Visual Concretization of Musical Concepts as Applied by Engineers: A Case Study

Johanna Maria Roels[1], Peter Van Petegem[2]

University of Antwerp, Department of Training and Education Sciences, Belgium[1,2]

Abstract

Brain research has shown that vision is our most dominant sense and that more information is absorbed visually than through any of the other senses. How visual techniques may contribute to developing musical skills is an area that remains largely unexplored. The current case reports on how two engineers – students from my piano class - integrated cognitive *visual strategies to handle musical complexities. Their approach illustrates how engineering knowledge and skills can be applied to creating music and comprehending musical concepts. This study indicates that our neural networks can be trained to become more sophisticated and foster the intellectual capacity to solve musical intricacies. In addition, we also suggests that music teachers may benefit from the problem-solving attitude and visual thinking abilities of engineers as a valuable transdisciplinary input to find solutions to specific problems.*

Keywords*: brain research, engineers, keyboard, music, visual learning.*

Introduction

There is still a great deal to discover about the learning styles of engineers (Baukal & Ausburn, 2016). However, doubts have been expressed by some researchers (Ansari *et al*., 2012) regarding the existence of learning styles or the notion that some individuals are better auditory learners while others may excel if material is presented visually or kinesthetically. Nevertheless, brain research suggests that vision is by far our most dominant sense and that we absorb more information visually than through any of the other senses (Baukal & Ausburn, 2016; Felder & Silverman, 1988; Wolfe, 2010).Visualizers tend to think concretely and personalize information (Jonassen & Grabowski, 1993), and therefore prefer learning tasks such as mechanical drawing, measuring and estimating visual distances or relationships, and using learning strategies such as mnemonics. Regarding the latter, mnemonics are based on the principle that the brain is a pattern-seeking device, always looking for associations between the information it receives and the information it has already stored (Wolfe, 2010). One of the conclusions drawn by Baukal and Ausburn (2016) concerning the verbal-visual learning preferences of engineers working in the industrial combustion industry is that working engineers may have a strongly visual cognitive style. Therefore, high visibility of learning environments enhance engineering education. Felder and Silverman (1988) suggest that both visual and auditory learning involve the component of the learning process in which information is perceived, while kinesthetic learning involves both information perception (touching, tasting, smelling) and information processing (moving, relating, doing something active while learning). Regarding engineering education, they suggest to focus on visual and auditory learning as the perception-related aspects of kinesthetic learning are only marginally relevant at best. The extent to which engineers prefer visual over auditory and kinesthetic learning when developing musical skills is an area that has been largely unexplored. In this study we will focus on visual strategies.

2. Research question

What is the rationale for engineers to implement visual strategies in comprehending and creating music?

2.1 Background

Over more than thirty years of piano teaching practice I have had many adults in my class. Among them have been a few engineers such as Richard and Hans. Richard, aged 58, is an engineer in electro-mechanics and electronics. He works for Assa Abloy Belgium as a Product Manager Benelux Access Control. Hans, aged 49, is an engineer in computer technics. He works as a solution architect for Telecom, Nokia Networks.

Richard and Hans exhibited a way of learning that was different from that of other students, something so remarkable that it encouraged me to study their underlying thoughts and actions. One of their notable learning characteristics is that they integrated visual strategies that originated from technical thinking and drawing in engineering. Due to the abstract nature of music, they often struggled with problems involving decoding scores, composing, noting down, and understanding music theory. Conditioned by their education they tried to solve these problems by visualizing electromechanical principles, integrating colors and experimenting with 'visual' notation. I wish to thank Richard and Hans for their generous efforts to provide me with the data.

3. Methodology and analysis

This research was conducted in the real-life context of my piano class. The inventions of Richard and Hans were not generated through specific tasks within a predefined time limit; instead, they emerged from within a context of dialogue and mutual empathy. In line with the phenomenological approach, this study utilizes a double hermeneutic in that the researcher intends to make sense of the participant's experience in trying to make sense of what is happening to them (Smith *et al.*, 2009). Phenomenological research is idiographic. It involves an in-depth exploration of the personal experiences of only a few participants; in this case, Richard and Hans, who both experienced the same phenomena (Smith *et al.*, 2009). Following the suggestions of Van Manen (1990), the results will be presented in form of a dialogue including descriptive and interpretative aspects offered by Richard, Hans and myself. This approach allows me to speak directly to the reader and to share insights. In addition, complicated coding procedures and specific pre-determined analytical models can be avoided. The latter might, indeed, impose serious limitations on the original data (Johnson and Onwuegbuzie (2004).

4. Results

Richard and Hans explain that engineers are strong in 'pattern recognition' and that their problem-solving thinking is to make the complexity of nature comprehensible through mathematical laws and visualizations.

4.1 Decoding existing scores, noting down own music, and the use of colors

T: Why do you need colors when decoding scores?

R: I'm used to thinking in terms of coordinate systems consisting of a horizontal and vertical axis as well as to start counting from the intersection of these axes; the origin or zero. For example, in the decimal number system +5 and – 5 are listed on the same line opposite the zero point (fig. 1). In the graphical representation of the traditional music notation I miss this reference point, in both treble and bass clef. It's not clear to me opposite which value pitches are placed. If I would create a zero (a do-line) then +5 refers to sol (treble clef) and -5 to fa (bass clef) - based on the seven - number system (seven notes on the white keys). On the same line, opposite the zero, we find both two different written notes and two different sounding tones (fig. 1). By introducing colors, I created 1 code for 1 note, irrespective of whether the note is written between or on the line, irrespective of whether the note is preceded by an accidental. Color has become my reference point; color notation has substituted my zero notation (fig. 2).

Figure 1 Axes - Zero notation versus a do-line

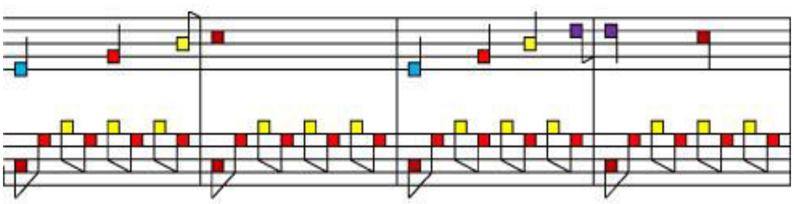


Figure 2. Color notation

T: Hans, how do you read a score?
H: Reading notes fluently is a problem, as I started with it later in life. My feeling is that the visual difference between treble and bass clef creates a kind of dyslexia by which
none of these can be read easily. As I am skilled in recognizing patterns, it is the patterns or figures - and not the individual notes - which help me during decoding, rehearsing and memorizing a score.
T: Does recognizing patterns happen in a mainly visual way or is it also auditory?
H: Difficult to say, mainly visual, but I think I recognize the patterns as also auditory.
T: Dyslexia, comparable to Richard's problem with 'axes'?
H: Indeed, it would be much more logical if the same notes were noted on the same line in both treble and bass clef.

4.2 Composition 'Toggling Flow' and the visualization of electromechanical principles

(Richard, aged 58)
Richard wanted to compose music with a flowing character. He presented the flowing movement of his bass as 'sinusoid' and pressing down the keys of the melody as 'toggling'. After discussing some possible starting points, Richard chooses a few chords, a four-bar pattern, and then states that he needs axes: R: "For this composition, I think from two coordinate systems; one for the input (voltage) and one for the output (current). The input stands for the cause in function of time and the output for the effect in function of time. Voltage and current change in function of time. Analogously I start, musically, from two timelines in which the input represents the bass

and the output the melody. The change of quantities in function of time can be seen as the change of pitch in function of time." Richard then presents his bass and adds: "I started from the term **Sinusoid** (Fig. 3). Vertical (voltage in Volts) and horizontal (vibration frequency in Hertz) intervals of the sinusoid are constants. Musically, we can compare the voltage with the pitch whereby intervals are repeated and the frequency with the duration of time whereby the bass motif is repeated every measure. There is always voltage – current which musically represents a constant fluid motion without interruption in the sound."

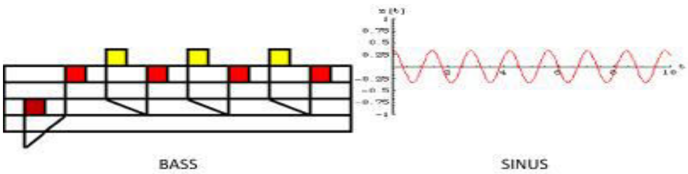


Figure 3 Sinusoid

In developing the melody Richard uses more principles such as toggling. He explains: "**Toggling** (Fig. 4) refers to pressing down the keys: the tone of a pressed key lasts as long as the next key is pressed down. When the tone of one key disappears, the new tone sounds. Thus, there is always tone. You can compare it with a bi-functional switch whereby (by pressing the button) the light from one bulb is turned off while simultaneously from the other bulb is turned on. Thus, there is always light. On-off in a constant motion-timeline."

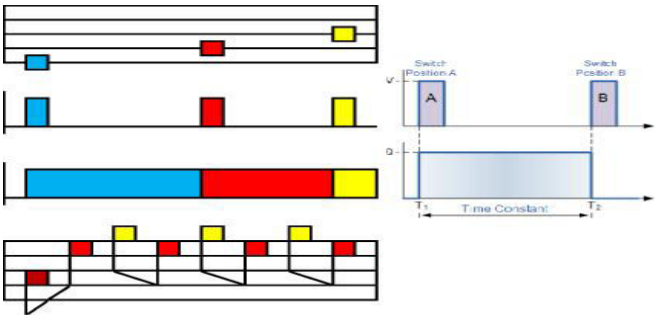
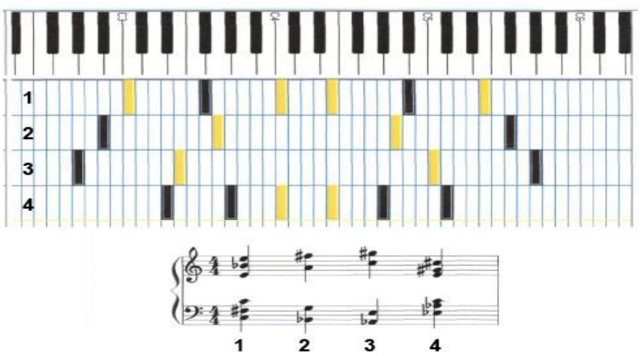


Figure 4 Toggling

T: Toggling, does it happen intuitively or rather intellectually?
R: Toggling opposite the sinus is variable and usually happens intuitively; for example, start the sentences with 'upbeat' or 'on the beat', and in the formation of sequences.
R: Both toggling and sinusoid create a certain unrest. Nevertheless, the piece sounds restful.

T: Do you experience this duality of restfulness and unrest from the interaction between the toggle and sinus?
R: No, from sinus and toggling separately; the observation of two layers at the same time is too complex.
T: Suppose, in a new composition, you anyway wanted to shorten the tone length, how would you note it? Could you visualize it by adding a new symbol?
R: I'll probably switch to the traditional notation form.

4.3 Visualization of a 'mirror-pattern' (Hans, aged 45)
Hans' task is to compose a **'mirror-piece'** based on the structure of the keyboard. He starts with four chords and looks for a notation (fig. 5).



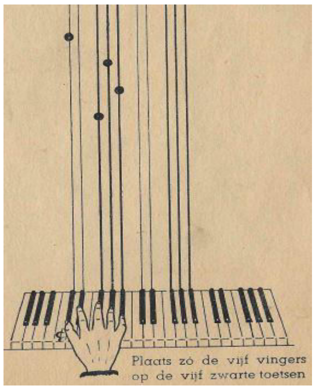


Figure 5 Mirror-notation

Figure 6 Klavarskribo (Music book, Slikkeveer- Rotterdam, s.d.)

T: Why did you design this score?
H: In an attempt to find another way to read more fluently. It is an experiment with visual representation (by using the software Anvil Studio), based on the piano roll of the former mechanical pianola which works with a punch card book (barrel organ).
T: *Your score is comparable to* ***Klavarskribo*** (Fig. 6), *did you know this?*
H: No. Cool, it looks similar.

5. Conclusion
According to Jonassen and Grabowski (1993), engineers are visual learners who think more concretely, personalize information, and use strategies such as mechanical drawing, measuring visual relationships, and mnemonics. In our case study, Richard and Hans created their own image mnemonics so that they could absorb and memorize musical information. Wolfe (2010) states that the brain is a pattern-seeking device, always looking for associations between the information it receives and the information it has already stored. Richard and Hans spontaneously made associations between stored information, knowledge from engineering, and the new musical information they received. Another aspect of engineering education, emphasized by Felder and Silverman (1988), is that the perception-related aspects of kinesthetic learning are marginally relevant at best. When playing the piano the kinesthetic factor is dominant.
Conversely, in engineering the visual factor is dominant (Baukal & Ausburn, 2016). Richard and Hans created extra-visual data to develop kinesthetic skills, something most adult pupils do not need as they are able to link the kinesthetic to the auditory sufficiently well. The extra-visual data created by Richard and Hans include representations which refer to *Klavarskribo* (Berylia, 2014). Cornelis Pot who was disciplined in electro-mechanics developed this system as an accessible alternative to traditional music notation. Specific to *Klavarskribo* is that it is read vertically as a *direct visual representation* of the keys of the piano. It is also based on a 'time-proportional note placement' where the touch-moment of a key is indicated. The stop time of a tone must be understood from certain symbols. Pot's vision was 'to achieve extreme simplicity by strict logic'. Neither Richard nor Hans knew the *Klavarskribo.* Nevertheless, their inventions show similar features and they contribute to Pot's vision. By 'toggling', Richard has visualized the moment the tone sounds. The tone length must therefore be understood from his code-notation. Hans abstracted from a punch card book and designed a vertical

score with a visual representation of the keys he has to touch. Baukal and Ausburn (2016) noted that engineers appear to prefer visual content to a greater degree than the general population and ask what can be done to reach students whose learning styles are not addressed by standard methods of engineering education. To make learning more effective for these students, changes need to be made to the program. In the same way, we can also ask what can be done to reach students such as Richard and Hans, whose learning styles are not fully addressed by standard methods of music education. One change that could be made in music-pedagogical thinking would be to involve engineers in designing music-didactical toys to help pupils with specific problems such as dyslexia – as Richard and Hans have explained that they themselves had a 'dyslexia-experience'. The visual dimension can be a medium that helps to elicit and link previously acquired musical and non-musical knowledge and skills. This, in turn, can facilitate the absorption of new knowledge and the development of new skills. It can be the 'impetus' that accelerates the process of giving 'musical gestalt' to an inner concept.

References

[1] Ansari, D., De Smedt, B., & Grabner, R.H. "Neuroeducation – A Critical Overview of An Emerging Field*", Neuroethics,* 5, 2012, pp.105–117

[2] Baukel, C.E., & Ausburn, L.J. "Verbal-visual preferences of working engineers", *European Journal of Engineering Education,* 41 (6), 2018, pp. 660-677

[3] Berylia. "The Klavarskribo documentary part 1", 2014, August 31, Retrieved from https://www.youtube.com/watch?v=efTv05nWNhk

[4] Felder, R.M., & Silverman, L.K. "Learning and Teaching Styles in Engineering Education", *Engineering Education,* 78 (7), 1988, pp. 674–681

[5] Johnson, B. R., & Onwuegbuzie, A.J. "Mixed Methods Research: A Research Paradigm Whose Time Has Come", *Educational Researcher,* 33 (7), 2004, pp.14-26

[6] Jonassen, D. H., & Grabowski, B. L. "*Handbook of Individual Differences, Learning, and Instruction",* Hillsdale, NJ, Lawrence Erlbaum, 1993

[7] Smith, J. A., Flower, P., & Larkin, M. "*Interpretative phenomenological analysis: Theory, method and research",* London, UK, Sage, 2009

[8] Van Manen, M. "*Researching Lived Experience: Human Science for an Action Sensitive Pedagogy",* Ontario, Althouse,1990

[9] Wolfe, P. "*Brain Matters: Translating Research into Classroom Practice.* 2nd ed.", Alexandria, VA, ASCD, 2010