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Holistic education – a model based on three pillars from cognitive science. An example from science education

*A teacher takes a hand, opens a mind,
and touches a heart.*

Author unknown

Summary

In this conceptual article we present a modular model of holistic education. Within this approach, an educational activity (and a child's learning that derives from it) can be characterized in three dimensions: 1) safety, inclusion and participation; 2) interaction, cognition and representation; and 3) affective action leading to imagination and creativity. A holistic approach nurturing the full cognitive development of a child requires going beyond what a conventional school offers, but still presumes designed but liberating processes. We provide a neurobiological argument for holistic education supported by evidence for the featured three dimensions of holistic education along with illustrative examples.

Keywords: holistic education, neural networks, dimensions of holistic education – sensibility, functionality, rationality

Słowa kluczowe: edukacja holistyczna, sieci neuronowe, wymiary edukacji holistycznej – wrażliwość, funkcjonalność, racjonalność

Introduction

Learning is a complex process of constructing knowledge, an act that takes place at the interplay between personal experience in the perceived environment, discipline-based subject matter, internal reflection and social discourse. In order to construct own knowledge, in any meaningful sense, a child needs to process information. Such information processing involves the dynamic interplay of neural networks, including three that have

been extensively investigated: the fronto-parietal central executive network (CEN), the cingulo-opercular salience network (SN), and the medial prefrontal-medial parietal default mode network (DMN) (Chen et al. 2013). Learning can be thought of as a cognitive process that involves physical as well as social and emotional operations in a child's environment. The holistic approach to this complex process requires consideration of a broader perspective including achievements from cognitive sciences. In this article we present a **modular model of holistic education**, which is rooted in cognitive science.

We will provide arguments for the idea that the child's full cognitive, emotional and personality development consists of three elements, namely three worlds:

- the internal world – which is connected to the development of the sphere of security, engagement and participation, the social brain – as the most important area. The major question that is asked here is: what can we do to avoid exclusion, to attain participation, acceptance and inclusion. This is more than the idea of no child left behind; it is the idea of **inclusive education** as a fundamental, starting point.
- the external world – which is intensively researched by pedagogy, science education research and other disciplines. This world is where the learner seeks social interactions and epistemological objects that are interesting, engaging or attractive. This is where the teacher can find ideas for **good educational practices** such as problem solving, investigation, drawings, multiple representations, where all modern educational methods exist, and where it is possible to organize teamwork and identify creative affordances and cognitive tools. The major question that is asked here is – what frames the learner's experience and what can the school do to facilitate learning?
- the world of **imagination and internal values**, which refers to **axiological ideas**. Values are perceived as an integral part of the cognitive system and the mode of brain. For example, six fundamental values guide a large part of human behaviour: care, fairness, loyalty, authority, sanctity, and liberty. Jonathan Haidt (2012) claims that these six values are responsible for our decisions, questioning the economic analysis of costs and benefits (Ariely 2013). These values are thought to be crucial for the process of seeking meaning, striving for growth and self-formation. The major question that is asked here is – How can we find fulfilment in being novel and original and what can school do to facilitate students operating the “flow” stage and being reflective as well as creative human beings?

This article is conceptual, based on a meta-synthesis of existing literature. This work is the result of an analytical and synthetic review of the research literature from cognitive science and science education research. The cognitive and utilitarian purposes of the presented analysis and synthesis was to find the answer to the question: how can we conceptualize a holistic approach to education and what are its implications for nurturing the self-fulfilling development of each child.

Holistic education

The notion of holistic education is not new. Work on the importance of holistic education dates back at least to Pestalozzi, Thoreau, Dewey or Montessori. Ron Miller (2000) stressed in his *Introduction to holistic education* that “the education of young human beings should involve much more than simply moulding them into future workers or citizens”. All these great educators agreed that education should be understood as the art of enlightening every facet of the developing child including ethical, emotional, physical, psychological and spiritual. This initial claim is crucial, very wide and demands an interdisciplinary approach.

In a conventional educational system many of the priorities are determined by important ideas on how to present content, how to prioritize theory with respect to practice and how to connect the two, how to approach thinking about curriculum design, lesson design, assessment and accountability.

John Dewey identified the ensuing problem by writing: “A divided world, a world whose parts and aspects do not hang together, is at once a sign and a cause of a divided personality. When the splitting up reaches a certain point we call the person insane. A fully integrated personality, on the other hand, exists only when successive experiences are integrated with one another. It can be built up only as a world of related objects is constructed” (Dewey 1963: 44).

For Dewey it was of paramount importance, above anything else, that we need to develop an appreciation of how things are interconnected as necessary interdependencies from which to derive meaning for ourselves and our students. This highlights the value of linking theory and practice. From the perspective of a holistic modular approach, this is the second element. We would like to broaden the perspective of perceiving what holistic education is. Holistic education posits that educational design and lesson planning need to draw on three dimensions:

1. Sensibility (referring to those features of the design of a lesson and educational environment that serve to create a sense of welcoming comfort, safety, homeostasis and the motivation to participate actively). The element of holistic education related to the internal world is located here.
2. Functionality (features of the lesson that scaffold social interactions, discourse, cognitive processes and sense-making). The element of holistic education related to the external world is located here.
3. Rationality (referring to the facility of learners to reflect on six values – care, fairness, loyalty, authority, sanctity, and liberty – and how they relate to the elements present in each lesson or in a unit as a coherent sequence of lessons).

Complex cognitive processes, which cover many aspects of our being and feeling in the world from a sense of safety, acceptance and participation to the level of critical or creative thinking, are realized by disperse neuronal networks that can integrate different parts of the brain located in various lobes (Bressler, Menon 2010). These networks

undergo dynamic processes of activation and deactivation depending on: 1) the state in which the body is in; 2) the tasks that have to be handled; or 3) the amount of available energy. The networks that play an important role in our actions and cognitive processes are: salience network (Menon 2015), central executive network (Bressler, Menon 2010) and default mode network (Raichle, Snyder 2007). Mental states, which are generated by particular networks, take the form of feelings, informing humans of the state of their body (feelings of salience network), level of fluency of task that is being performed (feelings of central executive network), or the values around which humans build their own identity (feelings of default mode network). All these feelings are embodied in human nature and depend on various forms of action to be taken in accordance to the idea: “we feel because we do” (Ellard 2015).

The neurobiological foundation and its educational manifestations

Module 1: Sensibility – the child’s internal world

The feeling of safety and inclusion is generated by the activation of the salience network – the one that is processing and integrating information about the degree of available safety in the environment and is a key brain system for integrating cognition, action, and feelings (Menon 2015). Without activation of the salience network our actions might not effectively go into a productive mode nor into a creative mode. This crucial role of the salience network is visualised in figure 1. The salience network is responsible for switching between the default mode network and the central executive network (Goulden et al. 2014). Also, it has been shown that the salience network contributes to a variety of complex brain functions, including communication, engagement, motivation, social behaviour, and self-awareness through the integration of sensory, emotional, and cognitive information (Craig 2009; Gogolla et al. 2014; Menon, Uddin 2010, as cited in Menon 2015) (Fig. 1).

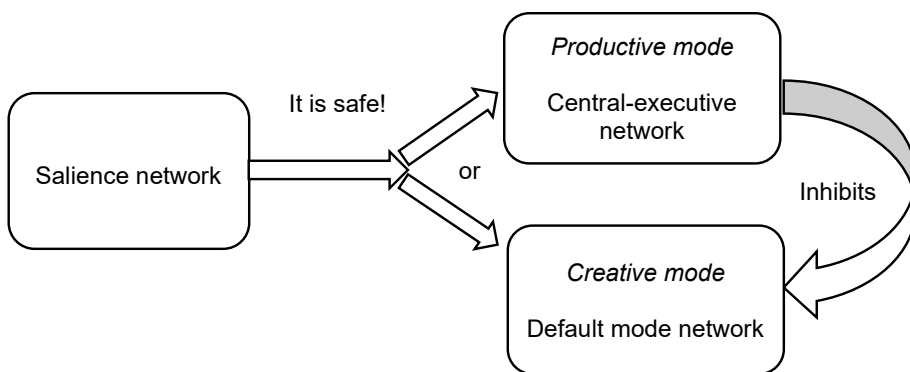


Figure 1. The crucial role of the salience network in subsequent levels of a fully experienced, well designed holistic lesson

Classroom implementation of sensibility

Sensibility refers to those features of the lesson that serve to create a **sense of welcoming comfort**, the **safety and homeostasis** that are necessary to engage with learning, to participate in the interactions and elicit the cognitive processes required for persistence and higher order thinking. While most educational studies are dedicated to the idea of effective implementation and formation of higher order thinking skills such as creative thinking (e.g. Diakidoy, Constantinou 2001; DeHaan 2011; Hadzigeorgiou et al. 2012), investigation (Constantinou, Papadouris 2012), critical thinking (e.g. Bailin 2002) and decision making (Papadouris, Constantinou 2010) it can all be insufficient and simply not working if a child does not feel safe and accepted at school. Therefore the main question that might be asked by a learner is “what do I sense?” Without an aspect of sensibility, the learner may not feel safe, so may not develop any cognitive action and may be relegated to anxiousness about feeling welcomed and accepted. Even when sensibility is not conscious, it serves as a base for any action and as a basic level for happiness. It is important for every teacher to appreciate that if a child is not made to feel safe, accepted, welcomed and appreciated in the classroom he/she won’t learn. Experienced teachers used to say: “Maslow before Bloom” meaning that deficiency needs (physiological, safety, love and belonging as well as esteem) have to be met first before didactic objectives. Discovery and description of the role of the salience network equips us with knowledge and arguments supporting this premise that previously was based on intuition and experience.

Module 2: Functionality – the child’s external world

A brain network responsible for high-level cognitive functions, particularly for the control of attention and working memory is the central-executive network (CEN). Cognitively demanding tasks evoke activation in the brain’s CEN (Sridharan et al. 2008; Bressler, Menon 2010). This network is active during tasks that require flow and maximum concentration, such as a critical problem solving activity, reasoning and controlling of habitual reactions. It is well documented that CEN is critical for the active processing, maintenance and operation of information in working memory, for discourse and social interaction with peers and teacher and also for judgment as well as decision making, especially in goal focused behaviours (Bunge et al. 2001; Crottaz-Herbette et al. 2004; Muller, Knight 2006; Sridharan et al. 2008). Additionally, work done, for example, by Devarajan Sridharan, Daniel Levitin, and Vinod Menon (2008) or Ashley C. Chen and co-workers (2013) has shown that the default mode network (DMN) is under **inhibitory control** specifically from a node in the CEN. This means that cognitively demanding tasks that evoke activation in the brain’s CEN also evoke decreased activation (deactivation) in the DMN (see fig. 1). From the perspective of a teacher, this means that he/she cannot expect from a child to process cognitively demanding tasks and be creative at the same time.

Classroom implementation of functionality

Functionality refers to any action that supports students' attention, working memory, and supports them in performing cognitively demanding tasks. It can be perceived as a cognitive sphere, with cognitive gadgets that support action. From this perspective, the question of how to empower learning highlights an important dimension: What can teachers do to guide and support students in their efforts with the complex process of learning.

This second aspect – external world in our proposed model of holistic education is supported by discoveries made within science education research¹. This dimension (functionality) can focus on all aspects of designing lessons that illustrate to the students that the world is cognitively interesting and a persistent effort to construct meaning that includes interaction with epistemological and physical objects can be rewarding and fulfilling (eg. Zacharia, Constantinou 2008; Pouw, Van Gog, Paas 2014). It is on these premises that strategies for holistic learning become meaningful: embodied learning and learning by doing (Schank et al. 1999) – with the usage of hands, body, gesturing, involving multimodal inquiry (e.g. Prain, Tytler 2012) and all activities that can relate to the question: how can students act in order to learn? In science education much attention is directed to ideas of inquiry, discursive dialogue, multimodality, external representations (especially their construction), problem solving and project-based learning. A broader perspective can be offered by multimodal inquiry and we will discuss implementation of functionality using this example.

Multimodal inquiry is an approach to teaching and learning in science that involves the construction of multiple representations and multimodal explorations. It comes as a bridge between using diverse knowledge representation tools to scaffold the process of learning and promoting learners' engagement in the authentic use of evidence to develop and evaluate interpretations for phenomena. The classroom use of multimodal inquiry can serve as a productive way to effectively promote robust learning. The structure in which these strategies can function in the classroom, so that learners and teacher can work together as a community to process information and reflect on experience, using dynamic representation tools, becomes a crucial object of educational research.

Such approaches draw on what Peter Hubber, Russell Tytler and Gail Chittleborough (2018) have described as guided inquiry, which “involves challenging students to generate and negotiate the representations (text, graphs, models, diagrams) that constitute the discursive practices of science, rather than focusing on the text-based, definitional versions of concepts”. We extend this framework by stressing the role of the body and its involvement in the process of learning, thus highlighting also the role of gesturing, haptic learning, and active usage of all the senses together with hands and acting out in a process of embodied learning.

¹ We have chosen science education due to the fact that one of the authors is a science education researcher.

We proceed to present an overview of multimodal inquiry learning with embodiment. We illustrate how phenomena can be represented and analysed through constructing multiple representations or through multimodal exploration. We also demonstrate how inquiry practices can supplement multimodal exploration and when embodied action can provide productive scaffolds to facilitate more holistic learning.

What are multimodal representations, multimodal explorations and multimodal learning?

Multimodal or cross-modal learning (used here as synonyms) refers to embodied learning situations where information is obtained from more than one modality. In sensory modality, a stimulus emerges from information obtained through a particular sensory input, for example, visual, auditory, olfactory, haptic or kinaesthetic information (Massaro et al. 2011; Skocaj et al. 2011). Multimodal learning can also be perceived more widely as a process in which multisensory approaches to learning are adapted and combined with higher order experiences such as interactivity. The use of well-designed combinations of text and visual materials, accompanied by interactivity, helps students to learn more effectively as compared to the use of text only. Additionally, interactivity influences positively the process of acquisition of higher-order skills (Fadel, Lemke 2011). The use of external representations (such as diagrams or graphs) as a means to externalize thought (Tversky 2011) strengthens the behavioural, aesthetic, cognitive and communicative aspects of learning. They also help to reveal the learner's understanding, their personal concepts and misconceptions, thereby making them more accessible for discussion and negotiation.

There are additional requirements that need to be fulfilled if multimodal learning is to be effective in empowering learners. First is a shift from teacher-centered to student-centered approaches. Teachers need to prepare scaffolds for students, offering them possibilities for active participation through experiencing objects and phenomena as well as constructing representations in response to structured challenges (Tytler et al. (eds.) 2013) involving inquiry and problem solving practices. The actual process of creating representations can support conceptual change (Tytler, Prain 2013), play a role in exploration and discovery, and can help in generating and communicating knowledge (Elkins 2011). Multimodal inquiry learning has a higher probability of engaging learners in epistemic practices (Prain, Tytler 2012; Evagorou et al. 2015). The construction of a multimodal representations and their use in generating and validating evidence adds a productive dimension to the science-learning environment.

The role of different representational modes and how these might best be coordinated to support learning were analysed and described by Mike Scaife and Yvonne Rogers (1996), Shaaron Ainsworth (2006, 2008) and Russell Tytler et al. (eds.) (2013). Scaife and Rogers (1996) claim that functions of external representations are:

- computational offloading (as a means of reducing the cognitive load);
- re-representation which refers to how different representations with the same abstract structure, make problem-solving easier or more difficult;
- graphical constraining – “limiting the kinds of inferences that can be made about the underlying represented world”.

The functions of multiple representations presented by Ainsworth (1999, 2008) are slightly different in stressing a more educational perspective. She highlights the following functions: complementary, constraining and deeper understanding. **Complementary function** refers to the “use of representations that contain complementary information or support complementary cognitive processes” (Ainsworth 1999). Representation can support complementary processes (in tasks, strategies and individual differences) or complementary information (by providing different information or shared information). **Constraining function** refers to such use of representations that the learner understands to aid the interpretation of another idea, or abstract representation. We might say that, in this case, the use of representations works like Ockham’s razor to reduce the range of possible interpretations by constraining by familiarity or by inherent properties. **Deeper understanding function** refers to the role multiple representations play in constructing deeper understanding by promoting abstraction, encouraging generalization and teaching the relations between represented items (Ainsworth 1999, 2008).

Why is multimodal exploration thought to be effective?

Learning is inseparably connected with cognition, and cognition itself is situated and embodied. Cognitive activity takes place in the context of a real-world environment. Thus, the brain needs not only the body but also the surrounding world in order to function properly. Kim Sterelny (2010) highlighted the importance of environmental resources in enhancing and intensifying our cognitive capacity through epistemic engineering. Nevertheless, cognition is also for action. The function of the mind is to guide action, to make decisions upon stimuli coming from the environment. Additionally, the brain is not separated from our bodies; so eyes, hands and more broadly our senses are an important part of the perceptual system and thus they play a crucial role in cognition. The phrase “cognition is embodied” illustrates the idea that the mind must be understood in the context of its relationship to a physical body that interacts with the world (Wilson 2002).

From that perspective, any use of tools for internalization, i.e. for achieving cognitive mastery (Kirsh 2010), facilitates self-development, self-fulfilment of a task and acts in cognition. This strategy works by providing a specific substructure or material (external, tangible) anchor (material anchor) (Hutchins 2005) for mental projection. Enactment helps in cognition, and the embodied cognition movement has emphasized that perception and action also play an important role in teaching and learning (Wilson 2002).

While taking action and manipulating real objects or multimodal representations, a student is involved in a process of enactment of practice. Students are thus concerned

with practical application of knowledge; they are involved in the direct use of concepts/theories within domain- or topic-specific knowledge. Such actions lead to epistemological understanding, acquiring a more holistic perspective and changing or developing aspects of students' personal knowledge (Aditomo et al. 2013).

By adopting multimodal perspectives on literacy we have to agree that meanings are made (as well as scattered, interpreted, modified, and re-formed) through many representational and communicational resources – not only through language but also through our hands and body (Kress, van Leeuwen 2001). As Jewitt argues: “Multimodality attends to meaning as it is made through the situated configurations across image, gesture, gaze, body posture, sound, writing, music, speech, and so on. From a multimodal perspective, image, action, and so forth are referred to as modes, as organized sets of semiotic resources for meaning making” (Jewitt 2008: 246). This perspective is also supported by Tytler and co-workers where they claim: “Thinking, reasoning and abstracting are grounded in perception, situated action, motives, embodiment and environmental affordances. (...) What we can visualize, perceive, rehearse, enact, simulate, feel, want and reflect upon forms the bases of our representations of knowledge and our capacity to symbolize and abstract” (Tytler et al. (eds.) 2013: 11)².

Module 3: Rationality – the world of internal values, imagination and creativity

It is currently considered that an integrated brain system for self-related cognitive activity, including autobiographical, self-monitoring and social functions is associated with the activation of the default-mode network (DMN) (Bressler, Menon 2010). When we are not involved in demanding tasks that require a high level of control of attention, the brain automatically switches to this network (Raichle, Snyder 2007). Under the activation of the DMN the mind easily wanders in time – memories of autobiographical experience and planning the future are evoked. A human mind is also said to wander in space, with empathizer thoughts and feelings for others (which is where empathy starts) as well as morally assessing their or our own actions. The states of the DMN relate to the content of the mind, particularly those related to the system of six values encoded in the ventrolateral frontal cortex, in the side pole frontal brain (lateral frontal area) (Neubert et al. 2014). The DMN is active when a person is not focused on the outside world and the brain is at wakeful rest (e.g. during daydreaming and mind-wandering). Another situation when this network is active is when the individual is thinking about others, thinking about themselves, remembering events from the past, and planning for the future (Buckner et al. 2008).

² It is also very easy to introduce multimodal approaches in ineffective ways and cause cognitive overload among students. Prain and Tytler (2012) are stressing the idea of introducing multimodality in a structured way, with pre-designed steps, avoiding pushing students to use many channels at the same time.

Classroom implementation of Rationality

As Maciej Błaszak and co-workers stated: “Mental representation of rationality corresponds to the subject/child personal judgement of the state of the mind as a reaction to the world’s form, so it serves as a so-called »real judgement«. This aspect is strongly related to the state of mind and to the feeling of potential realization” (Błaszak et al. 2019: 9).

In situations where a person has the feeling of potential realisation and fulfilment, the flow experience is more likely to happen. The state of flow itself was described and intensively investigated by Mihaly Csikszentmihalyi. It is now usually perceived as a state where assimilation and accommodation are in equilibrium, when skills and challenges are in balance, and this leads to the idea of experience and the role of experience in educational process (Csikszentmihalyi, Rathunde 2014). Dewey (1963) was describing a state that he called “optimal experiences” as affectively and cognitively engaging. At the same time this optimal experience would provide a sense of joyfulness and spontaneity, as well as a seriousness and focus on goals. Combining together factors such as joy, engagement and focus highlights the complexity of this state. According to Csikszentmihalyi (2014) in real situations the presence of “Flow” depends on two conditions:

1. The objective structure of the activity;
2. A personal perception of the structure of the activity.

“A decisive structural factor for enjoyment is the balance of challenges and skills. At any given moment, we process in consciousness two crucial pieces of information: »What can be done here?« and »What am I capable of doing?«” (Csikszentmihalyi 2014: 182).

Despite these two preliminary assumptions, a high level of challenges and well developed skills do not guarantee that the flow state will follow, and much lies within person-level variations (Schmidt et al. 2014). These authors have shown that internal dimensions of experience (such as for example one’s activities, mood, company, and perceptions) explain a much greater variation in flow than external dimensions of experience. Among the external dimensions of experience, activity explained the most variance in flow, especially leisure activities. They stated: “by contrast, the level of flow one experiences seems to depend a great deal on subjective elements of experience such as the perception of autonomy, the match of challenges and skills, success, importance, and focus in relation to daily activities” (Schmidt et al. 2014: 397).

As already mentioned, all these elements, including leisure activity and perception of autonomy, happen under the activation of the DMN. This highlights the important role of leisure time at school, the crucial role of providing space for reflection and consciousness of experiences that can generate a feeling of achieving the goal and a sense of personal fulfilment. Rationality comes into play when the student ask such questions as: what does it mean to me? How do I identify? Rationality refers to the facility of students to reflect on the six values – care, fairness, loyalty, authority, sanctity and liberty – and how these values relate to the elements present in the school environment and their own emotional engagement. Mental representation of rationality corresponds to the judgement of the state

of mind as a reaction to the world’s form, so it serves as a so-called “real judgement”. This can be perceived as an aspect of happiness and is strongly related to the state of mind and to the feeling of potential realization and self fulfilment.

Examples of Educational Activities for Holistic Teaching and Learning

Some illustrative examples of activities that can be introduced in the classroom for the benefit of children are presented in Table 1. The activity features are grouped along the three dimensions.

Table 1. Illustrative examples of classroom activity features for Holistic Education

Dimension of Holistic Education	Major Goal	Examples of activity features that support this dimension
sensibility	safetiness; building personal relations and a sense of welcoming comfort; creating a feeling of belonging to a community	<ul style="list-style-type: none"> – continuous formative feedback – children presenting personal achievements – teacher collecting information about his/her student interests/ abilities – group working with changing roles (e.g. in a jigsaw arrangement) – slow/smooth introduction of objects, first observation and operating with objects before cognitive tasks
functionality	cognition executive tasks	<ul style="list-style-type: none"> – multimodal approach in pre-designed activity structures – introducing the 5E model (with 5 phases: Engage, Explore, Explain, Elaborate, and Evaluate) – peer feedback scaffolded with templates to safeguard mutual respect and productive collaboration
rationality	flow and creativity students have opportunities for greater autonomy in individual and group activities	<ul style="list-style-type: none"> – time for personal and group explorations³ – open-ended and divergent questions with incubation time – constructing new ideas/new objects on the basis of what students have already learned in order to support creative problem solving and modelling; learning by design and constructionist learning – reflection, reporting and discussion. Classroom debates highlighting different perspectives on discussed issues and facilitating structured argumentation – taking care of plants that are located in the classroom (e.g. every child would have a chance to “adopt” one plant, and water it, draw the changes, measure it etc.)

³ This element would be a very important addition to those schools that are operating on a system of tasks and achievements, where children do not have time for personal explorations.

In a nut-shell

As teachers, parents and researchers we can observe the increasing number of students who are struggling with everyday life at school, who find it difficult to transition back and forth between the multiple stimuli in every day social/family life and the structured school routine, to respond there in accordance to (teacher) expectations, and to experience potential realization, a state of flow and self fulfilment. Additionally at every level of education, we observe a “powerpoint cult”. Instead of this, a good scaffold offered by a teacher to a learner could start from well-designed and goal-oriented multimodal explorations. Tytler and co-workers (2013) have provided strong evidence the multimodal explorations, especially the construction of representations while using multimodal tools, support student conceptual, and meta-representational learning at a deep level. The same authors highlight that challenges like ‘can you draw it for me?’ or ‘can you represent that?’ could productively occur more commonly in school teaching practices. Practical work involves action and reflection, which are important elements in the process of meaning-making for effective learning.

In this article, we have presented a holistic approach to education that combines three elements that re crucial when they exist in unison: starting from a feeling of safeness and inclusion through good scaffolding and ending with a flow experience.

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