in music education and stress that learning is a dynamic process in which meanings are constructed and transformed through individuals' active participation in activities (Lave and Wenger 1991; Rogoff 2008). The task's nature and its social context are pivotal in shaping learning, with verbal communication often being reported as the primary catalyst for learning and influencing action (Lave and Wenger 1991, 22). However, the concept of 'transformation of resources' within multimodal social semiotics', refers to changes of resources being made within the same mode of communication, to emphasise new meanings or signs of learning (Bezemer and Kress 2016; Jewitt, Bezemer, and O'Halloran 2016). For example, moving closer to the desk with a prolonged gaze may signal the pupils enthusiasm and attention. Diamantopoulou and Florén (2025) offer a compatible understanding of transformation, framing meaning-making as a socially situated and agentive process that involves the design and reconfiguration of modes.

As an analytical tool, the transformation of resources enables the identification of the signmaker's interactions that arise in response to different prompts, such as pointing or turning of the head to face each other. The pupils 'signs' of engagement will only be realised when they orchestrate different ensembles of modes, and their resources of mode (Bezemer and Kress 2016). For instance, a sign of learning may be observed when the direction of a pupil's gaze shifts from the computer screen to their hands on a MIDI keyboard. This means that within the context of interaction, or the process of interaction (Nijs and Bremmer 2019), when change occurs, there are possibilities for signs of learning to emerge (Bezemer and Kress 2016; Diamantopoulou and Florén 2025; Kress 2010). Thus, the design of the meaning-makers is an instance of transformation of resources and therefore an instance of learning (Bezemer and Kress 2016, 38).

Broadening the scope: non-verbal communications in music education

Theoretical foundations

Multimodal social semiotics has evolved from viewing linguistics as the basis of learning to considering communication and learning as unified and inseparable (Bezemer and Kress 2016; Hodge and Kress 1988; Kress and van Leeuwen 2001). This perspective aligns with sociocultural theory's view of teaching and learning as social practices, but importantly, it also sees them as instances of communication (Kress et al. 2021).

Although scholarly interest in multimodal social semiotics has increased since 2020, particularly in educational research, there is no relevant precedent for its application in the context of computer-based music composition and non-verbal communication.

Early research and key studies

Bezemer and Kress (2016, 41) discussed the concept of 'silence' in multimodal research referring to Jewitt's drawing (as reproduced in their study) that examined the body posture and gaze of a silent

female pupil in an English lesson. Using a social semiotic framework, they explored how silence was contextually situated in the pupil's active participation and introduced the notion of signs of engagement. The pupil's signs of engagement were noted through three different actions: the orientation of her posture; the direction of her gaze, whether at the text, teacher, or others in the classroom; and her interaction with textual resources (i.e. a worksheet) alongside gaze and hand movements.

The significance, however, lies in the argument that different configurations of modes and resources of modes, including the task's temporality, could influence the pupils' engagement, with silence being meaningful to the pupil.

The role of technology

With the addition of technology being more accessible and used to support the pupils' learning, numerous studies have reported the benefits and limitations within pupils' compositional work (e.g. Breeze 2011; Devaney, Ziegenmeyer, and Hughes 2024; Gall and Breeze 2008; Wise, Greenwood, and Davis 2011). For example, Sibelius software privileges notation-based approaches through default settings, such as time and key signatures, whereas GarageBand integrates audio and visual elements that support a more exploratory compositional practice (Devaney, Ziegenmeyer, and Hughes 2024). However, there are differences in accessibility and how technology supports pupils' learning between Key Stages 3 and 4 (Devaney 2019; Savage 2010). While these are important issues, other studies (Burn 2017; Mroziak 2017) have found that technology will structure how people communicate and interact. From a multimodal social semiotic perspective, incorporating technology in the classroom has expanded the range of modes and resources of modes available to pupils, thereby enhancing their meaning-making processes (Cowan 2020; Diamantopoulou and Florén 2025; Mavers 2009; Poulsen and Kvåle 2018).

Additionally, Poulsen and Kvåle (2018) suggest that how we communicate and interact with each other also depends on the type of technology we have and how we use it. This perspective challenges the dominance of language in teaching and learning, recognising that not all actions communicate the same meanings and prioritises action over language in a learner's communication and meaning-making (Lim 2019). Building on this, Diamantopoulou and Florén (2025, 3) state that, 'media, such as the computer screen, digital applications, pen and paper are cultural technologies for dissemination of meanings.' As such, multimodal texts are being redefined by technological developments, e.g. AI-generated content and interactive technologies.

Non-verbal communication in music performance

Research in global instrumental music studies highlights the importance of non-verbal communication, such as body movements, gestures, and facial expressions, in signalling communication and meaning-making in musicians' interactions with their instruments and performances (Haviland 2011; Marchetti and Jensen 2010; Pipe 2015). This description of non-verbal communication is best contextualised through Haviland's (2011) video-research of an undergraduate string quartet masterclass that examined the coordination of action and space among four string instrumentalists. The study aimed to understand how these musicians' interactions were synchronised to produce a cohesive performance. The study highlighted the uniqueness of non-verbal communication among musicians, such as upper body movements raising questions about how non-verbal prompts, such as posture and gaze, contribute to the ensemble's performance.

Haviland's research complements other studies in music education (e.g. Dillon 2003; Gall and Breeze 2008; Hewitt 2008) by highlighting the critical role of visual and auditory cues in interpreting non-verbal communications. By examining these modes of communication, the study broadens the understanding of non-verbal interactions in music education, offering deeper insights into how musicians communicate and collaborate beyond using speech.

Recent developments and broader implications

Recent research in music education, such as MacRae and Arculus (2020) and Pitt (2023), challenges the traditional emphasis on research methods that include verbal communication to instead focus on non-verbal interactions. For example, the relationship between human learners and non-human elements such as computers and disembodied sound (Pitt 2023). This shift away from the traditional research focus of language in music education signifies a broader, more inclusive approach to teaching and learning.

However, the importance of non-verbal communication in computer-based music composition remains largely underexplored, which underscores the need for further exploration in this area. Battersby (2009) and Battersby and Bolton (2013) argue that a teacher's non-verbal communication, such as body movement (kinesics), can impact pupils' engagement and learning. Despite the focus on dialogue in music education studies (e.g. Burnard and Younker 2008; Dillon 2003; Gall and Breeze 2008; Hewitt 2008; MacDonald and Miell 2000; Mellor 2008), non-verbal communication plays a significant role in music-making.

Early research by MacDonald and Miell (2000) and subsequent studies (Burnard and Younker 2008; Gall and Breeze 2008) collectively highlight the significant role of non-verbal communication in music composition. Non-verbal prompts enhanced the quality of the pupils' musical ideas, group cohesion, and emotional expression. Gestures, as a form of non-verbal communication, positively reinforced verbal messages and aided coordination in compositional collaboration. These studies emphasise that non-verbal communication conveys information and meaning beyond words, thereby strengthening the argument for understanding its critical role in computer-based music composition.

Therefore, this study acknowledges the value of sociocultural learning but operationalises concepts from multimodal social semiotic theory of communication and learning to thoroughly examine pupils' non-verbal communication in music education, highlighting its critical role in computer-based compositional tasks and challenges traditional research methods.

Research design

This doctoral study, approved by Bath Spa University's Ethical Committee and adhered to BERA's 2018 guidelines, used a qualitative approach and adopted concepts from multimodal social semiotics as a theoretical framework (Bezemer and Kress 2016; Kress 2010) to explore instances of non-verbal communication in music education. The research context examined how 'silence' as non-verbal communication unfolded between two Key Stage 3 pupils (ages 13–14) during computer-based music composition in a UK state secondary school. The pseudonyms Alex and Ollie are used to represent the two participants. The school's music department planned a six-week task where pupils used GarageBand on Mac computers to create three character leitmotifs for a 40-second segment from The Snowmen episode of BBC's Dr Who series (Metzstein 2012). They notated their leitmotifs and key signatures, composed a soundtrack, added chords and incorporated musical devices, e.g. movie markers.

Mapping of the pupils' modes and resources of modes used Bezemer and Kress (2016) concept of principles of recontextualization and identified the pupils' preceding modal prompt (modes visible two or three seconds before their non-verbal communication). The study challenged traditional research methods in music composition to highlight pupils' non-verbal semiotic work and communications. Data was collected using Camtasia™ (– a computer screen capture program) to record real-time interactions and a Sony camera to capture mouse movements and keyboard interactions. The data analysis involved two stages: the first generated a dataset using multimodal social semiotic theory, and the second was a transposition of theory to examine the pupils' designs for learning.

Generating and framing the data

Stage one

The first stage of the analysis involved four steps. First, pupils' verbal communication was filtered out by viewing video data with and without sound and images and identifying non-verbal instances lasting more than ten seconds. Second, maps were created by examining these instances to answer design questions about timing, duration, who prompted whom, standout moments of the interaction, compositional equipment used, and modes represented in the interactions. Third, the pupils' preceding modal prompt was analysed to identify the dominant mode or combination of modes from verbal, action, pointing, gesture, gaze, facial expressions, computer sounds, or body movements. Finally, the data for each of the four lessons was documented, as shown in Figure 1.

From the initial stage, seven modes (verbal communication, actions, mouse pointing or gestures, gaze, facial expressions, sounds, and body movements or positioning) were identified as representative and available as modal prompts. These modes helped differentiate various types of non-verbal communication. Their prominence guided the selection criteria for choosing 16 episodes to analyse as categories for interpretation in the second mapping process.

Stage two

The second stage of the analysis operationalised Bezemer and Kress (2016) principles of recontextualization: framing, selection, arrangement, and foregrounding, to map 16 instances of non-verbal communication for in-depth analysis. Each principle had a specific focus:

Framing. – identified all instances of non-verbal communication and mapped the modes and resources of modes available for communication in one-second intervals. The framing of each episode was established in stage one, where information about the preceding modal prompt arose, either within the interaction between the pupils or through the teacher's instructions.

Selection. – involved a series of design questions considering:
   What objects or artefacts were used for composition?
   Which modes were foregrounded?
   How did the modes interact?
   Were there any patterns?
   What was communicated?

Arrangement. – organised the mapping of pupils' resources to illustrate their compositional choices.

Instance	Start time in minutes and seconds	Time Ends	Duration in seconds	Preceding Modal Prompt	Description of Episode
1	01:55	02:06	11	**Teacher's verbal instructions:** (***remember I want to see what scale you're going for***) repeated twice Student One (Alex) movement and speech (*we need a bass or something to start off . so basically*) Student Two (Ollie) action keyboard	Pupils settling down Teacher continues with verbal instructions
2	02:41	03:01	20	Alex **notation** Ollie speech; gaze and **notating on worksheet** (*key A to A*)	Notating the key signature and Alex plays the scale on keyboard
3	03:22	03:40	18	**Teacher's verbal response + gesture to Alex question** (*the triads I'm just putting on the board*) Alex (*oh okay*) + turning movement **Ollie aural + action**	Alex continuation of notation on worksheet + gaze at board. Ollie gazes across room then plays keyboard

Figure 1. Stage One. Partial lesson map of instances of non-verbal communication.

Preceding Modal Prompt [Lesson 1 Episode 11]

Ollie gesture; **gaze + speech** (*put your headphones in*)

Time	Integrated Webcam	Side Camera	Action	Pointing/ gesture	Gaze	Facial expression	Body Movement and/or position	Sound from computer
12:57 (19)			Alex putting headphones on	Ollie's hands are over the keys on the keyboard	Ollie looks towards his partner		Ollie sits close to the desk, positioned slightly in front of Alex	Ollie headphones on
12:58			Ollie plays the keyboard	Ollie turns head to his right	Ollie focuses on his hands on the keyboard; Alex looks downwards at Ollie's hands		Alex leans to his left; head positioned to see Ollie play the keyboard	Both have headphones on

Figure 2. Stage Two. Partial representation of the mapping of resources available for communication.

Foregrounding. – identified which modes were more prominent than others within the mapping process by questioning any commonalities amongst instances and noting any modes and resources of modes that were missed or represented differently.

Multimodal theory recognises that some instances of communication may be prompted by multiple modes occurring simultaneously, and for analytical purposes, all these modes are important (Bezemer and Kress 2016). This means that the prompts identified in stage one (verbal communication, actions, mouse pointing or gestures, gaze, facial expressions, sounds, and body movements or positioning) remained relevant in the second stage. This approach ensured a systematic and comprehensive analysis of non-verbal communication in each of the selected instances of non-verbal communication.

Figure 2 shows the mapping of the resources available for communication from Lesson One Episode Eleven. For orientation, Ollie is seated on the left side of the picture, while Alex is on the right. This map is a partial representation of the eleventh instance of non-verbal communication or as indicated at the top, in bold, [**Lesson 1 Episode 11**]. This information served as a framing device for the episode's sequence within the first lesson. Each map displayed the available modes and highlighted the pupils' choices and selections that informed their meaning-making. In the mapping, I highlighted the preceding modal prompts (i.e. two to three seconds before speech paused) in bold font and indicated who prompted whom. For example, in Figure 2, Ollie prompted Alex through gaze and speech with the instruction 'put your headphones in.' Other framing devices included a time identifier in seconds, which showed the episode's position in comparison to the overall lesson – 12 min and 57 s. The next two columns focused on the available visual data, with two screenshots taken from Camtasia at one-second intervals. These screenshots visually represent the pupils at the computer workstation. Specific data from the computer's integrated camera captured the pupils sitting at and in front of the workstation, while a small camera provided a side view of the pupils and the equipment. The remaining six columns are labelled with the modes (from stage one) for interpretation and analysis.

Findings

This section provides an overview of the findings from the 16 instances of non-verbal communication. A full version of my doctoral findings, which would be difficult to summarise here, can be found through the University's ResearchSPAce.

Understanding the pupils' designs for learning involved 'uncovering and describing the transformations of resources' (Bezemer and Kress 2016, 38). The pupils' transformations of resources encompassed numerous ensembles and configurations of modes, highlighting their compositional intentions and an awareness of design for learning. Each transformation was complex and ongoing, made visible through their signs of engagement and interest, control and agency and negotiation.

Engagement and interest

Pupils demonstrated signs of engagement and interest that influenced the development of their composition. However, this depended on whether they engaged with each other's signs and prompts or ignored them, and whether they were self-driven or dependent on each other's signs to acquire knowledge or skills. For example, Alex sat close to the desk, leaned forward to play the keyboard and gazed at his hands as he experimented with different melodies for a character motif. He did not direct his gaze towards Ollie, nor did he gesture or move his body position to invite Ollie to share the experience. In contrast, Ollie's engagement was often shown by him sitting further back in his seat, usually positioned slightly behind Alex, watching his partner's hands or the monitor and listening to the computer-generated sound. Although seemingly doing nothing towards the composition, this behaviour showed a more vulnerable side to Ollie and provided an indication as to his level of musical understanding.

The analysis also highlighted how pupils' lack of response to non-verbal prompts, such as gaze and actions, can indicate disengagement. For example, Alex used eye contact and gestures to signal to Ollie to stop playing the keyboard while Alex tried out chords. Ollie chose to ignore this signal and took three seconds to understand Alex's next glance. Alex ignored Ollie's non-verbal attempts to communicate a further five times. Ollie tried different prompts, such as removing his hands from the keyboard and gazing at Alex to get his attention or stopping the playback to point out a specific issue in the composition. Although Alex disregarded these non-verbal communications, Ollie remained engaged and continued to show his interest in the composition. Additionally, Alex ignored Ollie's contributions by physically removing his hand from the mouse and keyboard, which is discussed as a sign of control. When the pupils ignored each other's prompts, this was viewed as a failed attempt at non-verbal communication, understood as being purposefully enacted. These situations suggest that pupils were following their independent interests, which can lead to questions about whether younger pupils in Key Stage 3 might prefer working independently, akin to their peers in Key Stages 4 and 5 (Devaney 2019; Savage 2010).

The choices and orchestration of modes (gaze, body positioning, gesture, and action) were often strong indicators of a pupil's motivation and active involvement in learning. Unfortunately, this self-driven approach overshadowed collaborative learning and hindered communication with Ollie.

Control and agency

Three distinct signs of control were identified:

Who decided on the musical content of the composition.
Who physically controlled the equipment, i.e. computer mouse and the MIDI keyboard.
How pupils used non-verbal behaviours to control the actions and attention of others.

These signs of control are interconnected. For example, a pupil might initiate an action, control the equipment, and use non-verbal prompts to communicate their idea to another pupil. While both Alex and Ollie participated in the learning process, their different approaches, such as signalling their intention, guiding attention, and asserting dominance, led to varied musical understandings. This underscores the multifaceted nature and complexity of non-verbal communication and its impact on learning.

As with other studies (e.g. Breeze 2011; Gall and Breeze 2008), non-verbal communication, such as pointing at the computer screen and maintaining eye contact with a partner, effectively communicated musical intentions and drew attention to compositional decisions. Alex's positioning close to the desk, along with his non-verbal communication, such as a forward-leaning body posture with his gaze following his hand gestures, demonstrated his control over the musical composition. The orchestration of body movements, gestures, and gaze effectively conveyed his intent and focus on the musical content.

In four episodes, Alex gained control of the mouse by moving his arm over Ollie's hand and, in the same way, controlled the MIDI keyboard. The orchestrated modes of action and gaze suggested a focus on adding to the composition, such as using the mouse to activate the record function or replaying a section while adding chords. Prior studies (Breeze 2011, 400; Haviland 2011) recognised pupils 'static seating positions', but this was not the primary interpretation of this particular non-verbal communication. Alex's orchestration of modes consistently led to him making the musical decisions regarding the composition's content. However, exerting control was intended to halt others' actions with input devices (mouse, MIDI, or QWERTY keyboard) rather than as an indicator of adding to the composition. Here, the resources of modes for gesture and gaze or action and gaze (e.g. stared intensely or exaggerated arm movements) were explicitly foregrounded as a display of control.

The last example highlights Alex's behaviour, which was interpreted as him asserting his dominance over Ollie. Ollie invited Alex to listen to him play the keyboard, but Alex responded by removing his headphones and moving away, laughing. The analysis of subsequent lessons showed that Ollie did not significantly contribute to the musical composition, highlighting a gap in his engagement and participation. This situation provided insights into how these non-verbal communications can be understood and used in the music classroom to recognise and address gaps in pupils' knowledge and engagement.

Negotiation

The pupils' mutual and fragmented agreements, along with task distribution, were clear signs of negotiation that contributed to shaping the overall outcome of their work. Similar to Breeze (2011) and Poulsen and Kvåle (2018), technology and software familiarity influenced their communication choices, but the pupils' relationships and understanding of specific features, such as musical quantisation significantly impacted learning. Negotiation and decision-making skills became visible when the pupils' foregrounded modes of gaze and gesture (embodied) with text layout (disembodied), which evidenced both, mutual and fragmented agreements. When pupils shared similar interests, their non-verbal cues, such as gaze and musical sound often established mutual agreements. However, misinterpretations of non-verbal communication adversely affected Alex and Ollie's collaboration and work.

Transformation of resources

From a multimodal social semiotic perspective, learning is evidenced through the process of transformations of resources (Bezemer and Kress 2016; Kress et al. 2021). Examining how the non-verbal modes of communication were chosen, used and transformed in the pupils' computer-based compositional work evidenced musical, social and technical learning. The analysis found that learning

was either immediate with quick responses and adaptations (short transformations of resources) or involved more depth and complexity of engagement (multiple transformations of resources).

The short transformation of resources generally occurred over a few seconds. They supported the pupils' decision-making and musical learning, in which pupils made confident decisions and took instant actions, such as creating a new track or stopping the composition playback at a specific point. For example, Alex often prompted Ollie to engage with a task in GarageBand by pointing at the monitor and redirecting his stare. In response to the prompt, Ollie orchestrated the modes of action (selected a piano sound using the mouse) and gazed as he navigated the software. This transformed into action as he played the MIDI keyboard, and his gaze focused on his hand movements. Here, we can understand how quickly Ollie adapted his approach to learning through the transformation of resources and how he engaged in the task. Even changes in body posture or positioning, such as Ollie shifting from an angled to upright seating position to signal engagement and interest contributed to understanding the pupils' learning.

In summary, short transformations of resources showed that musical learning was developed through active listening skills, replication and imitation of keyboard playing, spontaneous decision-making and experimentation with sounds and musical structures. Social learning involved collaboration and peer interaction, as pupils invited and responded to each other's ideas. Technical learning was shown through quick interactions with the computer-based technology, such as physical changes with gaze or gestures in mouse movement, changes in body movements or facial expressions upon hearing sound and general navigation of the software interface.

Contrastingly, multiple transformations of resources were both irregular and continuous during an episode and showed how pupils worked through musical problems before arriving at a resolution. Their choices and orchestration of modes likely supported their learning but also contributed something towards the composition. For example, in Lesson Two Episode Six, Alex started by leaning on the desk with his head hanging low and his hand covering his eyes. This transformed into the modes of body positioning, unfocused gaze and different hand gestures to convey his uncertainty as he looked around the classroom. Then, he returned to sit upright, redirected his gaze at the monitor and extended his right arm across to reach the mouse, showing confidence and readiness to action a decision.

Another example of multiple transformations of resources evidenced Alex's deep concentration; highlighted by his physical demeanour, movements and steady gaze. He positioned both elbows on the table, supported his head with a clenched hand, and covered his mouth. Then his posture, leaned forward towards the computer screen, along with his unwavering stare. This orchestration of modes suggests a significant degree of attentiveness and thought, providing a multimodal interpretation of the pupils' concentration and meaning-making.

Musical learning was found in multiple transformations of resources, for example were evidenced through extended focus and problem-solving skills as pupils explored melodic ideas, chordal sequences, sound placement and structuring of musical elements over time. Social learning was reflected in how pupils' ignored distractions, assessed the quality of their composition and made structural refinements, and balanced individual choices while navigating peer input. Technical learning was demonstrated through how the pupils' non-verbal modes of communication helped them to use the computer-based technology to refine musical ideas and organise elements within the composition to create a coherent piece.

Discussion

The study is positioned at the intersection of music education and multimodal communication and draws on selected concepts, such as transformation of resources and design for learning from Bezemer and Kress (2016) multimodal social semiotic theory of communication and learning. While it contributes to both research fields, I will discuss how operationalising a multimodal social semiotic

approach can examine pupils' non-verbal 'silent' communication in Key Stage 3 computer-based compositional work and make their learning visible.

Applying the concept of transformation of resources and the principles of recontextualization (Bezemer and Kress 2016), as interpretative tools enabled the theorisation of the pupils learning. This approach is consistent with recent developments in multimodal social semiotics that emphasises the construction of meaning through media, modes and resources of modes (Diamantopoulou and Florén 2025). To understand what pupils learned, it was important to use framing, selection, arrangement, and foregrounding (principles of recontextualization). These principles enabled the re-shaping of their semiotic work and communications. The analysis mapped the pupils' multimodal processes in 16 instances of non-verbal communication, showing how various modes and resources of modes were orchestrated to transform and inform the pupils learning. These transformations, based on pupils' signs of learning (engagement and interest, control and agency, and negotiation), played a significant role in making the pupils' semiotic work visible. This represents an instantiation of learning.

To recap, there were two stages in the process of generating and framing the data, with each stage addressing different design questions yet maintaining the same consistency of being theoretically informed by multimodal social semiotic theory (Bezemer and Kress 2016). In this way, the methodological process became a robust foundation in which to explore non-verbal communication. The first stage operationalised multimodal social semiotic theory in which transcripts mapped the pupils' work for each lesson. The pupils' interactions shifted from video to map representations, and it was my responsibility to create a transcript that accurately reflected their social meaning-making practices. This involved reshaping their semiotic work and interpreting their meaning-making process. At this stage, several key design questions were addressed to substantiate the methodology, including how to effectively filter out speech, identify who prompted whom, and document the data using Bezemer and Kress (2016) principles of recontextualization. Each lesson's map provided an overview of the availability of instances of non-verbal communication, made visible the available modes and resources of modes that supported selection choices for further in-depth analysis. Thereby, the first stage implemented the theory and was crucial to create the data set. This approach aligns with recent developments in multimodal social semiotics (Diamantopoulou and Florén 2025), showing how meaning can be shaped by the orchestration of media, modes and resources of modes.

In the second stage, once the modes and resources of modes were mapped, the analysis identified how the pupils' transformed their resources by highlighting which modes and resources of modes were foregrounded in their non-verbal communication. Each mode presented in the mapping has resources that support the materiality of the pupils' communication, such as the mode of gaze with its resources of intensity or directionality. In addition, the organisation of the mapping of pupils' resources available for communication, according to Bezemer and Kress (2016, 77), principles of recontextualization, specifically highlights that arrangement represents meaning. The arrangement was useful to illustrate and make visible the pupils' choices during their compositional work. This approach aligns with theoretical assumptions of multimodality, suggesting that examining each mode can lead to identifying the meanings being made (Bezemer and Kress 2016). This results in creating new ways of showing what they may understand or learn and forms Bezemer and Kress (2016) concept of *signs of learning*. Diamantopoulou and Florén's (2025: 3) conceptualisation of media, such as computer screens and software features like quantisation, provides insights that reinforce the dynamic nature of pupils' non-verbal communication observed in this study. As mapped through video and transcript representations, the orchestration of modes and resources of modes reflects how pupils' meaning-making practices are shaped by the technologies available to them. This perspective complements the principles of transformation and recontextualization (Bezemer and Kress 2016) and supports the interpretation that pupils' non-verbal communication is not only shaped by social interaction but also by the technological tools they engage with. Multimodal social semiotics examines how different modes (e.g. action and gaze) create meaning and

communication, such as ceasing to play the keyboard combined with a prolonged gaze, which prompted non-verbal communication. The participants' meanings materialised through prompts in which each sign showed learning (Bezemer and Kress 2016, 3).

Similar to previous studies (Bezemer and Kress 2016; Breeze 2008; Nijs and Bremmer 2019; Pramling and Wallerstedt 2009) learning materialised when there was a change in the pupils' resources of modes. However, the focus of their studies often emphasised speech. In this study, even when speech was absent, short and multiple transformations evidenced different signs of learning. For example, when working in pairs and one pupil put on headphones (a prompt), it signalled to the other pupil that something was about to happen. The nature of that event was often determined by a further combination of modes. If the same pupil then chose to play the keyboard, meaning was brought to life demonstrating learning. Thereby, as researchers and educators, we can hypothetically recover meanings through instances of non-verbal communication, selected modes, and the resources of modes, as all modes contribute to meaning (Bezemer and Kress 2016; Kress 2010).

Conclusions

This article builds on existing literature while providing valuable insights into the role of non-verbal communication in computer-based music composition and learning. It specifically highlights the significance of two pupils' non-verbal communication emphasising their choices and decisions of modes and their resources of modes, concentration levels, musical and technical knowledge, how they engaged in the compositional tasks and resolved challenges. The analysis confirmed that different signs of learning (engagement and interest, control and agency and negotiation) and transformation of resources illustrate the complexity involved in examining how non-verbal communication evidenced learning. In this study, the analysis further showed whether pupils preferred to work independently or leave the compositional content to someone more knowledgeable. This particular finding raises questions about the suitability of paired work with younger pupils in Key Stage 3 or whether they might prefer to work independently.

While this article addresses one small part of my doctoral study, it offers a practical solution using Camtasia software and a small camera to capture pupils' selection of non-verbal modes of communication and resources of modes that are often overlooked in learning. The study's methods, based on multimodal social semiotic theory and principles of recontextualization (Bezemer and Kress 2016), legitimised the pupils' semiotic work and could influence how teachers define or examine learning in computer-based composition. Using Camtasia and selected concepts from multimodal social semiotic theory to generate and frame data has potential in future research methodologies, one that provides a robust and comprehensive understanding of how non-verbal communications materialise and transform in learning.

I recommend further research with a number of participants, different instances of non-verbal communication, or different pupil pairings to see if they could yield valuable comparisons and additional insights.

Disclosure statement

Notes on contributor

Julie Byrne has recently completed her PhD in Education at Bath Spa University and works as a learning support assistant at Southampton University. Her research focuses on non-verbal communication during pupils' computer-based music composition, using a multimodal social semiotic theory of communication and learning to understand how learning materialises. Julie has a background as a primary and secondary school teacher, specialising in music.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author, [JB]. The data are not publicly available due to [restrictions e.g. their containing information that could compromise the privacy of research participants].

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