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**INNOVATIVE PEDAGOGIES FOR POWERFUL LEARNING**

**17-18 November 2016**

*Attached is an initial set of chapters prepared by experts in elaborating research relevant to the “Cs” framework being developed for the Innovative Pedagogies for Powerful Learning (IPPL) project. It provides background material for the item on IPPL at the November 2016 meeting of the CERI Governing Board.*

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## INITIAL PAPERS ON INNOVATIVE PEDAGOGIES FOR POWERFUL LEARNING

### THE PURPOSE OF PEDAGOGY

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Pedagogies provide frameworks for the many different decisions teachers have to make about how they teach. We *innovate* our pedagogies when we feel they are no longer quite meeting our needs. Like any kind of innovation, innovation in pedagogy takes existing ideas, tools or practices and brings them together in new ways to solve problems. To the extent that the two dilemmas above are shared challenges across the teaching profession, and *innovative* pedagogy is one which helps to resolve these dilemmas: by finding ways to realize the science of learning to meet and challenge more students where they are.

In the past, a choice of pedagogy might be made ad hoc or based on whatever a teacher had encountered in teacher education or their own schooling<sup>1</sup>. But where teachers are supported by high quality teacher education and strong professional infrastructures, teachers are enabled to make concerted decisions about pedagogy, acting as *designers of learning* by selecting approaches with a clear sense of their intended impact<sup>2</sup>.

Certain strands of education research are aimed at providing teachers with the evidence to make informed decisions about pedagogy<sup>3</sup>. But developing and selecting pedagogies involves more than working out what is ‘effective’, in terms of an impact on measures of learning. As this collection illustrates, different pedagogies are based on different theories of learning, and these theories entail not only different views of psychology but also of philosophy in terms of what is most important in a learning experience. The full power of a pedagogy – and of pedagogical innovation – can only be evaluated when we take into account all the things pedagogies are trying to achieve. This does not mean we have to have agreement about the outcomes of schooling before we begin – desired outcomes will always be diverse and manifold – but it is necessary to have some attention to our *intentions* when evaluating different kinds of pedagogies, and not assume that all pedagogies aim at precisely the same purposes.

This chapter addresses the question: why look at pedagogy at all? What advantage is there in studying education, teaching and learning in terms of pedagogy?

#### **The Functions of Pedagogies**

In order to evaluate whether a pedagogy is making an innovative contribution, it is necessary to first have a clearer sense of what pedagogy *is* and what pedagogies *do*. What is the value-add of talking about ‘pedagogy’ rather than ‘teaching methods’ or ‘practices’?

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<sup>1</sup> Lortie (2002)

<sup>2</sup> Vieluf et al. (2012); Jensen et al. (2015)

<sup>3</sup> Hattie (2011); Higgins et al. (2015)

There is no single meaning of the term pedagogy, and it has different connotations across cultures. For the purpose of this paper, pedagogy is used to refer to repeated patterns or sets of teaching and learning practices: practices that shape the interaction between teachers and learners. I refer to established but loosely defined sets of teaching and learning practices (for example, inquiry-based learning) as a ‘pedagogical approach’. In this paper, I describe how the development and use of pedagogy and pedagogical approaches fulfils a number of functions, over and above what is achieved by single teaching practices. Pedagogical approaches allow us to *pursue multiple purposes simultaneously*; they provide reliable ways of *organizing learning*; and they can be ways of *bundling practices*.

### ***Pedagogies aim at multiple purposes***

The goal of teaching is more than just the transfer of content from one person to another. The way that people are taught affects how and what students learn. Particular pedagogical approaches have been developed and refined to promote a variety of different kinds of learning: learning of explicit content, learning of particular ways of doing things, or learning of values and habits, for example. This creates decisions for teachers.

As an example: a Literature teacher knows that, according to his jurisdiction’s curriculum, all students in his class need to learn by heart a 16<sup>th</sup> century poem during that year. In pursuing this goal, there are several ways he may choose to try to do this, depending on the other developmental goals he or his school has prioritized. If his priority is for students to develop fluency with valorised culture, he might select a number of famous poems, and deploy ‘spaced learning’ over the course of the year to maximize the chance that students commit them to long-term memory. If his priority is for his students to develop emotional connections with literature, he might ask students to select from a wide range of poems one which is meaningful to them. If his priority is for developing communication skills, he might choose to spend considerable class time on practicing performance of the poem, working on elocution and oracy as well as memorization. Or he might decide that the memorization task is not a priority for the class and encourage them to learn something last minute, re-allocating the time to other activities.

Each of these routes entails choices about what the outcomes he is concerned with, besides the goal of memorizing a poem. His choice on this one activity is unlikely to make much impact on these outcomes. If, however, he makes consistent choices across several activities – and particularly if other teachers in his school are doing the same – we might expect to see progress in the personal development of the students. Thus, the teacher and his colleagues can choose to adopt a communal pedagogy in order to achieve both their discipline-centric teaching goals and other goals besides.

Frequently, teachers make choices about their pedagogy not in relation to their own preference but according to a local national curriculum structure. Many curricula now include ‘core competencies’, ‘transversal skills’ or ‘general capabilities’ which point towards certain kinds of pedagogy and provide alternative starting points for learning design<sup>4</sup>. Some curricula are constructed to be ‘competency-based’, with the idea that students should move through the development of different skills and knowledge levels at their own pace<sup>5</sup>. Many of the ‘innovative’ pedagogies we focus on for this project call for curricula where students can take more of a role in managing their learning, in order to develop the habits of metacognition in terms of knowing what one knows, and what one needs to understand better. A curriculum may be more or less specified, so teachers may then have different scope in the extent to which they or their students have choice about what knowledge to focus on.

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<sup>4</sup> UNESCO (2015)

<sup>5</sup> Bristow & Patrick (2014)

Beyond the factor of curriculum, choices about pedagogy may be determined by assumptions about the way different approaches produce certain outcomes. The table below seeks to make explicit some of these assumptions. The pedagogical approaches named here are not intended to provide a comprehensive list, nor to define terms – individual teachers, schools or systems often have their own language when it comes to describing their pedagogy. The intention is to illustrate how established pedagogical approaches have developed in line with different kinds of intentions, and therefore why comparisons of approaches comes down to more than just the question ‘which is most effective’.

**Table 1: Different approaches have different purposes**

|                  | <b><i>We use this approach so that students can...</i></b>   | <b><i>...with the intention of promoting...</i></b> |
|------------------|--|---|
| Mastery-based    | <i>build knowledge and skills sequentially with practice</i> | <i>Fluency, Automaticity</i>                        |
| Spaced learning  | <i>memorize core knowledge, practice recall</i>              | <i>Fluency, Automaticity</i>                        |
| Problem-based    | <i>apply skills or knowledge to a situation</i>              | <i>Meaning-making, Skill transfer</i>               |
| Place-based      | <i>connect knowledge with their context</i>                  | <i>Meaning-making, Identity building</i>            |
| Discussion-based | <i>practice articulation, take in other perspectives</i>     | <i>Communication, Perspective-taking</i>            |
| Flipped learning | <i>self-pace when meeting new content</i>                    | <i>Metacognition, self-management</i>               |
| Inquiry          | <i>make connections, make their own learning path</i>        | <i>Metacognition, self-management</i>               |
| Product-oriented | <i>be motivated, produce high quality work</i>               | <i>Engagement, Perseverance</i>                     |

Each of these pedagogical approaches take a particular route to promoting the acquisition of knowledge and skills, in line with particular intentions. There is a paucity of research on some of the intended outcomes of approaches. Moreover, the way that approaches may be combined to achieve a full range of desired outcomes is also a key area of need for innovation and research.

### ***Pedagogies organize people and time***

Teaching is an incredibly complex task. Over the course of each day, week and year, a teacher has to make thousands of decisions. On the one hand, there are choices about how to sequence and frame knowledge, and how to model and scaffold particular discipline-specific skills. To make these choices effectively teachers may draw on what is sometimes called *pedagogical content knowledge*. Then there are choices about how to initiate, organize and maintain momentum in periods of learning. This could cover anything from choosing how to group large numbers of young children, to deciding how much time adolescents should spend in an internship.

Many popular pedagogical approaches have developed as ways to organize a teaching and learning process. As such, they can support three key organizational tasks: choosing a focus for the learning, managing the learning process, and determining the length and shape of an ‘arc of learning’. Different kinds of pedagogical approaches are more or less compatible with different lengths of learning arcs: an

individual lesson, a series of tasks over some days, or a sequence or project stretching over weeks, months or more. Similarly, pedagogical approaches imply different decisions about how topics are chosen and scoped, and how the actual process of learning is managed. In other words, pedagogical approaches help to provide answers to three key dilemmas in teaching: What should students work on? How to ensure they keep working? And when do we move on?

Different established pedagogical approaches have different ways of answering these questions, often based on slightly different theories of learning, or in response to different organizational constraints.

**Table 2: Different approaches promote different ways of organizing learning**

|                  | <i>...chooses focus</i> |                | <i>...manages learning process</i> |                |               | <i>...ends the learning arc</i> |                |             |
|------------------|-------------------------|----------------|------------------------------------|----------------|---------------|---------------------------------|----------------|-------------|
|                  | <i>Teacher</i>          | <i>Student</i> | <i>Teacher</i>                     | <i>Student</i> | <i>Groups</i> | <i>Assessment</i>               | <i>Product</i> | <i>Time</i> |
| Mastery-based    | x                       |                | x                                  | x              |               | x                               |                |             |
| Spaced learning  | x                       |                |                                    | x              |               |                                 |                | x           |
| Problem-based    | x                       |                |                                    | x              | x             | x                               |                |             |
| Place-based      | x                       | x              |                                    |                | x             |                                 | x              |             |
| Discussion       | x                       |                | x                                  |                |               |                                 |                | x           |
| Flipped learning | x                       |                |                                    | x              |               | x                               |                | x           |
| Inquiry          |                         | x              |                                    | x              | x             | x                               | x              |             |
| Product-oriented | x                       | x              |                                    | x              | x             |                                 | x              |             |

Different pedagogical approaches give rise to different kinds of teaching and learning processes, each with advantages or disadvantages depending on our purposes and context. Some approaches are quite rigid in how they define a learning experience. Others, such as project-based learning (not featured here but often used as a catch-all term to describe product-oriented, place-based, and problem-based learning), have become so widely used they have become varied in form, and lend themselves to different balance points of teacher and student choice and management<sup>6</sup>.

For an expert teacher, it may be desirable to adopt an approach which acts as a loose frame, and allows for a great deal of flexibility within it. A more novice teacher might prefer to have a thoroughly-researched and codified approach to use with confidence. In the case of any approach, however, it is important to bear in mind that the same labels can mean quite different things at the level of practice, in terms of how they organize learning.

### ***Pedagogies bundle practices***

The final advantage to thinking in terms of established pedagogical approaches is that an approach typically groups together sets of discrete research-based practices. For example, inquiry based learning

<sup>6</sup> Vander Ark (2016)

may involve working with students on developing questions; developing self-regulated learning habits; and conducting assessment using portfolios and presentations of learning. A teacher who begins using an inquiry-based approach can find a range of high-quality supports for each of these practices, such as the Right Question Institute<sup>7</sup> on constructing questions, or the Exploratorium's Institute for Inquiry<sup>8</sup> on formative assessment in science inquiry. The pedagogy can act as a cornerstone that brings together a professional community and knowledge management efforts, all geared towards developing and refining practice.

An advantage in thinking about approaches as bundles of discrete practices is to aid communication across contexts, where different labels have become attached to similar bundles of practices. For example, support for project based learning within teacher education is impeded by a plethora of different notions of what 'PBL' entails. By focusing on specific practices, teachers can move beyond the buzz words to really understand the how and why of a particular pedagogical approach. Breaking down approaches into practices with specific aims – or even into the *mechanisms* which explain how a practice achieves its effect<sup>9</sup> – may be an important precursor to understanding the potential of new innovations in pedagogy.

In breaking down pedagogical approaches in this way, however, we must avoid being too mechanistic in the way we describe what teachers do and why. While evidence-based practices are a vital starting point, therefore, they are only the building blocks of impactful teaching and learning. If the 'science' of pedagogy is in identifying the mechanisms and potential impacts of different approaches, the 'art' is employing and combining pedagogies effectively to achieve a desired effect in context.

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<sup>7</sup> <http://rightquestion.org/>

<sup>8</sup> <http://www.exploratorium.edu/education/ifi>

<sup>9</sup> Peterson (2016)



## PEDAGOGIES AND DOMAINS (MATHEMATICS, NON-NATIVE LANGUAGES, AND SOCIO-EMOTIONAL EDUCATION): CONTENT

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### Introduction

In this chapter we analyse the affinity of pedagogies with domains. This question can guide pedagogical reform endeavours. Must teaching innovation seek one pedagogy as equally effective across domains? Or must it seek particular pedagogies to certain domains? To what extent are pedagogies sensitive to domains and particular learning goals? We focus on three specific areas: mathematics, non-native language, and socio-emotional education, each of which has its own priority in the educational contemporary agenda:

- Mathematics is a core curriculum area and plays a key role in promoting logical thinking, and crucial competences to work on science, engineering, and technology-related disciplines (Mevarech and Kramarski, 2014). Attention to pedagogy is needed given the common student low engagement and understanding of the subject.
- Non-native language learning is especially important in today's context of increased mobility, communication, and migration. Pedagogies aim to competence in order to get across and reach cultural understanding (Della Chiesa, Scott and Hinton, 2012).
- Socio-emotional learning is a decisive area for individual learning and development, and critical for achieving both personal well-being and social progress (OECD, 2015). School systems should look to foster social and emotional skills with the aim of enhancing students' overall learning and school socio-emotional climate.

In the next section we discuss to what degree pedagogies are sensitive to domains. Then we analyse the need to work on different learning goals at the same time, alongside the requirements that this poses to pedagogies. We also present the main pedagogical challenges and current responses that are driving teaching innovation in the three domains; we present them in detail, organised according to the 7 principles of powerful learning from previous OECD work (Dumont, Istance and Benavides, 2010). The chapter finishes with some conclusions.

### Pedagogies and domains: one pedagogy for all?

How independent are pedagogies from domains? Can we conceive one pedagogy as equally effective across domains? Or should we conceive specific pedagogies for particular domains and learning goals? Here we understand "domains" as particular fields of study or practice like mathematics, sports, or literature, that require certain knowledge, skills and attitudes to practice them.

Two main positions have emerged in that debate: first, a "*generalist*" approach that conceives the existence of pedagogies that can be similarly applied to whatever school subject and domain; second, a "*specialised*" approach that considers that pedagogies are domain-specific and, therefore, problematic to transfer across domains.

The *generalist approach* assumes that human development is based on the acquisition and progress of general human capacities such as understanding or speech, which are used by people in whatever context they act. Therefore, the primary focus of teaching should be contributing to individual development by consolidating the acquisition of domain-transcending competences like critical thinking and self-regulation. Likewise, the generalist approach assumes that process and content of teaching and learning are

independent entities. It means that cognition and cognised objects are perfectly separable entities so that learners may master the “process” (e.g., critical thinking), and then apply it to whatever contents they have to learn. As for teaching, there is a clear distinction between pedagogy and subject matter: one thing is to teach (the process), and another is what to teach (the content). The teachers’ task is to “pedagogise” subject matter in order to make it learnable by the students (Segall, 2004).

Such a generalist approach relies on the assumption that knowledge, skills and attitudes are easily transferable by students from one domain to another, working in abstract tasks and expecting students to transfer such learning to new situations that they will encounter in the future. Teaching aims at finding an effective pedagogy that will be “filled” with whatever contents the student has to learn.

The *specialised approach* considers that human development is primarily driven by the acquisition and accumulation of knowledge within the various domains (e.g., Carey, 1985): competences do not grow in the vacuum, but they originate through specific knowledge and experiences. Therefore, teaching aims at promoting domain-specific knowledge (Deng, 2015), and it commonly leads to knowledge-centric school curricula. This view emphasises that every domain has its own specific knowledge and skills, aimed at solving specific tasks.

The specialised approach considers that process and content are inextricable and cognition and emotion are always shaped by the object of such cognition or emotion. As for teaching, pedagogy becomes inseparable from what is being taught (Segall, 2004) and pedagogies cannot be considered simply as methods applied to content. Thus, the teachers’ task is not simply to add an upper layer of “pedagogy” to subject materials such as text-books and software, which are always based on an underlying conception of how people learn that matter; rather, teachers must identify the pedagogical nature of such materials, and work with and around them. The specialised approach considers that knowledge, skills and attitudes are not easily transferable among domains. In order for transfer of learning to happen, instruction must promote it through explicit and transfer-inducing practices, often working on contextualised and concrete scenarios (Dochy, 1992).

Here teaching aims at finding specific pedagogies suitable for particular domains. Pedagogical effectiveness is different across domains, and hence teaching must find the most effective pedagogies for any given domain and learning goal.

Teaching innovation and improvement would benefit from adopting a middle-ground position between the generalised and the specialised approach. We may call it the “*domain-sensitive approach*”; pedagogies are highly responsive to domain specificities, but they usually seek learning improvement pursuing similar underlying processes like enhancing learner engagement, or social interaction and collaboration. In other words, pedagogical innovation is concretised according to what is being taught and learned, but in the end it is usually underpinned by common fundamentals of human learning.

The domain-sensitive approach relies on several ideas that attempt to overcome apparently insoluble contradictions that have kept apart the generalist and the specialist approach:

- *Human development* is a process that *entails both knowledge acquisition and skills progress* as mutually interactive processes.
- *Knowledge, skills and attitudes can be domain-specific or domain-transcending.*
- *All domains have their own set of domain-specific knowledge, skills and attitudes.* Likewise, domains differ in the amount and nature of those elements required to successfully solve their tasks. Nevertheless, domains also rely to some extent on domain-transcending knowledge, skills and attitudes.

- *Learning generally comprises both domain-specific and domain-transcending processes*: for instance, learning geometry requires domain-specific concepts and skills, but also general elements like self-regulation skills and persistence.
- Learning transfer does not easily and automatically happen across domains; however, *students can achieve reasonable transfer*, especially when activated through appropriate teaching. If all learning were domain-specific with no possibility of learning transfer, it would be difficult to explain how learners deal with new situations and information (Alexander and Judy, 1988).

*School pedagogies are shaped by their domains at different levels of the educational ecosystem.* The literature often emphasises teacher’s knowledge on the subject and how to teach it – pedagogical content knowledge (PCK) (Shulman, 1986) - as the main reason for different subject pedagogies. However, there are many other factors in play contributing to those differences:

- Each domain encloses its own fundamental *epistemic structure and nature* which poses its own requirements on pedagogies. Every domain has its own specific knowledge, skills and attitudes. Such elements reflect the original human activity where they were produced, as well as the function to which they serve (Bosch and Gascón, 2006).
- School teaching of a certain domain can reflect “historical” tendencies or *traditions* whereby a subject has been taught in a particular fashion for a long period of time, sustained by such factors as national and regional policies, teachers’ education systems, popular beliefs about how a subject should be taught, and low levels of diffusion of domain advances and pedagogical innovation (Silver and Herbst, 2007).
- At the level of *school organisation and practice*, subjects are filters for teacher practice in schools. Through school subjects, teachers plan their work, create associations, respond to policy initiatives and interact with students (Grossman and Stodolsky, 1994). For example, teachers tend to form subject-related sub-cultures and identities led by particular beliefs, norms and teaching practices (Drake, Spillane and Hufferd-Ackles, 2001). These subject-related subcultures and identities are reinforced by certain school institutions such as school departments (Grossman and Stodolsky, 1995; Siskin, 1994).
- *Teachers’ knowledge, beliefs and emotions* about their subject define the context in which they teach, making some pedagogies more or less applicable according to their views (Depaepe et al., 2013; Gess-Newsome, 1999). Teachers develop beliefs about how a certain subject should be taught early in their careers, often anchoring them in their own experience as school students; later on, accumulated professional expertise and subject-related knowledge may reinforce or modify those early-developed beliefs.

The domain-sensitive approach seeks a balance between affirming an unambiguous relation between pedagogies and domains, while aiming at *the* innovative pedagogy that will enhance all learning across subjects and domains. Usually, it is not that a particular pedagogy can only be applied to a certain domain but “one pedagogy for all domains” regardless of contents and learning goals is a simplistic aim for educational policy and practice.

The question of how far pedagogies must be sensitive to domains needs to consider one more aspect: the aimed learning goals, and how far they are actually linked to domains.

## **Competences, domains and pedagogical priorities**

### *Competences as learning goals*

Learning goals play a decisive role in shaping pedagogies. School learning goals commonly revolve around the notion of *competence*. A competence is the capacity to mobilise and use knowledge, skills, and attitudes to meet complex demands or solve complex tasks (Ananiadou and Claro, 2009).

Working on competences, as opposed to content, orients pedagogies towards achieving *knowledge integration*, namely working to interrelate knowledge, skills and attitudes. Likewise, competences drive pedagogies towards increasing *learning functionality and transfer* to specific contexts. Acquiring competences involves mastering typical patterns of using knowledge, skills and attitudes to solve particular kinds of tasks.

*Knowledge* includes facts, concepts and principles that are highly domain-specific in nature like the concept of square root, or the Big Bang theory; however, knowledge also includes domain-transcending elements such as the concept of truth (Dochy and Alexander, 1995).

*Skills* embrace actions that can be performed in four different areas: cognitive and metacognitive, communicational, socio-emotional, and psychomotor. Skills embrace domain-transcending procedures like setting one's goals in a certain activity (metacognitive skill). Skills can also be highly domain-specific like visualising and using geometrical models for problem-solving (cognitive skill related to the mathematics domain).

*Attitudinal knowledge* includes attitudes, values and norms. Attitudes are sometimes defined according to specific domains like the norms that reflect the ethical principles of science. However, most attitudes can be perfectly applied across domains such as perseverance in the face of difficulties.

Although knowledge, skills and attitudes present both domain-specific and domain-transcending elements, they generally do not have the same degree of domain-specificity. Overall, knowledge tends to be more domain-specific than skills. Knowledge commonly reflects the nature of the ideas and concepts of particular domains, whereas skills tend to be more applicable across domains; especially when skills rely on the use of heuristic procedures, that is, open procedures that can be executed in different ways and lead to more than one result, like note-taking or concept-mapping (Poza and Postigo, 2000). Likewise, skills tend to be more domain-specific than attitudes, since attitudes reflect behavioural tendencies that are usually applicable across many different contexts and activities.

### ***Domain-specific and domain-transcending competences***

The *domain-specificity of competences* can be conceived as a continuum, rather than as dichotomy. And it is the product of two vectors:

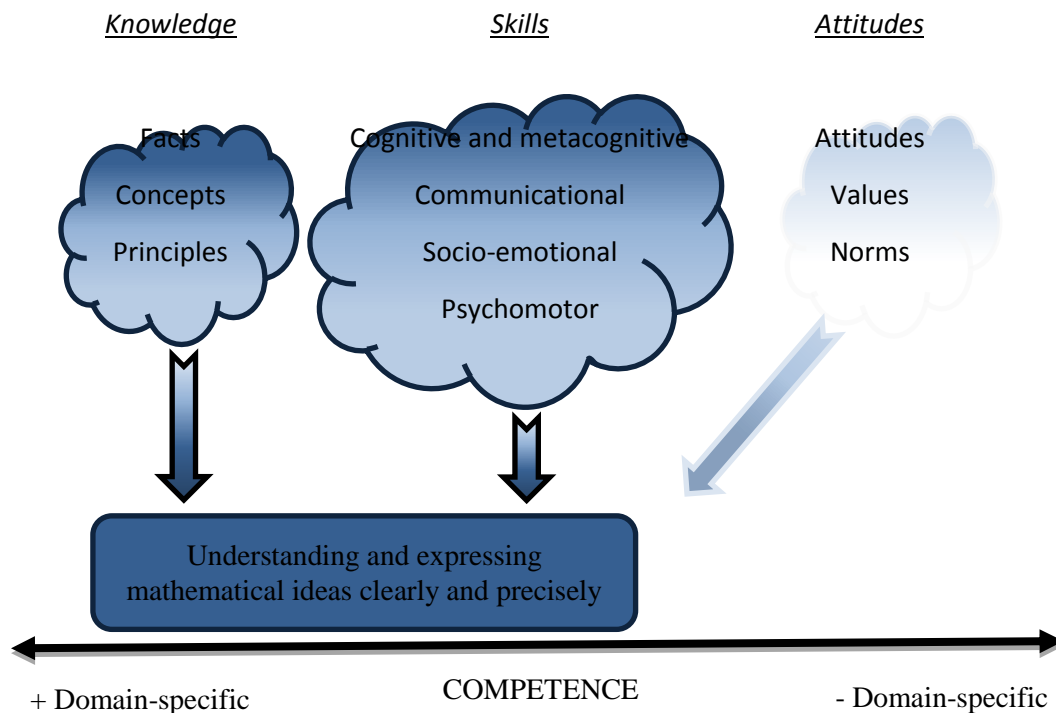
- *The emphasis placed on knowledge, skills and attitudes*; where knowledge acts as an attractor of domain-specificity, and attitudes draw domain-generalities.
- *The domain-specificity of those components*; where the more domain-related is each of those elements, the more domain-specific will be the competence.

Competences are tied to domain specificities when they draw heavily on knowledge, and such knowledge is highly domain-specific; such domain-specific competences typically require highly domain-specific skills.

On the other hand, competences are rather domain-transcending when they focus on the acquisition and use of attitudes, and such attitudes are mainly domain-transcending. These sorts of competences usually demand also the use of highly domain-transcending skills.

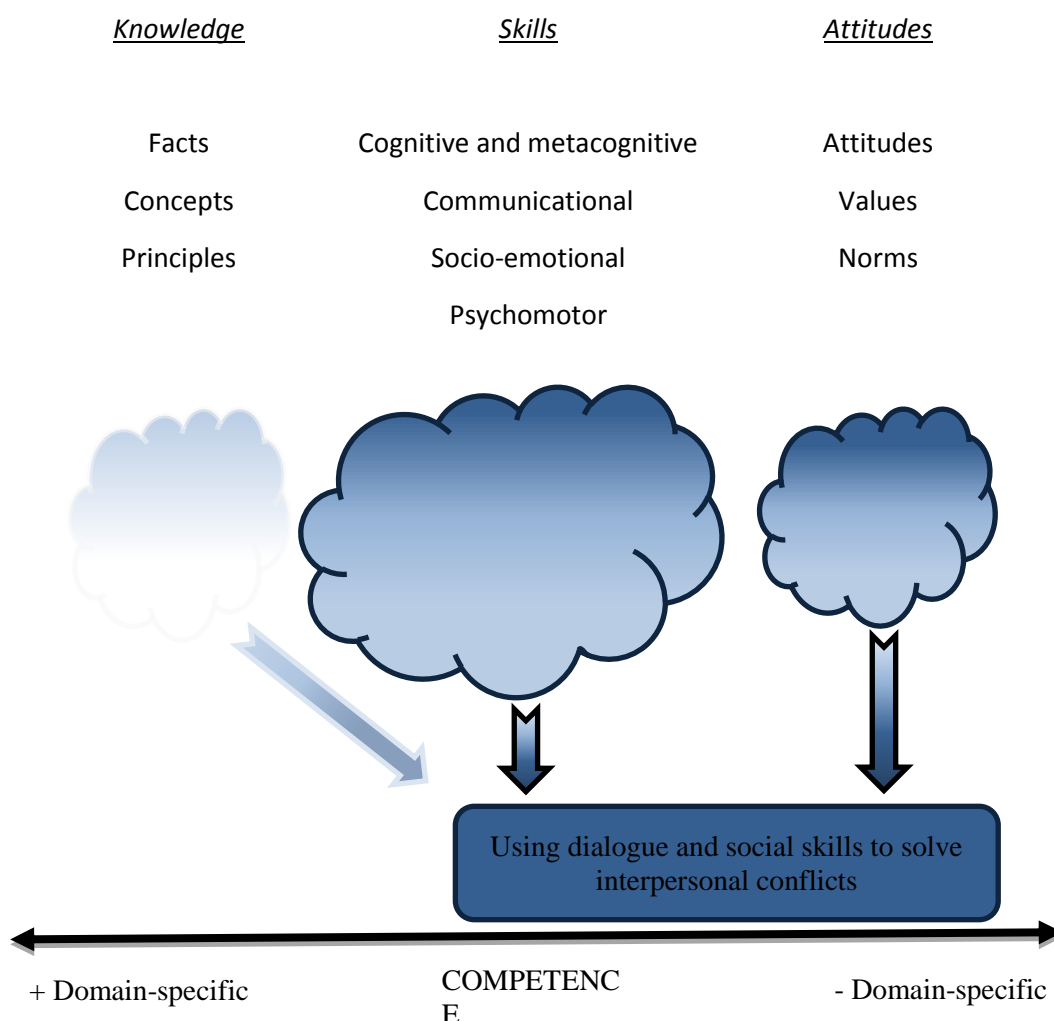
Mathematics is a subject that typically involves domain-specific competences: take, for example, “expressing mathematical ideas clearly and precisely using mathematical language, and understanding others’ ideas”. This competence relies on a large body of mathematical knowledge, especially concepts like the meaning of particular operations, concepts on algebraic calculations, geometric shapes, etc. The student also requires a large set of skills, most of which are relative to the mathematical domain; for instance, cognitive skills like performing function representation, or communicational skills such as using mathematical symbols to represent relations. Although domain-transcending skills and attitudes play a role in acquiring such competences, the emphasis on domain-specific knowledge and skills typically results in highly domain-specific competences. This is shown graphically in figure 1:

**Figure 1: an example of a highly domain-specific competence**



On the other hand, socio-emotional education typically involves highly domain-transcending competences, such as “using dialogue and social skills to solve interpersonal conflicts and promote a peace culture”. The student requires attitudes that can be used across many learning tasks and contexts, like accepting plurality and difference or like identifying and solving conflicts, and norms such as rejection of violence. The student also needs skills that can be largely applied in different contexts and tasks; for example, socio-emotional skills like regulating one’s emotions during discussions, or communicational skills such as expressing one’s opinions assertively. Although knowledge certainly plays a role, the focus on transversal attitudes and skills turns many of the socio-emotional-related competences into highly domain-transcending (see figure 2). In practice, this means that such competences can be learned in and applied to many different school subjects.

**Figure 2: An example of a highly-domain transcending competence**



***Consequences of domain-specific and domain-transcending competences on pedagogies***

When domain-specific competences are promoted, pedagogies must be responsive to peculiarities of the subject knowledge and skills that students have to interiorise, and the nature of the tasks or problems that they have to be solved. *Promoting specific competences may require particular teaching approaches very different from each other.*

For instance, in non-native language teaching, fostering the competence “understanding oral texts from the academic and daily life”, may rely mostly on *teacher-centred approaches* and the promotion of *knowledge understanding*. The teacher is usually the most important source of oral language in the classroom and s/he is in the best position to adapt the complexity and diverse features of their speech to promote higher levels of understanding by the students. A different example is the competence “successfully applying techniques and tactics of different sports” in the domain of physical education. Assuming that students have understanding of certain sport disciplines’ rules, the core of this competence relies on *performing* techniques and tactics in real-life situations. The use of *learner-centred scenarios* that involve students’ practice of those sports leads to the acquisition of disciplines-related techniques, and their strategic application in situations of real game.

The high variability of pedagogical priorities when it comes to teaching domain-specific-competences justifies adopting what we have called a “domain-sensitive approach”. Pedagogies must be planned and executed according to the learning domains and goals that they want to foster. Teaching to promote domain-transcending competences are likely to use pedagogies that are less dependent on the specificities of a particular domain though they will also have their own pedagogical priorities.

Overall, teaching general competences demands a strong focus on *student’s performance*, as the student must learn to apply general attitudes and skills to solve tasks. Such a focus makes *learner-centred pedagogies* particularly suitable to foster such competences. These pedagogies, such as inquiry-based learning or collaborative learning, give the learner an active role and promote the application of key skills and attitudes. In the same vein, *assessment* of such competences demands a strong focus on students’ performance, the use of complex and authentic tasks, and avoiding evaluation excessively focused on discrete knowledge.

This is not to say that instruction of those competences should exclude explicit guidance like teacher’s modelling and demonstrations, or presentation of information. Instruction of general competences should include those teaching formats at some point. Nevertheless, their use should be framed within a setting where the ultimate objective is to promote student’s performance and the adoption of an active role in solving tasks.

General competences like managing and solving conflicts, learning to learn, collaborating, or critical-thinking, transcend domains. Over recent years there has been a growing policy interest in this kind of competences, since most of the “21<sup>st</sup> century competences” (Voogt and Roblin, 2012) have been identified as general competences and not particular of any school subject.

However, such interest has led sometimes to instructional practices “apart from” school subjects and matter. Teaching those competences across subjects does not mean “regardless” of subjects (Partnership For 21st Century Skills, 2009). Teaching general competences among learning domains is key for students to know how to use them in different contexts and, thus, it should be a main objective of instruction. Students must learn the benefits and subtleties of applying those competences in particular domain-related situations. For instance, the skills and attitudes to collaborate in an art project and a mathematical problem-solving process may be different.

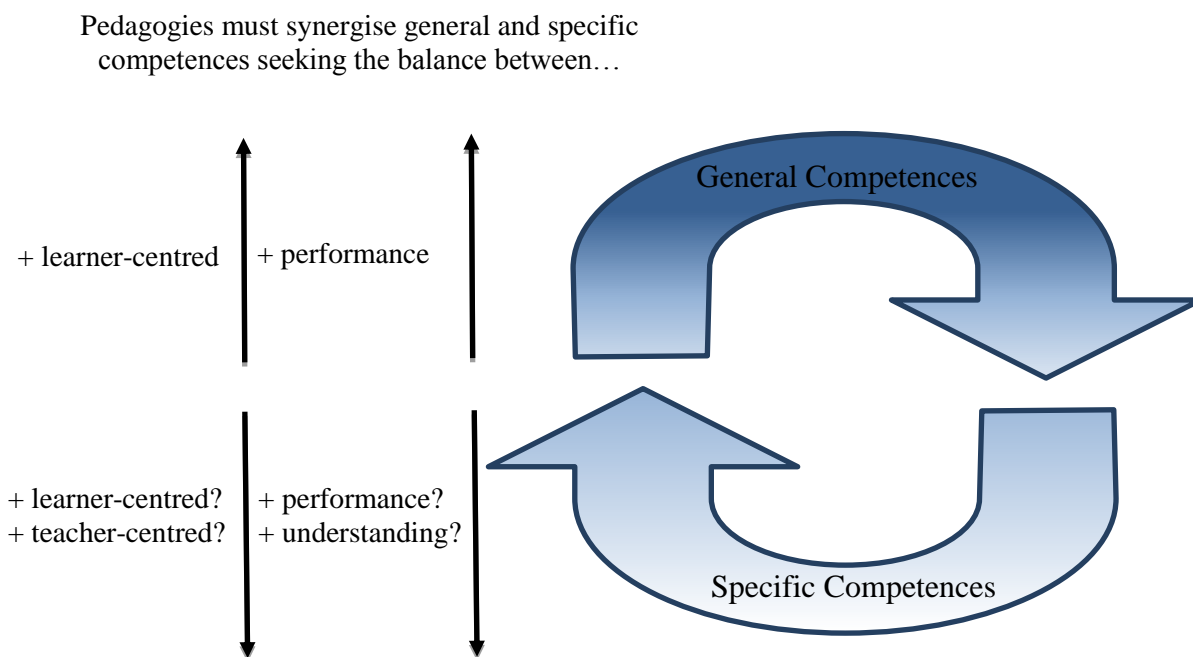
Therefore, *general competences should be ideally taught across subjects*. Case studies among nations suggest improvement of those competences learning when they are integrated across the school curriculum (UNESCO, 2015). Promoting general competences requires transcending the barriers of school subjects. Instruction must look to accommodate general competences to the pedagogical particularities of the subject/s at hand, and vice versa. This is a complex process, because general competences impose their own pedagogical requirements, which must be integrated with the pedagogical particularities of domain-related competences.

Thus, the matter of integrating general competences across the curriculum is not a simple question of adding general-competence-led instruction to specific-competence-driven teaching. Rather, integrating general competences into specific ones is about finding appropriate formulas to sequence and combine pedagogies to promote both kinds of competences at the same time. It is about finding ways for general and specific competences to boost each other.

The pedagogical formulas to achieve such synergy must take into account not only the learning goals (e.g., type of competences), but also key variables of the instructional context. For instance, the students’ expertise in a learning domain is crucial to deciding whether to use teacher- or learner-centred pedagogies

at a given time. Generally, the less able they are to provide internal regulation over the learning task, the more they will need explicit guidance through teacher-centred scenarios, and vice versa (Kalyuga, 2007).

Overall, fostering general and specific competences at the same time means *adopting sequences and combinations of pedagogies that find a balance between teacher-centred and learner-centred approaches; and between focusing on student’s understanding and student’s performance*. We illustrate these ideas in the following figure:



**Figure 3: pedagogies for synergising specific and general competences**

In the following we focus on teaching innovation and improvement efforts in mathematics, non-native language and socio-emotional instruction presenting the distinctive challenges of those three domains that teaching innovation needs to respond to

**Powerful pedagogies in mathematics, non-native language and socio-emotional education: singularities**

***Mathematics education: the on-going search for learner’s liking and increased results***

Despite many reforms, many issues around mathematics learning remain unsolved (Sriraman and English, 2010): *students’ results are seen as poor, and a great deal of learners feel disengaged with the subject* (especially female students). For example, results from PISA 2012 show that fewer than 1 in 100 students performed at the highest level in mathematics (Schleicher, 2014) and about a third (32%) of all students did not reach the baseline level.

Mathematics is a domain with a clear internal structure that heavily relies on the use of a specific notation, which promotes the development of logic and abstraction thinking skills. Mathematics can cover entirely



abstract concepts and relations, with no relation to the “real world” – pure mathematics. Mathematics can also apply such knowledge for practical purposes in fields like natural sciences, social sciences or engineering – applied mathematics.

While traditional teaching has tended to emphasise pure mathematics, more modern approaches tend to focus on applied mathematics. *Mathematics pedagogies should draw on both sides of this domain, seeking an optimal balance between abstraction and application of knowledge.* Pedagogies that over-emphasise any of those sides might induce either lack of interest and functionality (over-emphasising pure mathematics), or lack of understanding of basic concepts and ideas (over-emphasising applied mathematics).

The nature of the mathematics domain, with a clear internal structure and delineated rules as to how to use the mathematical notation, impacts the way that teachers conceive that domain and its pedagogies. For instance, some research suggests that mathematics teachers believe that their subject, compared to other subjects: must be more accurately sequenced; has content boundaries more clearly defined; and has contents that do not change much over time (Stodolsky and Grossman, 1995). Such “closed” conception of the domain may lead some teachers to use pedagogies that draw on isolated, mechanical and routine tasks as the principal means of teaching: mathematics instruction is often more structured and less engaging than other subjects such as social studies subjects (Stodolsky, 1988). Mathematics learning tasks tend to be more mechanical and less cognitively complex than in other subjects.

Pedagogical innovation is currently trying to meet the challenge of increasing students’ engagement and learning outcomes such as by using pedagogies that foster more open, complex and authentic tasks, such as problem-based, project-based, and inquiry-based learning (Atkinson and Mayo, 2010; Lesh and Zawojewski, 2007; Ruthven, 2011; Savelsbergh et al., 2016). Effective pedagogies need to focus on student’s mathematical reasoning and sense-making (Boaler, 2012), like fostering a conceptual discourse instead of a calculational one (Cobb and Jackson, 2011). Pedagogies may also promote visualisation of representations and the manipulation of materials to enhance understanding of mathematical relationships (NCTM, 2014), as in manipulative-based pedagogy (Carbonneau and Marley, 2012). Mathematics teaching can also rely on meta-cognitive processes as a way of improving students’ abilities to control mathematics learning (Mevarech and Kramarski, 2014). Likewise, pedagogies may draw on collaborative settings as a means to improving students’ engagement and learning outcomes (e.g., Slavin and Lake, 2008). Some research also suggests that using technology as a complementary support of teacher instruction (e.g., video gaming, computer-assisted instruction) can yield positive results (Steenbergen-Hu and Cooper, 2013).

The challenge of increasing student liking and results generally faces adverse motivations and emotions towards mathematics learning compared with other subjects (Punaro and Reeve, 2012; Wigfield & Eccles, 1992, 1994). Research also suggests that students’ self-efficacy in mathematics is more tied to their perceived personal ability to do the tasks, compared to other subjects (Stodolsky, Salk and Glaessner, 1991).

Negative attitudes towards mathematics learning of some students may be formed early in primary school (Larkin and Jorgensen, 2016). Blatchford (1997) suggests that when differences among domains are formed, such as higher students’ self-perceived ability for language learning compared to mathematics, they tend to remain throughout primary and secondary school. From a student’s point of view, perceived difficulty and lack of confidence (especially for female students) help to explain their disengagement with mathematics (Brown, Brown, & Bibby, 2008; Köğçe et al., 2009; McLeod, 1992).

The nature of mathematics may contribute to give students a positive sense of clearly delineated work and control over contents; however, it may also contribute to negative aspects like some students’ lack of confidence and learning anxiety. The perceived nature of the mathematics domain can lead to a sense of “obviousness” about mathematical concepts and calculations (e.g., mathematical calculations follow clear

steps and have an evident result). That sense of obviousness clearly reveals and exposes students' mistakes which, if not treated appropriately, may reinforce some students' insecurity and anxiety.

This all points to the importance of using pedagogies that treat learners' mistakes in mathematics to promote (and not impede) student learning (Borasi, 1994; Gresalfi et al., 2009). Likewise, some research highlights the importance of using a growth mind-set for increasing student's self-efficacy beliefs, and reducing their anxiety in task-solving (Boaler, 2011; Rattan, Good and Dweck, 2012).

### ***Non-native language education: looking for more time-efficient ways of instruction***

There is growing interest in finding more effective and efficient ways of promoting language acquisition. Among educational stakeholders there is certain discontent to find out that after many years of non-native language school instruction, the average student still struggles to accomplish daily tasks like holding a real conversation fluently. Research and innovation are thus challenged to *find pedagogies that make optimal use of instruction time and that can yield better results*.

All human languages have an obvious communicational function to sustain social life. Such communication draws on signs to refer to particular meanings. Languages also have a clear internal structure with specific rules on how to combine phrases, words and morphemes (i.e., grammar). This twofold nature of language has long impacted pedagogies, producing teaching practices focused either on communicative purposes, or centred on grammar acquisition producing a longstanding tension between the two (Musumeci, 2009). Non-native language teaching should find the right balance between those two elements as fluency and accuracy are both relevant for language command (Dalili, 2011).

Acquiring a language from birth is a process that is based on the communicative use of such language, and the implicit learning of its grammatical rules. Non-native language acquisition requires something other than implicit or "natural" learning of grammar. As a consequence, non-native language pedagogies have often responded by (over)emphasising the importance of explicit learning of grammatical rules at the expense of communicational use of language.

Accepting the challenge of combining communication and grammar gives a clear direction as to where innovative pedagogies should be headed. For instance, pedagogies should provide both input to the learner, and opportunity to create output (Wong, 2013). Pedagogies need to ensure that learning of grammatical form and communication are interconnected; and that they both are embedded in meaningful and authentic contexts (Dalili, 2011). Common pedagogies that attempt to respond to those challenges are task-based learning (Ellis, 2003), and project-based learning (Chang and Tung, 2009).

Likewise, the challenge of making the most of non-native language instruction may be responded to through extending it, both time and space-wise. That means connecting such teaching to other contexts - within the school, the meso-system, and the wider world. For instance, using non-native language as an instruction medium in other school subjects, as in bilingual or school immersion (Cummins, 2009); through place-based approaches that lead to study abroad experiences (Collentine, 2009); and using technology to connect learners to communities of practice where they have the chance to interact with native speakers (Black, 2009).

***Socio-emotional education: looking to become transversal, everyday teaching***

Over recent decades, research has shown that socio-emotional education can have a positive impact on many school-related processes. This has interested policy makers and practitioners, and has placed socio-emotional education on the educational agenda. Research has found that socio-emotional education may enhance subject-related learning outcomes (Durlak et al., 2011). Since socio-emotional education encompasses key transversal competences like collaboration and decision-making, this domain is increasingly regarded as important in fostering some of the so-called 21<sup>st</sup> century competences. Likewise, socio-emotional education can have a positive impact on students' well-being and the school climate (Djambazova-Popordanoska, 2016). Furthermore, socio-emotional education may in general contribute to social progress and prosperity (OECD, 2015).

Given this, socio-emotional education aspires to become a basic and transversal foundation of school education though it is not usually included in formal assessment for student promotion, and for teacher and school accountability in OECD countries (OECD, 2015). This may well weaken initiatives promote socio-emotional competences.

The socio-emotional domain embraces competences that can be learned and applied to many school subjects, facilitating its merging with other subjects learning. Thus, *innovation in the socio-emotional pedagogies is currently challenged to find ways of promoting such competences across curricular areas and learning contexts*. Socio-emotional education tends to be addressed in OECD countries through specific subjects (e.g., civic and citizenship education, physical and health education), and/or transversally across many curricular subjects (OECD, 2015). Hence, measures should incentivise interdisciplinary instructional initiatives, and professional development should aim at teacher competence to implement such endeavours.

The socio-emotional domain refers to the conjunction of the emotional and the social. It embraces both competencies referred to the "self" (and, especially to the emotions and feelings produced by oneself), and to the sphere of social relationships (CASEL, 2005). Self-related competences include, for example, self-awareness and self-management. Social competences include for instance social awareness and relationship skills. Therefore, *socio-emotional pedagogies should aim at the appropriate integration of working with the learners' personal feelings and thoughts, and acting on their social relationships*.

Promoting these sorts of competences demands a strong focus on learner-centred pedagogies and the performance-based. These pedagogical priorities accord with research that finds that social studies teachers overall conceive their subject as less defined, less sequential, and more dynamic than other subjects (Stodolsky and Grossman, 1995). As a consequence, social studies teachers may have a tendency to use less structured approaches, and a wider range of tasks to engage students (Stodolsky, 1988).

Pedagogical innovation in the socio-emotional domain seeks to respond to these challenges, for instance, active and performance-based pedagogies that work on students' personal feelings and their relationships like role-playing, collaborative-based pedagogies, gaming, case-study, and social problem-solving pedagogies (Durlak et al., 2011; Durlak, Weissberg and Pachan, 2010; Rimm-Kaufman and Hulleman, 2015). The use of collaborative approaches like small group learning, and socially interactive pedagogies like discussion-based learning are especially important for promoting communicational and emotional skills, as well as pro-social attitudes (Sprung et al., 2015; Yoder, 2014; Zins and Elias, 2007). The use of mindfulness-based approaches, where students focus on their current emotions and experiences, has gained importance and some research supports its implementation (Frank, Jennings and Greenberg, 2013; Zoogman et al., 2015).

Research on innovative experiences highlights the importance of integrating socio-emotional learning goals across curricular areas (UNESCO, 2015), and using meaningful and authentic opportunities for its learning. Likewise, socio-emotional pedagogies need to adopt a communitarian perspective, and mobilise different agents of the student's meso-system (Cohen et al., 2015; Elias, 2014; Thapa et al., 2013). Instruction is especially effective when aiming at improvement of the whole school climate.

### **Powerful pedagogies in mathematics, non-native language and socio-emotional education: common themes**

In this section we present in more detail the tendencies of pedagogical innovation and enhancement in the three domains using the seven principles of powerful learning (Dumont, Istance and Benavides, 2010) from previous OECD work.

#### ***Pedagogies for learner's engagement***

The first principle of powerful learning establishes that “the learning environment recognises the learners as its core participants, encourages their active engagement and develops in them an understanding of their own activity as learners” (Dumont, Istance and Benavides, 2010: 14).

In mathematics teaching, *problem-solving*, *project-based learning*, and *inquiry-based learning* are often used for increasing student engagement (Atkinson and Mayo, 2010; English and Sriraman, 2010; Ruthven, 2011; Savelsbergh et al., 2016). Problem-solving approaches usually revolve around a central problem or task that the student must solve (and sometimes pose too); project-based approaches involve planning and managing more complex and longitudinal tasks to create artefacts or give response to mathematical challenges; inquiry approaches involve students devising research questions and methods, collecting and analysing data, and interpreting the results.

These pedagogies currently face key challenges such as:

- Coupling learning of problem-solving skills with understanding of mathematics knowledge;
- Implementing effective scaffolding strategies likely to sustain learning;
- Abandoning routine and decontextualized problem-tasks as the main means of learning.

Indeed, these approaches usually recommend *using real-life, complex, non-routine tasks* where students have to create artefacts and interpret situations. Those problems, projects and inquiries may allow students to flexibly use mathematical procedures as well as domain-transcending skills (NCTM, 2014). Leveraging metacognitive skills, pedagogies based on metacognition have been used for increasing student's engagement and acquiring self-regulation competences (e.g., Mevarech and Kramarski, 2014). Here teachers scaffold their students by posing certain questions and helping them to find appropriate answers for promoting comprehension and strategic thinking.

Other strategies to enhance student's engagement are promoting *visualisation of mathematical relationships* to deepen student's understanding of mathematics contents. Students may draw on *multiple representations* like diagrams, graphical displays and symbols to help them visualise relationships (Flores et al., 2015). Likewise, pedagogies may foster students' physical interaction with objects to learn specific contents – *manipulative-based pedagogies* (Carbonneau and Marley, 2012). In this case, teachers may use play money with primary students to teach arithmetic functions, or plastic algebra tiles to teach multiplication and division skills. Meta-research studies show small to moderate effect sizes in favour of

such approaches compared with instruction that only uses symbolic information (Carbonneau, Marley and Selig, 2013).

*Encouraging reasoning and sense-making* is key for students to feel more engaged with mathematics (Boaler, 2012). Research suggests that pedagogies must focus on fostering understanding of tasks and contents, as it increases agency over the mathematical domain and learning transfer into adulthood.

Some research shows the benefits of engaging students through *discussion-based* approaches where they are encouraged to explain their own mathematical ideas, and to compare and connect those with other students' ideas (e.g., Ing et al., 2015). A fundamental aspect of these pedagogies is *promoting a conceptual discourse* where students explain why they used certain mathematical procedures, instead of a calculational discourse where students explain how they achieved the result (Cobb and Jackson, 2011; Webb et al., 2014).

Other studies focus on students' *identity as mathematics learners* (Andersson, Valero and Meaney, 2015; Gresalfi and Cobb, 2011), and their "*sense of belonging*" to mathematics – student's feelings of membership in the mathematics domain (Good, Rattan and Dweck, 2012), to explain student's engagement in mathematics learning. This partly explains the gender gap – female students' worse learning outcomes, and lower degree of commitment to pursue maths in the future. Pedagogies should thus work on student's self-definition as mathematics learners, their past experiences in mathematics, and their future expectations.

As for non-native language teaching, pedagogies engage students in language mastery when they foster both *mental representation of that language*, and *the ability to use it functionally* (Van Patten and Benati, 2010). Pedagogies should both ensure *structured input* to the student (receiving well-designed contents), and engage them in *producing output* (generating meaningful messages) (Wong, 2013). The regular use of a certain pedagogy that leaves aside any of those ingredients means neglecting either understanding or performance in language acquisition. For example, developing skills without mental representation like drilling, or providing input to the student through reading and listening, but not fostering output through speaking and writing.

Mirroring some of the proposals of mathematics teaching, common pedagogies in this field include *task-based* (Ellis, 2003) and *project-based learning* (Chang and Tung, 2009). Tasks should not be confused with "exercises" as tasks are based on real-life situations and focus on meaning rather than linguistic structures. These type of approaches provide opportunities for learners to explore and experiment with non-native language through *authentic, meaningful and functional use of language*. Comprehension and analysis of grammatical form is also encouraged, but the overall focus remains in communicating (Long, 1991; Nassaji and Fotos, 2010).

Other tendencies that may potentially increase student's engagement are:

- The *drama and movement-based teaching* (especially for early childhood learners), where kinaesthetic activities assist developing decoding skills, vocabulary, and fluency improvement (Rieg and Paquette, 2009). Nevertheless, there is still little empirical evidence on its impact on learning (Belliveau and Kim, 2013).
- *Storytelling*, where students engage in tasks like role-play or creating a digital narrative that revolve around a particular plot and characters. Some studies suggest potential positive consequences on learning outcomes, especially in primary school (Moodie and Nam, 2016).
- *Computer-Assisted Language Learning (CALL)*, where technology may support learning of specific vocabulary or pronunciation skills (Golonka et al., 2014; Presson, Davy and MacWhinney, 2013). Such materials include resources like map tours, subtitled video, chat rooms and learning

games. There is some evidence that learners tend to be more engaged when using technology over more traditional materials (Golonka et al., 2014). Nevertheless, meta-research up to date corroborates only the strong positive impact of computer-assisted pronunciation training and chat.

Socio-emotional teaching usually emphasises active and performance-based pedagogies to foster effective learning of those competences (Durlak et al., 2011; Reyes and Elias, 2011). Practice is necessary for the acquisition of socio-emotional competences and, therefore, the student's performance is a crucial ingredient of successful pedagogies.

*Role playing, gaming, collaborative-based pedagogies, discussion-based learning, case-study, (social) problem-based pedagogies, and service-learning* are commonly referred to in meta-studies as potentially effective pedagogies for socio-emotional learning (CASEL, 2013; Clarke et al., 2015; Durlak et al., 2011; Payton et al., 2008; Rimm-Kaufman and Hulleman, 2015; Sprung et al., 2015; Zins and Elias, 2007). These pedagogies allow the focus on students' personal feelings and relationships. In combination with teaching in which the teacher provides appropriate support such as presenting information, modelling and giving feedback, these pedagogies may effectively foster the practise and acquisition of new behaviours.

A common feature of socio-emotional pedagogies is engaging students in behaviour change *through their own ability to self-regulate*, rather than through direct regulation of their behaviour (Domitrovich, Cortes and Greenberg, 2007). Pedagogies seek to create opportunities for students to be self-directive, activating meta-cognitive and meta-affective processes. Teachers help students to derive the logical consequences of not following the rules, but avoid over-managing student's behaviour (Yoder, 2014). Likewise, pedagogies look to engage student in learning by increasing their autonomy and responsibility (Rimm-Kaufman and Hulleman, 2015). For instance, teachers give students structured and meaningful choices, as in students contributing to create classroom rules.

### ***Pedagogies for social learning***

Powerful learning is based on the development of social activities that can sustain learning. According to Dumont, Istance and Benavides (2010: 15), "The learning environment is founded on the social nature of learning and actively encourages well-organised co-operative learning".

In mathematics instruction, initiatives that change the pedagogy are more likely to yield positive results, instead of simply "adding" new elements via curriculum like using new textbooks or a certain technology platform. The strongest effects are associated with the implementation of *cooperative-learning programs* (Slavin and Lake, 2008; Slavin, Lake and Groff, 2009).

Therefore, implementing well-designed co-operative-based pedagogies becomes an important principle of effective mathematics education. When using *small group learning*, members' interactions must be characterised by the *contribution of all its members* (Cobb and Jackson, 2011), where teachers interject to guide learners and solve doubts when necessary. Through discussions, students can bring up productive *cognitive conflicts*. As students' different interpretations emerge, they "suffer" cognitive perturbations which facilitate the reorganisation of their mathematical reasoning.

Collaboration and social interaction underpin most of technology's potential in mathematics instruction. Using *technology* to complement the teacher – Supplemental Computer-Assisted Instruction - yields better results than just using technology to deliver instruction – Computer-Management Learning (Cheung and Slavin, 2013; Steenbergen-Hu and Cooper, 2013). In the same vein, *videogames* work better when they are

used by highly interactive teachers (Atkinson and Mayo, 2010) and have great potential to promote student collaboration.

Collaboration and social interaction is also a cornerstone of non-native language teaching. For instance, developing *instructional conversation* is an important resource for integrating communicational and grammatical learning aims. Teachers or more expert peers scaffold the learner through meaning-centred interaction. They hold meaningful verbal exchanges, while helping the learner to focus on grammatical forms (Dalili, 2011).

*Language minority children*, who learn the societal language as a non-native tongue, can especially benefit from cooperative learning (Cheung and Slavin, 2012). Peer support gives learners the chance to improve their confidence in using academic linguistic codes in meaningful contexts. *One-to-one tutoring* and *small group learning* may support those students in acquiring better reading skills.

*Technology* opens up new avenues to change traditional teacher-centred instructional settings; for example, by facilitating communication with native speakers through social networking sites, or establishing communities through virtual worlds (e.g., Chen, 2016). Meta-research shows that mobile devices can especially support language learning when they present different approaches based on a mix of pedagogies where social interaction is often present, such as self-directed study and a collaborative learning task (Sung, Chang and Yang, 2015).

The value of social and collaborative settings for socio-emotional teaching and learning is obvious, because they represent both the means and the final purpose of such instruction. Therefore, collaborative approaches like small group learning and socially interactive pedagogies such as role-playing or social problem-solving are recurrent resources for promoting socio-emotional competences.

When socio-emotional education crosses subjects, there is common value in *collaborative learning pedagogies*, where students work towards collective goals and seek to gain communication and emotional skills as well as pro-social attitudes (Yoder, 2014; Zins and Elias, 2007). Likewise, other *socially interactive pedagogies* like social problem-solving look to engage students inviting them to bring in their own viewpoints and feelings and to engage in dialogue critically and respectfully. Teachers support the discussion, ensuring that everyone has the sufficient knowledge, skills and attitudes to hold a meaningful dialogue.

Socio-emotional pedagogies may indeed have a recursive *positive effect on learning outcomes* across subjects, as they address important social dimensions of learning (Durlak et al., 2011). Socio-emotional instruction can build on social factors that sustain powerful learning such as improving student-teacher and peer-to-peer interactions, or enhancing the classroom and school climate (Zins and Elias, 2007). Socio-emotional instruction can combat *dropping out* of school as it opposes its main causes, namely, not getting along with peers or teachers, or feeling left out. This is especially true for virtual educational settings, where socio-emotional connections are key to keeping students engaged (Delahunty, Verenikina and Jones, 2014). Therefore, virtual teaching can benefit especially from using socio-emotional pedagogies that foster social interaction and the construction of a sense of community.

### ***Pedagogies for learner's motivations and emotions***

Emotions, affect and motivation are key aspects to powerful learning. “The learning professionals within the learning environment are highly attuned to the learners’ motivations and the key role of emotions in achievement” (Dumont, Istance and Benavides, 2010: 15).

As for mathematics teaching, innovation may address two interrelated aspects that have a major role in hampering mathematics learning: fixed mind-sets on mathematics intelligence, and mathematics anxiety. Mathematics pedagogies should promote *growth mind-sets* –the belief that mathematics intelligence can be developed by learning specific mathematical contents. Pedagogies should be founded on growth mind-set messages because they have a large positive impact on student’s attainment (Boaler, 2013; Rattan, Good and Dweck, 2012). Conversely, pedagogies that rely upon fixed ability thinking, such as rigidly and permanently grouping students by their prior competences and outcomes, risk to increase inequality and limit student’s attainment.

Pedagogies should also address the important issue of *mathematics anxiety* (Dowker, Sarkar and Looi, 2016). Some studies distinguish between anxiety as state – the temporary anxiety felt when facing or anticipating certain mathematical tasks - and anxiety as trait – the stable attitude of rejecting and feeling anxiety towards the mathematical domain (Buckley et al., 2016). State mathematics anxiety decreases learning outcomes, while trait mathematics anxiety leads to avoiding subjects and careers involving mathematics. Pedagogies face a double challenge here: preventing anxiety in learning tasks in the short term, and increasing engagement with the domain in the long term.

Three ingredients emerge for innovation through pedagogies to promote growth mind-sets and prevent mathematics anxiety:

- *Encouraging learning progress and awareness.* Pedagogies encourage every student to advance their learning, and foster self-awareness of their personal progress.
- *Treating mistakes productively* to enhance mathematics learning while preserving self-esteem and self-efficacy beliefs. Pedagogies should treat mistakes as opportunities for learning (Ingram, Pitt and Baldry, 2015), providing conceptual and procedural tools to overcome errors in a supportive environment.
- *Emphasising mathematical processes instead of final results.* Pedagogies avoid over-emphasis of “right answers and right methods”, and focuses on developing ways of reasoning and doing mathematics (Philipp, 2007). Learning assessment shifts from appraising “the final answer” to evaluating student’s comprehension (Näslund-Hadley, Cabrol and Ibararan, 2009).

Some experiences developed around *assessment for learning* suggest that when students are assessed and given feedback throughout their learning, their levels of mathematics anxiety are lower (Núñez-Peña, Bono and Suárez-Pellicioni, 2015), as they become more aware of their learning advances and difficulties, and empowered to further learning.

Innovation in non-native language instruction has also focused on preventing *language anxiety* (Hashemi and Abbasi, 2013). Language anxiety is more likely to appear in students in listening and speaking tasks (Horwitz and Young, 1991). The goal is not to suppress pedagogies based on those tasks, but to find ways of helping students overcome their anxiety. Common sources of language anxiety by students are: excessively demanding expectations by teachers and very formal classroom settings; specific tasks like giving presentations in front of the classroom; and fear of making mistakes and losing one’s positive image in front of teachers and peers.

Research suggests (Hashemi and Abbasi, 2013):

- *Treating linguistic mistakes naturally*, providing constructive feedback to overcome mistakes but not interrupting the communicative flow, like providing corrections once the student’s presentation is over.
- *Discussing emotions overtly in the classroom*, making clear that feelings of insecurity and uneasiness are very common while speaking a non-native language.



- *Encouraging the participation of all students* in collective activities, including those who may regularly avoid making a public contribution, reassuring and positively reinforcing their performance.
- *Setting high but realistic expectations for every student*, but avoiding perfectionist approaches such as achieving perfect pronunciation or faultless grammar.
- *Making the classroom environment more informal*, like using gaming pedagogy or drama-based pedagogy.

The concept of “*integrativeness*” is key for pedagogies to promote student’s motivation (Gardner, 2006). Integrativeness refers to promoting positive attitudes towards the non-native language community and interest in acquiring their language and feeling integrated within that community. Pedagogies that look to promote student’s interaction with native speakers and knowledge about their community, such as study abroad, discussion and collaborative pedagogies through technology offer opportunities to foster such motivation.

The emotional field is a crucial underpinning of socio-emotional teaching. Students’ emotions are both the medium and the final goal of socio-emotional education. Socio-emotional instruction generally yields *positive emotional-related outcomes*, such as students’ positive self-perceptions and bonding to the school, decreased emotional distress and disruptive behaviours (Payton et al., 2008; Rimm-Kaufman and Hulleman, 2015).

Those emotional processes are thought to have a positive impact recursively on learning outcomes across subjects (Durlak et al., 2011). Advances in the field of psychology and neuroscience have established that *emotion and cognition* are more integrated in humans’ brains than previously thought (D’Mello and Graesser, 2012; Immordino- Yang and Damasio, 2007). While it is perfectly reasonable and useful to distinguish between emotion and cognition, those two processes happen to a large extent in an integrated and overlapped fashion in the human mind. Key cognitive processes that lead to learning like reasoning or attention are driven and initiated by emotional processes, and they occur in prototypical combinations. These are serious reasons for innovative pedagogies to seek learning improvement from “the emotional side”, alongside the cognitive.

One approach that has gained momentum over the last years is *mindfulness*. This approach makes the participants focus on their present experience and emotions with the aim of achieving greater levels of well-being (Baer, 2003). This kind of programme targets either the teacher or the students. In the first case, the programme looks to directly increase the teacher’s well-being and emotional competence and, indirectly, to improve the classroom climate and students’ academic outcomes (Jennings et al., 2011; Roeser et al., 2013). Although research on this topic is still not plentiful, it suggests that when the teacher is calmer and less emotionally reactive, the students’ needs for safety and structure are better fulfilled, and their need for acting out decreases.

When the programme is addressed to students, it typically aims to promote emotions regulation, stress control, and identification of somatic symptoms (Zoogman et al., 2015). Research shows that experiences of mindfulness and yoga-based programmes may decrease students’ hostility, and enhance their interpersonal relationships and emotion-regulatory skills. Mindfulness pedagogies are compatible with a wide range of learner-based approaches where students have to focus and work on their own feelings and experiences, such as discussion-based learning or role-playing.

Socio-emotional programmes have been used for *preventing school violence* as well (e.g., Cedeno et al., 2010), by enhancing students’ feeling of belonging to the school, student’s individual coping skills, and school climate (Thapa et al., 2013). Such experiences suggest that pedagogies can support such goals when they target specific emotion-related processes, namely: giving students a voice and involving them in

school issues; using collaborative and social pedagogies; avoiding discrimination and counteracting stereotypes; and communicating high expectations and recognising the student's efforts.

### *Pedagogies for individual differences*

Powerful pedagogies consider every student's learning needs and include every learner in the educational process. "The learning environment is acutely sensitive to the individual differences among the learners in it, including their prior knowledge" (Dumont, Istance and Benavides, 2010: 16).

Research and innovative mathematics instruction often acknowledge reaching all students as a key component of enhancing teaching. A multiplicity of student variables produce differences in the way students learn mathematics. Over recent decades, two main variables have gathered most of the attention: the influence of gender, and the role of socio-economic and cultural background in mathematics learning (Pais, 2012). Among the causes of the gender gap, research commonly cites an interaction between biological factors, students' personal beliefs and emotions where mathematics anxiety plays a prominent role, the perceived usefulness of maths in the future, and teachers' differential treatment (Jacobs, 2010).

Pedagogies should take into consideration the cultural beliefs and stereotypes that underlie those differences, and attempt to undermine them (Mendick, 2005; Gherasim, Butnaru and Mairean, 2013; Kaiser, 2010):

- Watching out for grouping or tracking measures such as fixed ability grouping that might end up discriminating students according to their gender; when students are grouped, student distribution should reflect a gender balance (Esmonde, 2009).
- Avoid pedagogical techniques that might reinforce boys' performance at the expense of girls such as competitive settings by instead setting up collaborative and supportive environments.
- Using pedagogies that emphasise discussion: addressing not only cognitive aspects but also emotions during the learning experience. Talking and writing about emotions in the classroom (e.g., Park, Ramírez and Beilock, 2014) may have beneficial consequences for those students less engaged with the domain.

Students' *socio-economic and cultural background* impacts the way they tend to reason and talk about mathematics, and how they shape the norms and practices established in the classroom (Cobb and Hodge, 2002). Pedagogies should look to align mathematics classroom expectations with the cultural frameworks of all students. Some experiences propose contextualising the learning tasks into the communitarian and cultural context of the students, including the use of place-based learning experiences, as an opportunity to improve students' understanding of mathematical contents (González, McIntyre and Rosebery, 2001). Proposals in that regard advocate the use of de-tracked grouping where tasks are appropriate for different levels (e.g., Boaler, 2008; Marks, 2014), and capitalise on students' diversity as a resource for teaching instead of experiencing it as a source of problems.

Another approach to analysing the impact of individual differences on mathematics learning is *educational neuroscience*. Basic research in this field has identified how brain areas are activated differently across learners in certain mathematical tasks, hence opening the way for better understanding the biological foundations of individual differences (Looi et al., 2016). Nevertheless, these results have not yet produced clear pedagogical direction as to how to make the most of those individual differences. The main challenge of educational neuroscience for the next years to come is to engage in interdisciplinary work to guarantee ecological soundness of its results, and to produce practical outcomes likely to shape more effective pedagogies (Campbell, 2010).

As for non-native language teaching, research on language acquisition has traditionally pointed to *learner's age* as the key factor to predict facility of language learning (Long, 1990). The younger the learner, the more they will rely on natural-communicational activity to acquire the language, and the more quickly they will do it. The older the learner, the more they will depend on the deliberate learning of knowledge and meta-knowledge like grammar rules; and the more slowly they will learn the language. This would suggest that during the learners' early years pedagogies for language acquisition should focus on *communication-based approaches*, while from a certain point on those pedagogies should be mixed with *grammar-based approaches*.

While the existence of maturational issues in language acquisition is undeniable, there is a lack of evidence about clear maturational cut-off points associated with the end of a critical period for learning a non-native language (Muñoz and Singleton, 2011). Moreover, there are many other variables that predict the effectiveness of non-native language learning. For instance, the degree of similarity between native and non-native language and the learners' attitudes and motivations towards language learning (Lindgren and Muñoz, 2013). Therefore, non-native language pedagogies should go beyond the age factor and consider how to adjust when students have different mother tongues, and how to promote positive attitudes and motivations to learning.

Paralleling mathematics instruction, a comparable interest on *socio-economic and cultural learner's variables* has also emerged in non-native language teaching. Pedagogies must take into account the cultural conventions of the student's cultural group, because they may impact the way they regard the non-native language and its learning (García et al., 2010). For instance, motivation and emotions are not homogeneous across students from different cultural backgrounds. Those in Confucian heritage cultures (e.g., Chinese, Japanese, Korean) display higher language anxiety levels than in European and South American cultures (Woodrow and Chapman, 2002).

For *language minority children* who learn the societal language as a non-native tongue, although they tend to perform less well than their native-speakers classmates (e.g., lower reading comprehension), they often catch up during primary school if appropriate measures are adopted (Chen, Geva and Schwartz, 2012). Some research suggests using programmes of bilingual school immersion, where the societal language is learned across subjects. These experiences are often led by a content-based language pedagogy that provides a language focus within subject matter activities (Dalton-Puffer, 2011). Nevertheless, a daily block of time may also be devoted to such language learning itself (Saunders, Goldenberg and Marcelletti, 2013). These programmes often recommend carefully grouping students by language proficiency during those blocks of time, but not segregating them throughout the rest of the day.

Socio-emotional teaching is also progressively developing interest in understanding the role of individual differences in socio-emotional competences and how to respond to different student profiles. Research has also focused on key differences related to students' gender and socio-economic and cultural background. Some studies suggest the existence of *gender differences* in such competences in favour of female students, which can be already identified in early school years. Boys are often perceived as more aggressive and less pro-social than girls (Keenan and Shaw, 1997; LaFreniere and Dumas, 1996), and less able to identify emotions than girls (McClure, 2000). Likewise, learners from disadvantaged *socio-economic backgrounds* tend to show less socio-emotional competence starting from the early stages of their development (Campbell and Stauffenberg, 2008; Ryan, Fauth and Brooks-Gunn, 2006).

Denham et al. (2012) advocate a *person-centred approach* to socio-emotional education, as not every student has the same learning needs. They were able to identify different socio-emotional profiles in early childhood learners:

- *At-risk*: learners have trouble understanding emotions and regulating their behaviour, along with aggressive patterns for problem-solving and the common display of negative emotions;
- *Competent-restraint*: learners generally have good competence but show aggressive responses in problem-solving, along with less social interaction;
- *Competent social-expressive*: learners commonly display good competence in all aspects.

These works suggest that socio-emotional education would benefit from using pedagogies that consider the learners' needs and adjust to them. Adoption of personalised approaches could benefit everyone, but especially those who gather certain variables associated with an at-risk profile.

Some studies suggest that socio-emotional education may contribute to *student's resilience*, though the evidence is also not well developed (Ager, 2013). Socio-emotional programmes should be adapted to the particular circumstances of the students and provide learning objectives and tasks suitable for their socio-cultural background (Elias and Haynes, 2008). Pedagogies should strengthen teacher support, as it is crucial to foster school attendance and positive learning outcomes of students from disadvantaged backgrounds (Roorda et al., 2011). Developing socio-emotional competence in school is important because it provides the opportunity to acquire such competences for children who do not necessarily have ideal role models at home.

### ***Pedagogies for challenging students***

Pedagogies are effective when they promote learning with tasks that students cannot solve immediately and automatically, but that they can sort out with the appropriate support and effort. "The learning environment devises programmes that demand hard work and challenge from all without excessive overload" (Dumont, Istance and Benavides, 2010: 16).

Mathematics teaching acknowledges the importance of working on challenging tasks, but at the same time providing students with *continuous support and opportunities to overcome difficulties*. The learning task difficulty should be adjustable to the learner, and should challenge them to reason through the use of multiple resources to represent mathematical phenomena like graphics or puzzles (Boaler, 2012). Overall, the sequence of learning tasks should present an increasing degree of difficulty, whereby the student reaches further understanding and performance (Cobb et al., 2011).

This balance between challenge and support underlies some of the concerns about learner-centred approaches in mathematics (e.g., problem-solving, project-based learning, discovery learning), as well as in other domains (Kirschner, Sweller and Clark, 2006). Problem-solving requires mastering complex and difficult skills like strategic thinking, meta-cognitive, and social skills, as well as conceptual knowledge (English and Sriraman, 2010). Project-based learning requires that students develop worthwhile questions, plan and monitor complex tasks, and collaborate effectively (Atkinson and Mayo, 2010). Yet it is unlikely that all these elements will be acquired by students exclusively working on their own. Therefore, learner-centred approaches should ensure that students have the knowledge, skills and attitudes to follow, leaving room to implement more teacher-centred strategies such as modelling or lecturing when necessary.

Appropriate scaffolding is also important in helping students overcome *disengagement with mathematics* (Guifford, 2014). For instance, some research shows that the use of short and intensive *one-on-one tutoring* programmes could alleviate mathematics anxiety of students (Supekar et al., 2015). Other studies have focused on using a variation of problem-based learning, *problem-posing*, where students are challenged to come up with their own problem formulations (Cai et al., 2015) or highlight the importance of challenging students to use *creativity* in mathematics learning (Mann, 2006), which emphasises the importance of using open-ended tasks and promoting critical thinking (Lev-Zamir and Leikin, 2011). Creativity is thus

considered as an essential component of mathematics learning that enables elaboration of constructs and development of abstract ideas.

Non-native language teaching also stresses the importance of making tasks progressively more demanding for the student (Barcroft, 2012): pedagogies should ensure that the learner is constantly, but appropriately, challenged to understand increasingly more difficult input, and to produce more complex and correct output.

As for the *input*, the student can be frequently presented with new words, expressions, grammatical forms, and text genres. This may happen not only through intentional learning – following designed sequences and materials - but also through incidental learning such as acquiring new vocabulary through informal or unplanned messages (Sharples et al., 2015). New grammatical forms and words may be embedded in sentences or discourses within authentic contexts (Dalili, 2011). The student may be also increasingly presented with non-native specific word meanings, that is, meanings that cannot be univocally translated to any student's mother tongue word. Specific strategies might support such learning. For instance, instruction may follow a clear acquisition plan that prioritises learning of the most frequent vocabulary and grammatical forms (Barcroft, 2012). New elements to be learned may be illustrated in meaningful sentences or discourses. Presenting new elements in an enhanced manner like highlighted or defined may help the student to focus on new stuff.

As for the *output*, students may be “pushed” to produce specific linguistic forms in the context of meaningful tasks (Dalili, 2011). Students may be required to use the new linguistic forms in an increasingly fluent and correct fashion, both through speaking and writing. Students are challenged to use new words and forms in a variety of contexts, and to produce new meanings beyond the examples given. Instruction should facilitate the production of ever-more complex and correct output (Barcroft, 2012). For instance, pedagogies should not force the production of output like sentence writing before the student has understood the new input. Likewise, providing scaffolding support at different stages of the student's output production such as writing compositions is commonly cited by research as a helpful method (e.g., Schwieter, 2010).

Appropriate teaching support has positive consequences on emotions as well. Making sure that students have understood the task requirements, and that they have the sufficient knowledge and skills to complete the task, are important aspects to relieve student's *language anxiety* (Hashemi and Abbasi, 2013). The early stages of non-native language learning are crucial for the learner's attitudes towards that language. Therefore, pedagogies should avoid learning tasks that promote early frustration, and they should ensure that the student is progressing before moving forward to more difficult tasks.

Challenging students and providing supporting structure to their learning have also been identified as important in effective socio-emotional instruction. The teaching and learning of socio-emotional competences demand sufficient time and attention (Durlak, Weissberg and Pachan, 2010; Durlak et al., 2011), and pedagogies need to promote them over reasonable periods of time and using diverse learning tasks. Such tasks should be planned, and sequenced in such a way that they connect the different steps of learning. The students may be challenged to reflect about the different attitudes, skills and knowledge that are required to exercise a certain socio-emotional competence, and teachers should sure that students learn them step by step.

Pedagogies put forward challenging goals to students, but not excessively so. At a collective level, this means that learning tasks are planned considering the developmental level of all students, departing from that level and looking to stretch it (Zins and Elias, 2007). At a personal level, teachers should be aware of every student's individual emotional features and sociability, and call on student's potentialities to push them to achieve more complex and healthy socio-emotional competences. Scaffolding structures help

learners, with teaching providing support especially in the first phases of learning like introducing or modelling a certain competence, such as showing how to react when facing an interpersonal conflict. And later they provide less assistance over time, intervening when necessary, taking advantage of natural situations – “teachable moments” (Domitrovich, Cortes and Greenberg, 2007) - when the learner experiences emotional reactions like conflicts with peers. Pedagogies that follow this sequence work towards making students more independent in the use of socio-emotional competences.

### ***Pedagogies for formative assessment and feedback***

Powerful pedagogies understand that assessment can only enrich learning when it clearly communicates what is expected from the students, and when it provides information to close the gap between student’s current performance and what is expected from them. “The learning environment operates with clarity of expectations and deploys assessment strategies consistent with these expectations; there is strong emphasis on formative feedback to support learning” (Dumont, Istance and Benavides, 2010: 17).

Research and innovation experiences in mathematics instruction commonly claim to de-emphasise occasional assessment practices at the end of the lesson (summative assessment), in favour of continuous evidence about student’s performance and understanding – *formative assessment* (NCTM, 2014). When teachers rely on continuous evidence, they can better assess student’s progress and provide more accurate feedback, adjusting instruction to further promote learning. Assessment practices should align with more *open-ended, complex and authentic tasks* in mathematics learning (Jones and Inglis, 2015). It is about coherently using the pedagogical approaches as in problem-based assessment. Open, complex and authentic tasks allow better assessment of the student’s competence in the targeted problems, as opposed to closed and mechanical tasks that allow the assessment of discrete and de-contextualised mathematical knowledge and skills.

Nevertheless, the use of this type of assessment approach requires change to traditional ways of correction like exclusively focusing on the final result and assessing its correctness. Instead, there needs to be a focus on analysing student’s intentions and approaches to solving the task, which can be done by using different assessment criteria as in *rubrics assessment* (Diefes-Dux et al., 2012). *Feedback* must provide information not only about the correctness of results (“corrective feedback”), but also about the student’s performance and how to improve in the future (“elaborative feedback”).

The use of formative assessment and feedback through complex and authentic tasks shows a clear path to innovation in mathematics assessment, most of which is currently based on technology. The use of digital tools such as video-games and virtual scenarios can be used for mining data on the student’s performance in complex and real-like situations (Dede, 2014; Fisch et al., 2011), in which data are continuously gathered on the student’s mathematical reasoning and skills. Feedback may be automatically provided to the student by technology, or given by the teacher upon observing the student and analysing available data (or both). In any case, it is valuable to have key information about the student’s performance in order to inform instructional arrangements.

Research and innovation programmes on non-native language also emphasise the use of assessment for learning and formative feedback. Traditionally, non-native language assessment has used standardised tests for summative purposes like promoting students to the next level, and it has focused on measuring the student’s proficiency, with little or no feedback to improve their learning (Kunnan and Jang, 2009). However, if the ultimate goal is to improve learning, pedagogies need to go beyond standardised testing and rely more on *classroom-based methods* to assess the student’s progress on certain curricular goals. Such assessment practices may allow tasks that are more coherent with previous learning tasks developed in the classroom, more adapted to the local particularities, and enabling more authentic and complex

approaches. In this sense, some experiences of national scale innovation suggest that greater emphasis on teacher-constructed and teacher-assessed products can be beneficial (East and Scott, 2011).

The use of *authentic, complex and performance-based tasks* is important to assess student's competences. Such tasks lead to assessing not only input-related skills – reading and listening - but also output-related ones –writing and speaking. Some (Bachman and Palmer, 2010) claim that tasks should not be artificially separated by one skill as in listening test or speaking test; rather, they should involve a mix of different skills as they are applied in real-life tasks. Such assessment practices often involve the production of open and *meaningful output*: for instance, digital stories where learners use compilations of photo, video, audio and text to produce personal narratives (Rowinsky-Geurts, 2013); written essays or reports on certain topics; portfolios where students gather evidence about their learning and reflect upon it; performance tasks like role-plays, debates, or discussions – either face-to-face or through technologies like chats, virtual worlds or serious games. The use of CALL environments can make accurate automated diagnosis about specific skills like pronunciation or mastery of particular rules (Presson, Davy and MacWhinney, 2013). But, current environments have serious limitations to diagnose performance in complex tasks. Therefore, they might be better used as a complement to other assessment tasks and teachers' feedback, rather than replacing them.

Assessment should shift focus from only appraising the student's language learning to further improving it – *assessment for learning*. This means that assessment should also shift from being static to dynamic: there is dynamic interaction where the examiner responds to the examinee's difficulties with appropriate support and feedback (Leung, 2007). When such feedback is based on knowledge about students and their progression, it can be tailored according to their specific situations. Greater emphasis on formative assessment and feedback, and perceived support during assessment tasks, may also help to decrease students' language anxiety (Hashemi and Abbasi, 2013).

Research suggests that socio-emotional instruction is more effective when it is driven by clear learning objectives, which facilitates explicit communication to the students about what they are expected to learn and what will be the assessment standards (Durlak et al., 2011). Students need to be aware of the socio-emotional learning objectives and the consequences of their behaviour on assessment, something that might not happen when socio-emotional instruction is infused across subjects. Socio-emotional programmes have often recommended using standardised tests and scales for assessment purposes (Denham, Ji and Hamre, 2010; Haggerty, Elgin and Woolley, 2011). Such one-size-fits-all tools are claimed to be cost-effective, easy to administer, and to increase reliability and validity of measures (Kendziora et al, 2011). However, the exclusive use of such testing promotes an assessment *of* learning, instead of an assessment *for* learning approach in the classroom. Such tools are usually administered at the end of learning processes, commonly presented as disconnected from the previous learning activities, and they do not usually promote specific feedback to the learner as to how to improve their learning. Socio-emotional instruction will benefit from *formative assessment* procedures where the student reaches better insight on their current performance through real-time feedback on their socio-emotional strengths and areas of need.

*Performance-based tasks* may be appropriate to promote learning and assessment of those competences, with teachers setting tasks that make students activate their skills and attitudes such as collaborative settings, problem- or conflict-solving, debates or argumentation, role-playing, etc. Socio-emotional instruction may take advantage of situations that emerge naturally in the classroom such as conflict between classmates or collective decision-making to assess students' competences. Teacher's observation may be crucial for gathering relevant data on student's performance and for keeping track of their progression. Clear assessment criteria and repeated observations might be needed to ensure reliable assessment. Research might usefully inform innovative endeavours in this area. Finally, some recommend using self-assessment procedures (Kendziora et al., 2011). These practices should be guided and accurately

designed according to the student's developmental stage. Promoting student's reflection on their behaviours and emotions may benefit socio-emotional learning.

### *Pedagogies for horizontal connectedness*

Powerful pedagogies look to enrich learning by connecting it to different contexts. "The learning environment strongly promotes 'horizontal connectedness' across areas of knowledge and subjects as well as to the community and the wider world" (Dumont, Istance and Benavides, 2010: 17). Whether this connectedness involves interdisciplinary instruction, or teaching across different contexts like family or community, the students increase learning transfer and benefit from working on real-life situations.

Innovation in the mathematics domain has to respond to the challenge of finding pedagogies that overcome excessive use of closed and routine but highly de-contextualised tasks without any connection to other domains or real-life contexts. A common response is to propose *problem, inquiry and project-based approaches* as a means to enrich mathematics learning. For instance, the use of problem-solving and modelling has led to situations where the learner is presented with a problem and has to create rules or artefacts needed to accomplish some goals (Lesh and Zawojewski, 2007). Over recent years there has been a growing interest in using multidisciplinary problems with the expectation of enhancing learning transfer. However, such learning approaches are complex and assume that the student has the prior knowledge and skills to perform adequately, as well as having guidance to facilitate transfer of knowledge between domains. Such approaches must be well-designed and their use demands high coordination of teaching from different domains.

Project-based learning and inquiry-based pedagogies often involve challenging real-world tasks that call for competences from different domains, as well as general competences like learning self-regulation. Given that these two approaches facilitate interdisciplinary teaching, they have often been used to develop mathematics in science-related, STEM education (Näslund-Hadley and Bando, 2015; Ruthven, 2011).

Some pedagogical approaches may facilitate particular interdisciplinary teaching. For instance, *mathematics history-based* teaching proposes using historical contexts to introduce and frame mathematical contents (Fauvel and van Maanen, 2002). This may go from illustrating mathematical contents with historical facts, to introducing certain historical problems and methods to work on mathematical content, to establishing history itself as a frame to chronologically sequence mathematical contents (Jankvist, 2011). Some studies have suggested its suitability to improve learning outcomes in the mathematics domain (e.g., Lim and Chapman, 2015).

What transpires in the classroom must be connected to the wider community context, and vice versa. *Context-based pedagogy* and *extra-curricular activities* can help to engage learners and optimise mathematics learning (Savelsbergh, 2016). In context-based pedagogies, the students develop tasks that emphasise the relevance and applicability of mathematics in society and their personal lives. Extra-curricular activities are developed outside the classroom environment but they are connected to curricular activities (e.g., lab visits, guest lectures).

*Interdisciplinary instruction* is also seen as a means to improve language learning outcomes. In practice, this has led to experiences where students are taught regular school subjects both in their native and in another non-native language – *bilingual or school immersion* (Cummins, 2009). Such experiences usually highlight the importance of:

- having well-planned instruction, where teaching in both languages is well organised and distributed across certain subjects to achieve proficiency in the two languages.
- maintaining those programmes for long periods of time, for instance throughout primary school.



- Emphasising teaching through the non-native language, assigning it at least half the instructional time.

Although such programmes have tended to separate instruction in one language or the other –having two distinct monolingual teaching environments - recently, more have advocated using the native language to support learning of the non-native language. These programmes are also recommended for language-minority students. Many studies conclude that language-minority children benefit more from bilingual education than non-native language monolingual instruction (Cheung and Slavin, 2012; Cummins, 2012).

Connecting non-native language instruction to the student’s meso-system and to the wider world is also important for innovative approaches to teaching. For instance, *place-based learning* may be used to improve language learning in study abroad experiences (Collentine, 2009). Study abroad programmes are good opportunities for learners to enhance fluency, and they can make the most of such experiences when they are well-designed and involve:

- preparing the student before the abroad stay with appropriate levels of grammar and vocabulary knowledge, as well as metacognitive strategies such as monitoring and self-correction.
- Coordinating school teaching and in-place teaching practices; in-place instruction should focus on grammar to complement learning through communicative daily contexts.

Non-native language learning outcomes are closely related to exposure to such language in out-of-school contexts, for example, listening to music with lyrics, and especially watching subtitled audio-visuals (Lindgren and Muñoz, 2013). The literature on *watching TV or films with same-language subtitles* shows positive results (Vanderplank, 2016). Pedagogies that bring students to interact with captions as in freeze-framing subtitles, or identifying and defining unknown words might yield good results but supportive evidence is still insufficient.

Innovative pedagogies can create *synergies with out-of-school contexts* through specific classroom tasks and projects. The use of technology is a promising avenue to achieve such learning synergies. Learners can engage with real *communities*, and through the use of specific communication-based tools like chats or forums, they can interact with native speakers and learn common textual artefacts (Black, 2009). Also, participation in such communities allows learners to first observe and then use real, popular and culturally-valid forms of communication that go beyond text and embrace multimodal communication (Fandiño, 2013). Pedagogies may also create synergies with non-formal settings like the *popular technological applications and platforms* used for non-native language acquisition. Such applications include features to increase learners’ motivation such as social collaboration, game-like features like scoring mechanisms, adaptive difficulty, and de-emphasis of explicit grammar instruction (Kallioniemi et al., 2015).

Although socio-emotional education is implemented in some OECD countries as a curricular subject, the weight of general attitudes and skills in socio-emotional competences makes them especially suitable for *curricular transversal instruction*. When implemented in an interdisciplinary fashion, socio-emotional competences are learned and applied to tasks carried out for, and become part of, the standard curriculum. Socio-emotional programmes are usually more effective when they are implemented by school staff rather than external professionals (Capsada, forthcoming). Integrating socio-emotional education into the existing curriculum involves coordinating its learning goals, activities and assessment practices with those of other subjects (Durlak et al., 2011; Zins and Elias, 2007). Likewise, innovative experiences commonly seek to use *meaningful and authentic opportunities* for students to generalise socio-emotional competences for daily life.

Socio-emotional programmes are effective when they connect to the classroom and school “life”, and contribute to developing a more positive *school climate* (Elias, 2014). For instance, some studies suggest

that only a continuous process of school climate improvement can act as effective bullying prevention (Clarke et al., 2015; Cohen et al., 2015). Research also suggests the relevance of adopting a *community-based approach* in socio-emotional instruction (Durlak et al., 2011). This means linking the school to its community (Elias, 2014), involving students' parents and establishing wider partnerships in the community. Socio-emotional pedagogies need to adopt a wider perspective and mobilise different agents of the student's meso-system; for instance, by building synergies with out-of-school activities like arts or sports (Clarke et al., 2015), or by creating avenues for hearing parents' insights and promoting their collaboration with the school's practices. School climate enhancement can only take place when all stakeholders (e.g., parents, teachers, students, school personnel, district leaders, the private sector, policy makers) develop a shared vision of how they want to improve their school (Cohen et al., 2015).

Finally, *technology* may well help to achieve the above mentioned goals. Nevertheless, technology is currently still underused to implement socio-emotional instruction [World Economic Forum (WEF), 2016]. Technological development shows promising tendencies that might support students acquiring socio-emotional competences such as affective computing, virtual worlds, and wearable devices. However, the aim should be to integrate those technologies in coherent pedagogical frameworks that promote both subject-related learning and the development of socio-emotional competences. When it comes to supporting interdisciplinary instruction, it might be important to choose among all the technologies that are designed to promote subject-related learning like an interactive platform for science learning, those that additionally include features that may foster socio-emotional competences such as tools for communication and negotiation.

## Conclusions

Each domain has its own particular challenges, epistemic nature, teaching traditions, subject-related subcultures, and teachers' knowledge, beliefs and emotions about their subject. Those elements create different pedagogical trends among subjects in schools. Nevertheless, pedagogical innovation, as shown in this chapter, ultimately reflects common principles as to how to promote powerful learning. Pedagogical reform endeavours may well be led by general principles, but it is also relevant to address specific subject needs by giving subjects enough room to apply their own pedagogies.

Competences may be more domain-specific or domain-transcending. Overcoming the debate about promoting one or the other, school education could look for ways of creating synergies between those two types of competences. Promoting general competences means to transcend the barriers of school subjects and infuse them across subjects. This means finding appropriate formulas to sequence and combine pedagogies to promote both types of competences at the same time.

Pedagogical innovation in the mathematics domain is urged to find ways of increasing students' engagement and learning outcomes, especially for female learners. Mathematics pedagogies should find a balance between the pure and applied. The main innovation trends show efforts to find more effective ways of implementing open, complex and authentic tasks; promoting deeper mathematical reasoning; increasing student's self-efficacy beliefs; and making the most of collaborative settings.

The non-native language domain is challenged to find pedagogies that make the most of instruction time: more effective ways of extending instruction and connecting it to other contexts inside the school, the meso-system, and the wider world. Non-native language pedagogies should emphasise both communication and grammatical forms. Pedagogies must provide both input to the learner and opportunity to create output. Likewise, they are challenged to find ways of embedding communication and grammatical forms in meaningful and authentic contexts.

Socio-emotional education needs pedagogies that help it to become a basic and transversal foundation of school education. Pedagogies should look to integrate socio-emotional learning goals with daily curricular activities, using meaningful and authentic learning opportunities. Likewise, socio-emotional pedagogies need to adopt a community and preventive perspective, looking to improve the whole school climate, and exploring the use of active and performance-based pedagogies that affect students' feelings and relationships.

Despite enthusiasm of pedagogical innovation in learner-centred approaches, the practical implementation of such approaches will have to look for appropriate balances with more teacher-centred approaches. Finding suitable combinations and sequences of both will ensure that the students are effectively scaffolded during the learning process, and that they have the chance to acquire both general and specific competences.

## REFERENCES

- Ager, A. (2013), “Annual research review: Resilience and child well- being –public policy implications”, *Journal of Child Psychology and Psychiatry*, Vol. 54/4, pp. 488-500.
- Alexander, P.A. and J.E. Judy (1988), “The interaction of domain-specific and strategic knowledge in academic performance”, *Review of Educational Research*, Vol. 58, pp. 375-404.
- Ananiadou, K. and M. Claro (2009), “21st Century Skills and Competences for New Millennium Learners in OECD Countries”, *OECD Education Working Papers*, No. 41, OECD Publishing, Paris. <http://dx.doi.org/10.1787/218525261154>
- Andersson, A., P. Valero and T. Meaney (2015), “‘I am [not always] a maths hater’: Shifting students’ identity narratives in context”, *Educational Studies in Mathematics*, Vol. 90/2, pp. 143-161.
- Atkinson, R.D. and M.J. Mayo (2010), *Refueling the US Innovation Economy: Fresh Approaches to Science, Technology, Engineering and Mathematics (STEM) Education*, The Information Technology & Innovation Foundation, Washington.
- Baer, R.A. (2003), “Mindfulness training as a clinical intervention: A conceptual and empirical review”, *Clinical Psychology: Science and Practice*, Vol. 10, pp. 125-143.
- Bachman, L.F. and A.S. Palmer (2010), “Language assessment in practice: Developing language assessments and justifying their use in the real world”, Oxford University Press, Oxford, UK.
- Barcroft, J. (2012), *Input-Based Incremental Vocabulary Instruction*, TESOL International Association, Alexandria, VA.
- Belliveau, G. and W. Kim (2013), “Drama in L2 learning: A research synthesis”, *Scenario*, Vol. 7/2, pp. 3-23.
- Black, R. (2009), “English-language learners, fan communities, and 21st-century skills”, *Journal of Adolescent and Adult Literacy*, Vol. 52/8, pp. 688-697.
- Blatchford, P. (1997), “Students’ self assessment of academic attainment: accuracy and stability from 7 to 16 years and influence of domain and social comparison group”, *Educational Psychology*, Vol. 17/3, pp. 345-359.
- Boaler, J. (2013), “Ability and mathematics: The mind-set revolution that is reshaping education”, *Forum*, Vol. 55/1, pp. 143-152.
- Boaler, J. (2012), “From psychological imprisonment to intellectual freedom –The different roles that school mathematics can take in students’ lives”, in *Proceedings of the 12th International Congress on Mathematics Education*.
- Boaler, J. (2008), “Promoting ‘relational equity’ and high mathematics achievement through an innovative mixed- ability approach”, *British Educational Research Journal*, Vol. 34/2, pp. 167-194.
- Borasi, R. (1994), “Capitalizing on errors as" springboards for inquiry": A teaching experiment”, *Journal for Research in Mathematics Education*, pp. 166-208.
- Bosch, M. and J. Gascón (2006), “Twenty-five years of the didactic transposition”, *ICMI Bulletin*, Vol. 58, pp. 51-63.
- Brown, M., P. Brown, and T. Bibby (2008), “‘I would rather die’: Reasons given by 16-year-olds for not continuing their study of mathematics”, *Research in Mathematics Education*, Vol. 10/1, pp. 3-18.
- Buckley, S. et al. (2016), “Understanding and addressing mathematics anxiety using perspectives from education, psychology and neuroscience”, *Australian Journal of Education*, published online, doi: 10.1177/0004944116653000

- Cai, J. et al. (2015), “Problem posing research in mathematics: Some answered and unanswered questions”, in F.M. Singer, N. Ellerton and J. Cai (eds.), *Mathematical Problem Posing: From Research to Effective Practice*. Springer, New York, NY.
- Campbell, S. (2010), “Embodied minds and dancing brains: New opportunities for research in mathematics education”, in B. Sriraman and L. English (eds.), *Theories of Mathematics Education: Seeking New Frontiers*, Springer, Heidelberg.
- Campbell, S. and C.V. Stauffenberg (2008), “Child characteristics and family processes that predict behavioral readiness for school”, in A. Booth and A.C. Crouter (eds.), *Disparities in School Readiness: How Families Contribute to Transitions in School*, Taylor & Francis, Group/Lawrence Erlbaum Associates, New York, NY.
- Capsada, Q. (forthcoming), *Are Socio-Emotional Education Programmes Effective Tools to Enhance Students’ Competences?*, Institut Català d’Avaluació de Polítiques Educatives, Fundació Jaume Bofill.
- Carbonneau, K.J. and S.C. Marley (2012), “Activity-based learning strategies and academic achievement”, in J.A.C. Hattie and E.M. Anderman (eds.), *The International Handbook of Student Achievement*, Routledge, New York, NY.
- Carbonneau, K.J., S.C. Marley and J.P. Selig (2013), “A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives”, *Journal of Educational Psychology*, Vol. 105/2, pp. 380-400.
- Carey, S. (1985), *Conceptual Change in Childhood*, MIT Press, Cambridge, MA.
- CASEL (2013), *2013 CASEL Guide: Effective Social and Emotional Learning Programs –Preschool and Elementary School Edition*.
- CASEL (2005), *Safe and Sound: An Educational Leader’s Guide to Evidence-Based Social and Emotional Learning (SEL) Programs, Illinois Edition*, Author, Chicago IL.
- Cedeno, L.A. et al. (2010), “School Violence, Adjustment, and the Influence of Hope on Low- Income, African American Youth”, *American Journal of Orthopsychiatry*, Vol. 80/2, pp. 213-226.
- Chang, S.Y. and C.A. Tung (2009), “Incorporating 21st century skills into business English instruction”, *Feng Chia Journal of Humanities and Social Sciences*, Vol. 19, pp. 255-286.
- Chen, J.C. (2016), “The crossroads of English language learners, task-based instruction, and 3D multi-user virtual learning in Second Life”, *Computers & Education*, Vol. 102, pp. 152-171.
- Chen, X., E. Geva and M. Schwartz (2012), “Understanding literacy development of language minority students: An integrative approach”, *Reading and Writing*, Vol. 25/8, pp. 1797-1804.
- Cheung, A.C. and R.E. Slavin (2013), “The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis”, *Educational Research Review*, Vol. 9, pp. 88-113.
- Cheung, A.C.K. and R.E. Slavin (2012), “Effective reading programs for Spanish-dominant English language learners (ELLs) in the elementary grades: A synthesis of research”, *Review of Educational Research*, Vol. 82/4, pp. 351–395.
- Clarke, M.M. et al. (2015), *What Works in Enhancing Social and Emotional Skills Development during Childhood and Adolescence?*, WHO Collaborating Centre for Health Promotion Research, National University of Ireland Galway.
- Cobb, P. and K. Jackson (2011), “Towards an empirically grounded theory of action for improving the quality of mathematics teaching at scale”, *Mathematics Teacher Education and Development*, Vol. 13/1, pp. 6-33.

- Cobb, P. et al. (2011), "Participating in classroom mathematical practices", in E. Yackel, K. Gravemeijer and A. Sfard (eds.), *A Journey in Mathematics Education Research – Insights from the Work of Paul Cobb*, Springer, Dordrecht.
- Cobb, P. and L.L. Hodge (2002), "A relational perspective on issues of cultural diversity and equity as they play out in the mathematics classroom", *Mathematical Thinking and Learning*, Vol. 4, pp. 249-284.
- Cohen, J. et al. (2015), "Rethinking effective bully and violence prevention effects: Promoting healthy school climates, positive youth development, and preventing bully-victim-bystander behaviour", *International Journal of Violence and Schools*, Vol. 15, pp. 2-40.
- Collentine, J. (2009). "Study abroad research: Findings, implications, and future directions", in M.H. Long and C.J. Doughty, *The Handbook of Language Teaching*, Blackwell Publishing, West Sussex, UK.
- Cummins, J. (2012), "The intersection of cognitive and sociocultural factors in the development of reading comprehension among immigrant students", *Reading and Writing*, Vol. 25/8, pp. 1973-1990.
- Cummins, J. (2009). "Bilingual and immersion programs", in M.H. Long and C.J. Doughty, *The Handbook of Language Teaching*, Blackwell Publishing, West Sussex, UK.
- Dalili, M.V. (2011), "On the integration of form and meaning in English Language Teaching (ELT): An overview of current pedagogical options", *Procedia-Social and Behavioral Sciences*, Vol. 15, pp. 2117-2121.
- Dalton-Puffer, C. (2011). "Content-and-language integrated learning: From practice to principles?", *Annual Review of Applied Linguistics*, Vol. 31, pp. 182–204.
- Dede, C. (2014), *The Role of Digital Technologies in Deeper Learning*, Students at the Center: Deeper Learning Research Series, Jobs for the Future, Boston, MA.
- Delahunty, J., I. Verenikina and P. Jones (2014), "Socio-emotional connections: Identity, belonging and learning in online interactions. A literature review", *Technology, Pedagogy and Education*, Vol. 23/2, pp. 243-265.
- Della Chiesa, B., J. Scott and C. Hinton (eds.) (2012), *Languages in a Global World: Learning for Better Cultural Understanding*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264123557-en>
- Deng, Z. (2015), "Content, Joseph Schwab and German Didaktik", *Journal of Curriculum Studies*, Vol. 47/6, pp. 773-786.
- Denham, S.A. et al. (2012), "Social-emotional learning profiles of preschoolers' early school success: A person-centered approach", *Learning and Individual Differences*, Vol. 22/2, pp. 178-189.
- Denham, S.A., P. Ji and B. Hamre (2010), *Compendium of Preschool Through Elementary School Social-Emotional Learning and Associated Assessment Measures*, Social and Emotional Learning Research Group, University of Illinois at Chicago, Chicago, IL.
- Depaepe, F. et al. (2013), "Do teachers have a relationship with their subject? A review of the literature on the teacher-subject matter relation", *Teoría de la Educación, Revista Interuniversitaria*, Vol. 25/1, pp. 109-124.
- Diefes-Dux, H.A. et al. (2012), "A framework for analyzing feedback in a formative assessment system for mathematical modelling problems", *Journal of Engineering Education*, Vol. 101/2, pp. 375-406.
- Djambazova-Popordanoska, S. (2016), "Implications of emotion regulation on young children's emotional wellbeing and educational achievement", *Educational Review*, Vol. 68/4, pp. 497-515.
- D'Mello, S. and A. Graesser (2012), "Dynamics of affective states during complex learning", *Learning and Instruction*, Vol. 22/2, pp. 145-157.
- Dochy, F. (1992), *Assessment of Prior Knowledge as a Determinant for Future Learning*, Lemma B.V., Jessica Kingsley Publishers, Utrecht, London.
- Dochy, F. J. and P.A. Alexander (1995), "Mapping prior knowledge: A framework for discussion among researchers", *European Journal of Psychology of Education*, Vol. 10/3, pp. 225-242.

- Domitrovich, C.E., R.C. Cortes and M.T. Greenberg (2007), “Improving young children’s social and emotional competence: A randomized trial of the preschool ‘PATHS’ curriculum”, *The Journal of Primary Prevention*, Vol. 28/2, pp. 67-91.
- Dowker, A., A. Sarkar and C.Y. Looi (2016), “Mathematics anxiety: What have we learned in 60 years?” *Frontiers in Psychology*, Vol. 7/508, doi: 10.3389/fpsyg.2016.00508
- Drake, C., J.P. Spillane and K. Hufferd-Ackles (2001), “Storied identities: Teacher learning and subject-matter context”, *Journal of Curriculum Studies*, Vol. 33/1, pp. 1-23.
- Dumont, H., D. Istance and F. Benavides (eds.) (2010), *The Nature of Learning: Using Research to Inspire Practice*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264086487-en>
- Durlak, J.A. et al. (2011), “The impact of enhancing students’ social and emotional learning: A meta- analysis of school- based universal interventions”, *Child development*, Vol. 82/1, pp. 405-432.
- Durlak, J.A., R.P. Weissberg and M. Pachan (2010), “A meta-analysis of after-school programs that seek to promote personal and social skills in children and adolescents”, *American Journal of Community Psychology*, Vol. 45/3-4, pp. 294-309.
- East, M. and A. Scott (2011), “Assessing the foreign language proficiency of high school students in New Zealand: From the traditional to the innovative”, *Language Assessment Quarterly*, Vol. 8/2, pp. 179-189.
- Elias, M.J. (2014), “The future of character education and social-emotional learning: The need for whole school and community-linked approaches”, *Journal of Research in Character Education*, Vol. 10/1, pp. 37-42.
- Elias, M.J. and N.M. Haynes (2008), “Social competence, social support, and academic achievement in minority, low-income, urban elementary school children”, *School Psychology Quarterly*, Vol. 23/4, pp. 474-495.
- Ellis, V. (2007), “Taking subject knowledge seriously: from professional knowledge recipes to complex conceptualizations of teacher development”, *The Curriculum Journal*, Vol. 18/4, pp. 447-462.
- Ellis, R. (2003), *Task-Based Language Learning and Teaching*, Oxford University Press, Oxford.
- English, L., and B. Sriraman (2010), “Problem solving for the 21st century”, in B. Sriraman and L. English (eds.), *Theories of Mathematics Education: Seeking New Frontiers*, Springer, Heidelberg.
- Esmonde, I. (2009), “Ideas and identities: Supporting equity in cooperative mathematics learning”, *Review of Educational Research*, Vol. 79/2, pp. 1008-1043.
- Fandiño, Y.J. (2013), “21st century skills and the English foreign language classroom: A call for more awareness in Colombia”, *GIST Education and Learning Research Journal*, Vol. 7, pp. 190-208.
- Fauvel, J. and J. van Maanen (2002), *History in Mathematics Education: The ICMI Study*. Dordrecht: Kluwer.
- Fisch, S.M. et al. (2011), “Children’s mathematical reasoning in online games: Can data mining reveal strategic thinking?”, *Child Development Perspectives*, Vol. 5/2, pp. 88-92.
- Flores, R. et al. (2015), “Multiple representation instruction first versus traditional algorithmic instruction first: Impact in middle school mathematics classrooms”, *Educational Studies in Mathematics*, Vol. 89/2, 267-281.
- Frank, J.L., P.A. Jennings and M.T. Greenberg (2013), “Mindfulness-based interventions in school settings: An introduction to the special issue”, *Research in Human Development*, Vol. 10/3, pp. 205-210.
- García, E. et al. (2010), “Developing responsive teachers: A challenge for a demographic reality”, *Journal of Teacher Education*, Vol. 61/1-2, pp. 132-142.

- Gardner, R.C. (2006), “The socio-educational model of second language acquisition: A research paradigm”, in S.H. Foster-Cohen, M. Medved Krajnovic and J. Mihaljevic Djigunovic (eds.), *Eurosla Yearbook Volume 6*, John Benjamins Publishing.
- Gess-Newsome, J. (1999), “Secondary teachers’ knowledge and beliefs about subject matter and their impact on instruction”, in J. Gess-Newsome and L.M. Lederman (eds.), *Pedagogical Content Knowledge and Science Education*, Kluwer, Boston.
- Gherasim, L.R., S. Butnaru and C. Mairean (2013), “Classroom environment, achievement goals and maths performance: Gender differences”, *Educational Studies*, Vol. 39/1, pp. 1-12.
- Gresalfi et al., (2009), “Constructing competence: An analysis of student participation in the activity systems of mathematics classrooms”, *Educational Studies in Mathematics*, Vol. 70/1, pp. 49-70.
- Gresalfi, M.S. and P. Cobb (2011), “Negotiating identities for mathematics teaching in the context of professional development”, *Journal for Research in Mathematics Education*, Vol. 42/3, pp. 270-304.
- Golonka, E.M. et al. (2014), “Technologies for foreign language learning: A review of technology types and their effectiveness”, *Computer Assisted Language Learning*, Vol. 27/1, pp. 70-105.
- González, N., E. McIntyre and A.S. Rosebery (2001), *Classroom Diversity: Connecting Curriculum to Students’ Lives*, Heinemann, Portsmouth, NH.
- Good, C., A. Rattan, and C.S. Dweck (2012), “Why do women opt out? Sense of belonging and women's representation in mathematics”, *Journal of Personality and Social Psychology*, Vol. 102/4, pp. 700-717.
- Grossman, P.L. and Stodolsky, S.S. (1995), “Content as context: The role of school subjects in secondary school teaching”, *Educational Researcher*, Vol. 24/8, pp. 5-23.
- Grossman, P.L. and Stodolsky, S.S. (1994), “Considerations of content and the circumstances of secondary school teaching”, *Review of Research in Education*, Vol. 20, pp. 179-221.
- Guifford, S. (December 19 2014), “Early years mathematics: How to create a nation of mathematics lovers?”, Maths Memos Blog, Advisory Committee on Mathematics Education, UK, [www.acme-uk.org/maths-memos-acme-blog/2014/12/19/early-years-mathematics-how-to-create-a-nation-of-mathematics-lovers](http://www.acme-uk.org/maths-memos-acme-blog/2014/12/19/early-years-mathematics-how-to-create-a-nation-of-mathematics-lovers)
- Haggerty, K., J. Elgin and A. Woolley (2011), *Social-Emotional Learning Assessment Measures for Middle School Youth*, Social Development Research Group, University of Washington, Raikes Foundation.
- Hashemi, M. and M. Abbasi (2013), “The role of the teacher in alleviating anxiety in language classes”, *International Research Journal of Applied and Basic Sciences*, Vol. 4/3, pp. 640-646.
- Horwitz, E.K. and D.J. Young (1991), *Language Anxiety: From Theory and Research to Classroom Implications*, Prentice Hall, Englewood Cliffs, NJ.
- Ing, M. et al. (2015), “Student participation in elementary mathematics classrooms: The missing link between teacher practices and student achievement?”, *Educational Studies in Mathematics*, Vol. 90/3, pp. 341-356.
- Ingram, J., A. Pitt and F. Baldry (2015), “Handling errors as they arise in whole-class interactions”, *Research in Mathematics Education*, Vol. 17/3, pp. 183-197.
- Immordino- Yang, M.H. and A. Damasio (2007), “We feel, therefore we learn: The relevance of affective and social neuroscience to education”, *Mind, Brain, and Education*, Vol. 1/1, pp. 3-10.
- Jacobs, J. (2010), “Feminist pedagogy and mathematics”, in B. Sriraman and L. English (eds.), *Theories of Mathematics Education: Seeking New Frontiers*, Springer, Heidelberg.
- Jankvist, U.T. (2011), “Anchoring students’ metaperspective discussions of history in mathematics”, *Journal for Research in Mathematics Education*, Vol. 42/4, pp. 346–385.



- Jennings, P. et al. (2011), "Improving classroom learning environments by Cultivating Awareness and Resilience in Education (CARE): Results of two pilot studies, *Journal of Classroom Interaction*, Vol. 46, pp. 37–48.
- Jones, I. and M. Inglis (2015), "The problem of assessing problem solving: Can comparative judgement help?", *Educational Studies in Mathematics*, Vol. 89/3, pp. 337-355.
- Kaiser, G. (2010), "Preface to part XIV. Feminist pedagogy and mathematics", in B. Sriraman and L. English (eds.), *Theories of Mathematics Education: Seeking New Frontiers*, Springer, Heidelberg.
- Kallioniemi, P. et al. (2015), "Berlin kompass: Multimodal gameful empowerment for foreign language learning", *Journal of Educational Technology Systems*, Vol. 43/4, pp. 429-450.
- Kalyuga, S. (2007), "Expertise reversal effect and its implications for learner-tailored instruction", *Educational Psychology Review*, Vol. 19/4, pp. 509-539.
- Keenan, K. and D. Shaw (1997), "Developmental and social influences on young girls' early problem behaviour", *Psychological Bulletin*, Vol. 121, pp. 95-113.
- Kendziora, K. et al. (2011), *Strategies for Social and Emotional Learning: Preschool and Elementary Grade Student Learning Standards and Assessment*, National Center for Mental Health Promotion and Youth Violence Prevention, Education Development Center, Newton, MA.
- Kirschner, P.A., J. Sweller and R.E. Clark (2006), "Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching", *Educational Psychologist*, Vol. 41/2, pp. 75-86.
- Köğçe, D. et al. (2009), "Examining elementary school students' attitudes towards mathematics in terms of some variables", *Procedia-Social and Behavioral Sciences*, Vol. 1/1, pp. 291-295.
- Kunnan, A.J. and Jang, E.E. (2009), "Diagnostic feedback in language assessment", in M.H. Long and C.J. Doughty, *The Handbook of Language Teaching*, Blackwell Publishing, West Sussex, UK.
- LaFreniere, P.J. and J.A. Dumas (1996), "Social Competence and Behavior Evaluation in children aged three to six: The Short Form (SCBE-30)", *Psychological Assessment*, Vol. 8, pp. 369-37.
- Larkin, K. and R. Jorgensen (2016), "I Hate Maths: Why Do We Need to Do Maths?" Using iPad Video Diaries to Investigate Attitudes and Emotions Towards Mathematics in Year 3 and Year 6 Students", *International Journal of Science and Mathematics Education*, Vol. 14/5, pp. 925-944.
- Lesh, R. and J.S. Zawojewski (2007), "Problem solving and modelling", in F. Lester (ed.), *The Second Handbook of Research on Mathematics Teaching and Learning*, Information Age Publishing, Charlotte, NC.
- Leung, C. (2007), "Dynamic assessment: Assessment as teaching?", *Language Assessment Quarterly*, Vol. 4, pp. 257-78.
- Lev-Zamir, H. and R. Leikin (2011), "Creative mathematics teaching in the eye of the beholder: Focusing on teachers' conceptions", *Research in Mathematics Education*, Vol. 13/1, pp. 17-32.
- Lim, S.Y. and E. Chapman (2015), "Effects of using history as a tool to teach mathematics on students' attitudes, anxiety, motivation and achievement in grade 11 classrooms", *Educational Studies in Mathematics*, Vol. 90/2, pp. 189-212.
- Lindgren, E. and C. Muñoz (2013), "The influence of exposure, parents, and linguistic distance on young European learners' foreign language comprehension", *International Journal of Multilingualism*, Vol. 10/1, pp. 105-129.

- Long, M.H. (1991), “Focus on form: A design feature in language teaching methodology”, in K. d. Bot, R. Ginsberg, and C. Kramsch (eds.), *Foreign Language Research in Cross-Cultural Perspective*, John Benjamins, Amsterdam.
- Long, M.H. (1990), “Maturational constraints on language development”, *Studies in Second Language Acquisition*, Vol. 12/3, pp. 251–285.
- Looi, C. et al. (2016), “The Neuroscience of Mathematical Cognition and Learning”, *OECD Education Working Papers*, No. 136, OECD Publishing, Paris. <http://dx.doi.org/10.1787/5jlwmn3ntbr7-en>
- Mann, E.L. (2006), “Creativity: The essence of mathematics”, *Journal for the Education of the Gifted*, Vol. 30/2, pp. 236-262.
- Marks, R. (2014), “Educational triage and ability-grouping in primary mathematics: a case-study of the impacts on low-attaining pupils”, *Research in Mathematics Education*, Vol. 16/1, pp. 38-53.
- McClure, E.B. (2000), “A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents”, *Psychological Bulletin*, Vol. 126, pp. 424-453.
- McLeod, D.B. (1992), “Research on affect in mathematics education: A reconceptualization”, in D.A. Grouws (ed.), *Handbook of Research on Mathematics Teaching and Learning*, Macmillan, New York, NY.
- Mendick, H. (2005), “A beautiful myth? The gendering of being/doing ‘good at maths’”, *Gender and Education*, Vol. 17/2, pp. 203-219.
- Mevarech, Z. and Kramarski, B. (2014), *Critical Maths for Innovative Societies: The Role of Metacognitive Pedagogies*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264223561-en>
- Muñoz, C. and D. Singleton (2011), “A critical review of age-related research on L2 ultimate attainment”, *Language Teaching*, Vol. 44, pp. 1-35.
- Musumeci, D. (2009), "Social, Political, and Educational Contexts of Language Teaching", in M.H. Long and C.J. Doughty, *The Handbook of Language Teaching*, Blackwell Publishing, West Sussex, UK.
- Moodie, I. and H.J. Nam (2016), “English language teaching research in South Korea: A review of recent studies (2009–2014)”, *Language Teaching*, Vol. 49/1, pp. 63-98.
- Näslund-Hadley, E. and R. Bando (2015). *All Children Count. Overview Report. Early Mathematics and Science Education in Latin America and the Caribbean*. Inter-American Development Bank.
- Näslund-Hadley, E., Cabrol M. and P. Ibarra (2009), *Beyond Chalk and Talk: Experimental Math and Science Education in Argentina*, Inter-American Development Bank, Washington, DC.
- Nassaji, H. and S. Fotos (2010), *Teaching Grammar in Second Language Classrooms: Integrating Form-Focused Instruction in Communicative Context*, Routledge, Taylor & Francis Group, New York.
- NCTM (2014), *Principles to Actions: Ensuring Mathematical Success for All*. Author, Reston, VA.
- Núñez-Peña, M.I., R. Bono and M. Suárez-Pellicioni (2015), “Feedback on students’ performance: A possible way of reducing the negative effect of math anxiety in higher education”, *International Journal of Educational Research*, Vol. 70, pp. 80-87.
- OECD (2015), *Skills for Social Progress: The Power of Social and Emotional Skills*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264226159-en>
- Pais, A. (2012), “A critical approach to equity in mathematics education”, in O. Skovsmose and B. Greer (eds.), *Opening the Cage: Critique and Politics of Mathematics Education*, Sense Publishers, Rotterdam.
- Park, D., G. Ramírez and S.L. Beilock (2014), “The role of expressive writing in math anxiety”, *Journal of Experimental Psychology: Applied*, Vol. 20/2, pp. 103-111.

- Partnership For 21<sup>st</sup> Century Skills (2009), *The MILE Guide. Milestones for improving Learning and Education*, [www.p21.org/storage/documents/MILE\\_Guide\\_091101.pdf](http://www.p21.org/storage/documents/MILE_Guide_091101.pdf) (accessed 27 September 2016).
- Payton, J. et al. (2008), *The positive impact of social and emotional learning for kindergarten to eighth-grade students: Findings from three scientific reviews*, Collaborative for Academic, Social, and Emotional Learning, Chicago, IL.
- Philipp, R. (2007), “Mathematics teachers’ beliefs and affect”, in F.K. Lester Jr. (ed.), *Second Handbook of Research on Mathematics Teaching and Learning*, National Council of Teachers of Mathematics, Reston, VA.
- Pozo, J.I. and Y. Postigo (2000), *Los Procedimientos Como Contenidos Escolares: El Uso Estratégico de la Información* [Procedures as School Contents: Strategic Use of Information], Edebé, Barcelona.
- Presson, N., C. Davy and B. MacWhinney (2013), “Experimentalized CALL for adult second language learners”, in J. Schwieter (ed.), *Innovative Research and Practices in Second Language Acquisition and Bilingualism*, Benjamins, Amsterdam, The Netherlands/Philadelphia, PA.
- Punaro, L. and R. Reeve (2012), “Relationships between 9-year-olds’ math and literacy worries and academic abilities”, *Child Development Research*, Vol. 2012, <http://dx.doi.org/10.1155/2012/359089>
- Rattan, A., C. Good and C.S. Dweck (2012), “‘It’s ok—Not everyone can be good at math’: Instructors with an entity theory comfort (and demotivate) students”, *Journal of Experimental Social Psychology*, Vol. 48/3, pp. 731-737.
- Reyes, J.A. and M.J. Elias (2011), “Fostering social–emotional resilience among Latino youth”, *Psychology in the Schools*, Vol. 48/7, pp. 723-737.
- Rieg, S.A. and Paquette, K.R. (2009), “Using drama and movement to enhance English language learners’ literacy development”, *Journal of Instructional Psychology*, Vol. 36/2, pp. 148-155.
- Rimm-Kaufman, S.E. and C.S. Hulleman (2015), “Social and emotional learning in elementary school settings: Identifying mechanisms that matter”, in J. Durlak and R. Weissberg (eds.), *The Handbook of Social and Emotional Learning*, Guilford, New York, NY.
- Roeser, R.W. et al. (2013), “Mindfulness training and reductions in teacher stress and burnout: Results from two randomized, waitlist-control field trials”, *Journal of Educational Psychology*, Vol. 105, pp. 787-804.
- Roorda, D.L. et al. (2011), “The influence of affective teacher-student relationships on students’ school engagement and achievement: A meta-analytic approach”, *Review of Educational Research*, Vol. 81/4, pp. 493-529.
- Rowinsky-Geurts, M. (2013), “Digital stories in L2 classes: High-impact practices and affective learning”, in J. Schwieter (ed.), *Studies and Global Perspectives of Second Language Teaching and Learning*, Benjamins, Amsterdam, The Netherlands/Philadelphia, PA.
- Ruthven, K. (2011), “Using international study series and meta-analytic research syntheses to scope pedagogical development aimed at improving student attitude and achievement in school mathematics and science”, *International Journal of Science and Mathematics Education*, Vol. 9/2, pp. 419-458.
- Ryan, R.M., R.C. Fauth and J. Brooks-Gunn (2006), “Childhood poverty: Implications for school readiness and early childhood education”, in B. Spodek and O.N. Saracho (eds.), *Handbook of Research on the Education of Young Children (2nd ed.)*, Lawrence Erlbaum Associates, Mahwah, N.J.
- Saunders, W., C. Goldenberg and D. Marcellitti (2013), “English language development: Guidelines for instruction”, *American Educator*, Vol. 37/2, pp. 13-39.

- Savelsbergh, E.R. et al. (2016), “Effects of innovative science and mathematics teaching on student attitudes and achievement: A meta-analytic study”, *Educational Research Review*, Vol. 19, pp. 158-172.
- Schleicher, A. (2014), *Equity, Excellence and Inclusiveness in Education: Policy Lessons from Around the World*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264214033-en>
- Schwietter, J.W. (2010), “Developing second language writing through scaffolding in the ZPD: A magazine project for an authentic audience”, *Journal of College Teaching and Learning*, Vol. 7/10, pp. 31-45.
- Segall, A. (2004), “Revisiting pedagogical content knowledge: The pedagogy of content/the content of pedagogy”, *Teaching and Teacher Education*, Vol. 20/5, pp. 489-504.
- Sharples, M., et al. (2015), *Innovating Pedagogy 2015: Open University Innovation Report 4*, The Open University, Milton Keynes.
- Shulman, L.S. (1986), “Paradigms and research programs in the study of teaching: A contemporary perspective”, in M.C. Wittrock (ed.), *Handbook of Research on Teaching (3<sup>rd</sup> ed.)*, MacMillan, New York.
- Silver, E.A. and P. Herbst (2007), “Theory in mathematics education scholarship”, in F.K. Lester (ed.), *Second Handbook of Research on Mathematics Teaching and Learning*, National Council of Teachers of Mathematics, Information Age Publishing and Reston, VA, Charlotte, NC.
- Siskin, L.S. (1994), *Realms of Knowledge: Academic Departments in Secondary Schools*, Falmer Press, Washington, DC.
- Slavin, R.E. and C. Lake (2008), “Effective Programs in Elementary Mathematics: A Best-Evidence Synthesis”, *Review of Educational Research*, Vol. 78/3, pp. 427-515.
- Slavin, R.E., C. Lake and C. Groff (2009), “Effective programs in middle and high school mathematics: A best-evidence synthesis”, *Review of Educational Research*. doi: 10.3102/0034654308330968
- Sprung, M. et al. (2015), “Children's emotion understanding: A meta-analysis of training studies”, *Developmental Review*, Vol. 37, pp. 41-65.
- Sriraman, B. and L. English (2010), “Surveying theories and philosophies of mathematics education”, in B. Sriraman and L. English (eds.), *Theories of Mathematics Education: Seeking New Frontiers*, Springer, Heidelberg.
- Steenbergen-Hu, S. and H. Cooper (2013), “A meta-analysis of the effectiveness of intelligent tutoring systems on K–12 students’ mathematical learning”, *Journal of Educational Psychology*, Vol. 105/4, pp. 970-987.
- Stodolsky, S.S. (1988), *The Subject Matters: Classroom Activity in Math and Social Studies*, University of Chicago Press, Chicago IL.
- Stodolsky, S.S. and P.L. Grossman (1995), “The impact of subject matter on curricular activity: An analysis of five academic subjects”, *American Educational Research Journal*, Vol. 32/2, pp. 227-249.
- Stodolsky, S.S., S. Salk and B. Glaessner (1991), “Student views about learning math and social studies”, *American Educational Research Journal*, Vol. 28/1, pp. 89-116.
- Sung, Y.T., K.E. Chang and J.M. Yang (2015), “How effective are mobile devices for language learning? A meta-analysis”, *Educational Research Review*, Vol. 16, pp. 68-84.
- Supekar, K. et al. (2015), “Remediation of childhood math anxiety and associated neural circuits through cognitive tutoring”, *The Journal of Neuroscience*, 35, pp. 12574-12583.
- Thapa, A. et al. (2013), “A review of school climate research”, *Review of Educational Research*, Vol. 83/3, pp. 357-385.
- UNESCO (2015), *Transversal Competencies in Education Policy and Practice (Phase I), Regional Synthesis Report*, <http://unesdoc.unesco.org/images/0023/002319/231907E.pdf> (accessed 27 September 2016).

- Vanderplank, R. (2016), “‘Effects of’ and ‘effects with’ captions: How exactly does watching a TV programme with same-language subtitles make a difference to language learners?”, *Language Teaching*, Vol. 49/2, pp. 235–250.
- Van Patten, B. and A. Benati (2010), *Key Terms in Second Language Acquisition*, Continuum, London.
- Voogt, J. and N.P. Roblin (2012), “A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies”, *Journal of Curriculum Studies*, Vol. 44/3, pp. 299-321.
- Webb, N.M. et al. (2014), “Engaging with others’ mathematical ideas: Interrelationships among student participation, teachers’ instructional practices and learning”, *International Journal of Educational Research*, Vol. 63, pp. 79–93.
- WEF (2016). *New Vision for Education: Fostering Social and Emotional Learning through Technology*, Industry Agenda, Cologny/Geneva.
- Wigfield, A. and J.S. Eccles (1992), “The development of achievement task values: A theoretical analysis”, *Developmental Review*, Vol. 12/3, pp. 265-310.
- Wigfield, A. and J.S. Eccles (1994), “Children's competence beliefs, achievement values, and general self-esteem change across elementary and middle school”, *The Journal of Early Adolescence*, 14/2, pp. 107-138.
- Wong, W. (2013), “Input and output in SLA. Applying theories of mental representation and skill”, in J. Schwieter (ed.), *Innovative Research and Practices in Second Language Acquisition and Bilingualism*, Benjamins, Amsterdam, The Netherlands/Philadelphia, PA.
- Woodrow, L. and E. Chapman (2002) (1-5 December 2002), “*Second language speaking anxiety of learners of English for academic purposes in Australia*”, paper presented at the AARE 2002 Annual Conference, Brisbane, Australia, [www.aare.edu.au](http://www.aare.edu.au) (accessed 16 August 2016)
- Yoder, N. (2014). *Teaching the Whole Child: Instructional Practices that Support Socioemotional Learning in Three Teacher Evaluation Frameworks. Revised Edition*. American Institutes for Research.
- Zins, J.E. and M.J. Elias (2007), “Social and emotional learning: Promoting the development of all students”, *Journal of Educational and Psychological Consultation*, Vol. 17/2-3, pp. 233-255.
- Zoogman, S. et al. (2015), “Mindfulness interventions with youth: A meta-analysis”, *Mindfulness*, Vol. 6/2, pp. 290-302.

## INNOVATIVE PEDAGOGIES FOR POWERFUL LEARNING: COMBINATIONS

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### Introduction

Above we set out how pedagogical approaches have developed to promote different educational goals. This chapter builds on this to explain how *combinations* of approaches have developed to fulfil the multiple purposes of education. To the extent that education has multiple goals, the design of learning will always require drawing on a variety of practices and pedagogical approaches. As we have seen, in some cases a pedagogical approach can act as a frame that combines sets of compatible practices within an overarching sequence such as a student inquiry or project. Other approaches may involve adopting several discrete practices and using them in sequence. At a school level, we find teachers using a variety of approaches appropriate to different developmental stages and subjects, and thinking about how these might combine to achieve broader, more complex educational goals over time.

There are therefore two layers at which we can think about combinations, one in terms of discrete practices within a framing pedagogical approach, and one about how combinations of established approaches can meet long-term educational goals. A central finding of this inquiry is that where schools are thinking carefully about their learning design, they tend to anchor that design in a small number of approaches which are defined by the different ways they arrange time and agency. There seem to be benefits of having a limited set of framing approaches which students can become familiar with. For example, project or inquiry based learning provide a framework for activities, solving some of the dilemmas of organisation and allowing students to get used to sequences of more self-directed learning within an overall teacher-managed arc. Then each one of these frames involves more discrete pedagogies to achieve more specific teaching and learning goals within the sequence. It may be difficult to meet all learning outcomes within just one of these framing approaches: in the schools featured in this chapter, they choose to combine a small number of frames to achieve the full set of their school goals.

The study of pedagogical combinations offers a fruitful way to understand how established pedagogical approaches can be brought together to create effective learning designs. This focus takes us beyond the study of learning environments to consider school models, and long trajectories of student learning and development.

The first part of this chapter introduces a key factor driving the adoption of different pedagogies, namely the shift in focus towards developing higher-level personal and social competences throughout education. This shift has led to a greater emphasis on ‘student-centric’ pedagogies which aim to promote student agency and abilities for independent action and social interaction. This in turn creates a challenge for teachers in balancing this focus with adequate attention to student acquisition of a necessary breadth and depth of knowledge, promoted by more discipline-centric pedagogies.

The second part illustrates how combinations of practices and approaches can meet this challenge. After setting out some ways in which combinations occur, I provide some examples of how individual school networks are balancing learning goals across different pedagogies.

### *Evidence base*

This chapter is based on three types of sources: academic literature on the learning sciences, pedagogy, and youth development; international visits to schools deemed ‘innovative’ and schools engaged in teacher-led inquiry and practice development; and an online scan of school networks with distinct pedagogical models (see Appendix).

The learning sciences and the science of youth development provide a foundation for understanding the range of outcomes which pedagogies seek to achieve<sup>10</sup>. The long traditions of pedagogical theory provide a basis for defining certain approaches and their contribution to outcomes. The ability to describe teaching and its impacts accurately has advanced through large-scale studies of teaching, including video studies and international surveys<sup>11</sup>. One such sequence of studies, carried out predominantly in Germany, concludes that impactful teachers are those who consistently achieve three central tasks: classroom management (structure); classroom climate (support); and cognitive activation (engagement and challenge)<sup>12</sup>. This framework is supported by a great variety of other research into teaching, as well as by the science of learning, which highlights the importance of both the social and emotional conditions created by interaction with teachers and peers, and the cognitive demand of tasks<sup>13</sup>. Different pedagogies have developed different ways of balancing these three tasks, and some give greater emphasis to one or other. To achieve these three components, teachers are likely draw on a combination of pedagogical approaches, but there is further work to be done to understand the contribution different pedagogies can make.

Definitive knowledge on the relationships between pedagogical combinations and a variety of educational outcomes is limited. The majority of research on teaching practices takes an evaluative frame and seeks to establish the ‘effect’ of a practice, using causal inference methods which require focusing on an individual pedagogy rather than on pedagogical combinations. And there is no guarantee that practices which are studied in isolation have the same effect once combined (and ideally, any combination should equate to more than the sum of its parts). Systematic studies of the impacts of *combining* pedagogies may be found in studies of ‘deeper learning’ schools<sup>14</sup> or of the international baccalaureate programs<sup>15</sup>, which tend to involve combinations of more discipline-centric and more inquiry or project-based pedagogies. Research into these models has not been carried out with the aim of studying combinations, however, and the extent to which either model entails consistent combinations is open to question.

The lack of knowledge on the impacts of combining certain pedagogies is in part due to the struggle to measure many of the outcomes that pedagogies aim at<sup>16</sup>. Factors such as mind-sets, motivation and identify which some pedagogies seek to effect a remain difficult to study systematically – although work is developing in that direction<sup>17</sup>. Researchers thus have much more access to data from assessments of content recall and basic skill demonstration (‘first-order’ outcomes of learning), than assessments of some of the more complex or ‘higher-order’ outcomes of learning, such as general capabilities, dispositions, or identity. Incorporating qualitative research, we are still developing ways to recognize let alone assess these

<sup>10</sup> Dumont, Istance & Benavides (2010); Nagaoka et al. (2015)

<sup>11</sup> Tomáš & Seidel (2009); Vieluf et al. (2012)

<sup>12</sup> Klieme, Pauli & Reusser (2009)

<sup>13</sup> Bransford et al. (2000); National Research Council (2003)

<sup>14</sup> Zeiser et al. (2014)

<sup>15</sup> Saavedra (2014)

<sup>16</sup> Duckworth & Yeager (2015)

<sup>17</sup> Stecher & Hamilton (2014); Haynes et al. (2016)

higher-order outcomes. Studies which look at more long-range impacts of school networks and curricula, such as those referenced above, offer hope of developing our knowledge of how particular pedagogies relate to the outcomes.

For the most part, therefore, pedagogical combinations await further research, and one intention of this chapter is to provide common language and frameworks for studying the impact of pedagogical combinations in relation to their intentions.

### ***The Context for Combinations: Expanding the goals of education***

Everywhere around the world, the goals of education are multiple. Schools are expected to fulfill a number of important functions at once, including to prepare young people as future citizens, as well as to help them develop core knowledge and skills to be successful in work and life. Additionally, individual systems, leadership teams, teachers or students may have more specific goals which they seek to fulfill through schooling.

The purposes of education are typically inscribed in curriculum documents, whether school curricula or national curriculum frameworks. The goals in these documents can be divided into academic and long-term aims. Academic aims cover the discrete, concrete knowledge and skills children are expected to master. We might see these laid out as bullet points or ‘standards’, usually arranged by discipline, for example, that nine-year-olds should have a mastery of multiplying numbers up to twelve in their heads. Long-term aims are more general and abstract, and might be thought of as the headline aspirations of a curriculum, for example, that children become confident learners or healthy citizens.

The relationship between these two types of goals is contested. Some believe that if teachers teach and children meet all of the academic aims, this should lead to the natural emergence of desired long-term outcomes (thus we might think of these as ‘first-order’ and ‘higher-order’ goals). For others, personal, social and emotional competencies need to be developed concertedly. This has led to the development of different pedagogical traditions.

On the one hand, educators have made great progress in developing *discipline-centric pedagogies* which offer improved ways to teach specific concepts or develop specific skills relevant to a domain of knowledge. These developments build on advances in cognitive science and in our understanding of conceptual learning. For example, study of the misconceptions people hold about the natural world has led to the development of new methods for teaching physics and chemistry, using carefully targeted questions and graphical representations to advance student understanding past common pitfalls.

In another tradition, educators have worked on developing more *student-centered pedagogies* targeted towards developing students’ personal competence as part of content learning. One strand of this tradition has emphasised the importance of *experiential learning*, believing that young people learn how to hold a discussion, how to speak in front of an audience, or how to manage an experiment by doing it. Another has focused on promoting *self-regulated learning*, developing theories and methods designed to support students to manage their own learning, in order that they become more competent at learning independently.

Yet we cannot draw a concrete line between knowledge-centered and student-centered methods. Teachers working to support self-regulated learning, for example, would always want to be mindful of whether students have the relevant knowledge for the task at hand, and be prepared to use an effective approach to supplement that knowledge where necessary. This is because of the central role of working memory in learning: the theory of ‘cognitive load’ have developed based on findings that learners can only handle a certain amount of new material at once. Teaching has to take this into account to ensure that learners, even



when they are working independently, have the necessary background knowledge or scaffolding to carry out a task<sup>18</sup>. Moreover, developing competences and skills should not be conflated with experiential learning. Studies of developing expertise find that ‘deliberate practice’ is key<sup>19</sup>: in learning a sport, for example, it can be more effective to practice specific moves and techniques rather than endlessly playing full games.

Despite these acknowledgements, however, the place of student-centered learning has continued to grow. Why is this the case?

### *New purposes, new pedagogies*

If education were all about imparting content knowledge, developing and evaluating pedagogy would be all about establishing the best methods to promote memorization and understanding of knowledge and concepts. And indeed, this forms the foundation of any education; content-less learning is quite literally meaningless. But discipline-centric pedagogies cover only part of what a teacher, school or system might want to develop in students. Schools have always been designed to teach students certain behaviors and dispositions as well as to impart knowledge. When Benjamin Bloom and colleagues sat down to create a ‘Taxonomy of Educational Objectives’ in 1956, they described learning as applying to cognitive, affective, and psychomotor dimensions<sup>20</sup>. Different traditions of pedagogical theory have developed which place different emphasis on each of these dimensions.

60 years later, while our terminology has changed, we still find debate about different dimensions of learning, and concerns about striking the right balance. In particular, we are witnessing a shift in focus from the ‘cognitive’ to other dimensions of learning. What exactly these dimensions are remains under-specified. The term ‘noncognitive skills’ derives from identifying these factors in terms of outcomes that go unexplained by cognitive achievement tests<sup>21</sup>. The term has achieved widespread use<sup>22</sup>, though many psychologists and educationalists tend to refer to ‘social and emotional skills’<sup>23</sup>, or ‘interpersonal’ and ‘intrapersonal’ factors<sup>24</sup>. Others have referred to ‘super-cognitives’, to emphasize the fact that these factors rely on and emerge from particular (cognitive) thoughts, ideas and developed meanings<sup>25</sup>. There is considerably overlap with these factors and what educationalists have called ‘21<sup>st</sup> Century Skills’, which cover skills for improved personal management and interpersonal interaction<sup>26</sup>. Whatever exactly these ‘skills’ are<sup>27</sup>, in many contexts there has been a concerted shift towards pedagogies which aim to develop higher-level personal and social competence.

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<sup>18</sup> Kirschner, Sweller & Clark (2006)

<sup>19</sup> Ericsson & Charness (1994)

<sup>20</sup> Bloom & Krathwohl (1956)

<sup>21</sup> Heckman & Rubinstein (2001)

<sup>22</sup> E.g. Farrington et al. (2012); Roberts, Martin & Olaru (2015)

<sup>23</sup> OECD (2015)

<sup>24</sup> Stecher & Hamilton (2014)

<sup>25</sup> Intrator & Siegel (2014)

<sup>26</sup> Pellegrino & Hilton (2012)

<sup>27</sup> A major debate about ‘noncognitives’ is to what extent they are stable attributes of persons as opposed to qualities of relationships and environments. For example, is it more accurate to say that a child has ‘grit’ or that they are interested in and motivated by the particular goal they are working towards. Should we worry about a child lacking interpersonal skills or focus on the qualities of relationships available to that child? In focusing on these dimensions of learning, pedagogies can seek to change the resources and relationship available to a learner, as much as their ‘skills’.

There are at least four factors driving this shift.

Firstly, there has been a recognition that developing students' personal and social competences are a foundation for higher learning.<sup>28</sup> The more students understand themselves and others, the more they can engage in complex learning activities; incorporate multiple perspectives; and reflect on and develop their own knowledge, beliefs and abilities. Moreover, without a sense of identity as a learner and supportive peer relations, students may not be receptive to teaching and learning opportunities. As is often pointed out, the 'noncognitives' are extremely poorly named. The contemporary learning sciences<sup>29</sup> establish the interdependence of affective, cognitive and physical processes, highlighting, for example, the role of emotions in cognitive activation<sup>30</sup>, or the place of embodied cognition as part of memory<sup>31</sup>. Attends to students' emotional and motivational state and development therefore becomes part of any pedagogical design.

Secondly, societies and industries founded on digital technologies require people to be practiced in managing and using a more complex array of information, and increase the value of social skills. One conclusion sometimes drawn from technological change is that new technologies lower the requirement to master knowledge and skills, as holding information and many basic tasks may be 'outsourced' to devices. This position goes too far in neglecting the importance of learned knowledge and skills as foundations for more complex abilities, but it must be acknowledged that the ready availability of information changes our learning needs.

A third factor in this shift is the way that societal changes have increased the complexity of choices and tasks young people face as they transition from adolescence to adulthood. Without wishing to oversimplify the past, up until the mid-point of the previous century most people in industrial societies faced a relatively limited array of options when it came to where they would live, what job they would do, whether they would marry, and whom. Liberalization has produced huge benefits in terms of expanding our opportunities for agency, and to live meaningful and successful lives. But it also demands new levels of personal and social competence to thrive in more diverse and complex societies.

Finally, we must place this shift in the context of other institutional changes in education. More explicit attention to 'super-cognitive' factors might be seen as a pushback against the intensified focus on standardized assessments of cognitive skills as part of hard and soft accountability regimes. Educators are concerned that efforts to optimize test scores have crowded out other activities which develop students along other dimensions. Additionally – and paradoxically – those seeking to maximize test scores have realized that intrapersonal factors such as mind-sets and motivations are an important step in opening up students to learning and achievement.

In understanding where this drive comes from, we can come closer to establishing what it hopes to achieve. On the one hand, developing pedagogies to promote super-cognitives may enhance individual achievement and success. This is primarily a focus on intrapersonal skills, and we might call it 'instrumental'. On the other hand, the changing nature of work and societies demands new competencies, in particular interpersonal competencies but also different intrapersonal ones. We might call this the intrinsic value of super-cognitives.

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<sup>28</sup> Farrington et al. (2012)

<sup>29</sup> Meltzoff et al. 2009

<sup>30</sup> Immordino-Yang & Damasio (2007)

<sup>31</sup> Claxton (2015)

It is important to hold these goals separate in order to avoid all learning dimensions becoming subservient to the ‘cognitive’. ‘Affective’ learning goals – such as developing emotional stability – must still be seen as educational ends in and of themselves, not just a means to higher test scores.

### ***Pedagogies for life-long learning***

The shift in focus towards learner-centered pedagogies is part of a larger change in the way we think about the goals of learning, who can learn and how. The science of learning has changed how we think about human potential and skill development. We see an increase in ‘mastery-based’ approaches to education which are intended to allow everyone to learn to a high level – a stark difference from the systems of a century ago.

The shift in the balance of educational purposes from imparting an established body of knowledge to preparing life-long learners has considerable implications for pedagogy. Teachers have developed pedagogies to promote learning skills and strategies even from young ages<sup>32</sup>, building the ‘developmental attributes’ such as ‘academic mind-sets and dispositions; self-regulated learning skills; and academic behaviors’<sup>33</sup>. These skills describe what the OECD has called ‘learning to learn’: the strategies, practices and motivations associated with high performance<sup>34</sup>.

In many contexts, new pedagogies are shaped around the notion of ‘self-regulated learning’: approaches that intend to develop people’s ability to manage and progress learning without the direct instruction of a teacher. The ‘three-layer model’ of self-regulated learning<sup>35</sup> is one framework which captures the different kinds of mind-sets, dispositions and skills which need to be developed in order for students to be able to learn productively on their own. The inner layer of cognitive regulation encompasses the practices a student needs to master to carry out information processing. The middle layer of metacognitive regulation describes the students’ knowledge and skills that allow them to make effective choices about what they study and how. The outer layer of motivational regulation represents the “self”, the learner’s own goals, needs, and expectancies. Teachers have the ability to influence each of these layers, and so designing pedagogy becomes a more complex – but potentially more rewarding – task.

### ***The vital role of pedagogical combinations***

The intention of the above account is to broaden our picture of the purposes pedagogies might aim at. This is vitally important so that we can evaluate and appraise pedagogies from an authentic position, rather than trying to pretend that all pedagogies aim at the same goals. The above account also established that *both* discipline-centric and student-centric pedagogies are fundamental to achieving the purposes of education: the study of how expertise develops and of ‘cognitive load’ highlights that explicit teaching of knowledge and skills is a vital part of education. But once we recognize that motivation and emotion are ‘the gatekeepers of learning’<sup>36</sup> any line between discipline-centric and student-centric pedagogies becomes more blurred: engaging with students as individuals is just the other side of the coin of teaching concepts and skills effectively. One definition of ‘deeper learning’ describes teaching for deeper learning as a ‘spiral’ of mastery, creativity, and identity<sup>37</sup>: students master new knowledge and skills, practice putting

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<sup>32</sup> Cervone & Kushman (2012); Swann et al. (2012)

<sup>33</sup> Haynes et al. (2016)

<sup>34</sup> OECD (2010)

<sup>35</sup> Boekaerts, Pintrich, & Zeidner (2000)

<sup>36</sup> Dumont, Istance & Benavides (2010)

<sup>37</sup> Mehta & Fine (2015)

them to work in new ways, and in doing so create meaning that helps them to define their identity. Thus the depth of outcomes – and the complexity of pedagogies a teacher can use – grows as learners develop more of that fluency and background knowledge.

In sum, the two traditions cannot survive in opposition: teaching to develop personal competence cannot be achieved effectively without some teaching for knowledge acquisition, while teaching knowledge alone is futile if students do not have the personal and social competence to put it to use. To this extent, it is only useful to talk about ‘discipline-centric’ and ‘student-centric’ pedagogies for the purpose of clarity about intentions. The need to separate pedagogies into different approaches arises not only from our tendency to dichotomize but also from the needs of research: in order to study accurately whether a set of practices is having a desired impact, it is helpful if we can codify it and examine it in relation to specific outcomes. In this way we can advance the science of teaching. For all purposes beyond clarity in research and evaluation, however, it may be best to steer clear of dichotomizing labels. In actual teaching, teachers find they need to bring these different pedagogies back together to meet the multiple dimensions of learning. Teaching is therefore all about *combinations*.

What are the ways in which combinations occur? In the next sections, I describe factors which appear to shape the creation of combinations at the classroom and school level.

### ***Achieving balance***

In combining pedagogies, the central question is one of *balance*. How teachers organize their own time and that of their students has implications for the range of opportunities students have to develop competence, and the depth and breadth of knowledge they acquire.

A central question of balance is of course about ‘the *what* of Education’<sup>38</sup>: how to create adequate depth and breadth of focus, taking into account the many different domains of knowledge and skills. A mandated curriculum may or may not leave many choices to be made. But if we are concerned with the development of students’ personal and social competences, an equally important question is about how students experience their day-to-day learning. Who are they working with? What control do they have over what they are doing? How are they receiving feedback? What do they think it is all for?

In the above chapter we proposed that an important function of pedagogy was to organize learning. The table below illustrates again how different established pedagogies tend to lead to different kind of learning experiences.

**Table 3: Different approaches create different learning experiences**

|                           |                | What makes students keep working? |                     |                |                       |                     |
|---------------------------|----------------|-----------------------------------|---------------------|----------------|-----------------------|---------------------|
|                           |                | Teacher instruction               | Self-managed        | Group dynamics |                       |                     |
| What do students work on? | Teacher choice | Lecture                           | ‘personalized’      | Collaborative  | Time-based            | When do we move on? |
|                           | Co-constructed | Mastery-based                     | Blended             | Discussion     | Continuous assessment |                     |
|                           | Student choice | Scaffolded Inquiry                | Independent Inquiry | Project-based  | Final product         |                     |

<sup>38</sup> Fadel, Trilling & Bialik (2015)

Each type of pedagogy comes with trade-offs related to the advantages and disadvantages of different set-ups. Educators might therefore choose to combine certain pedagogies to achieve a balance of types of learning experiences. For example, a teacher working on developing both student agency and self-regulation might choose pedagogies that allow students to select the focus of learning and to manage their own time, such as inquiry. If, however, the teacher is also concerned that student knowledge is lacking on certain topics and they need to maximize the efficient use of time, she might opt for combining that with periods of ‘personalized’ (often computer based) learning, which can be deployed within a specific time allotment.

### ***Trade-offs in combining pedagogies: variety vs familiarity***

If we were seeking to maximize the different kinds of learning experiences student have, we might think this is best achieved by combining as many pedagogies as possible. There are trade-offs, however, in the number of pedagogies a teacher tries to use. For each approach, there will be a learning curve. Recalling the earlier example of the Literature teacher: we may not want to *always* emphasize personal connection, or *always* give more time to oracy skills, but we also want to develop some consistency of emphasis over time so that it has a chance of real impact.

We saw already that we can also think about pedagogies as bundles of discrete practices. Combining pedagogies which share common practices can help reduce the trade-offs of using too many pedagogies. For example, in a school where students are practiced in inquiry-based learning, teachers might feel more confident in combining his approach with challenges or complex projects, knowing that students are competent at managing their own learning. Likewise, systems might create more effective professional development or teacher education opportunities by looking for coherence between pedagogies at the level of practices. By focusing on the core knowledge and skills that are common across many pedagogies, opportunities could develop these while still allowing teachers and schools to make their own decisions about they combine specific approaches.

Studying common combinations of pedagogies can help to identify those practices which are common to several pedagogies, such as presentations of learning, or student self-assessment. Building both teacher and student familiarity with these practices could make it easier to support a greater diversity of pedagogical combinations across a school or system.

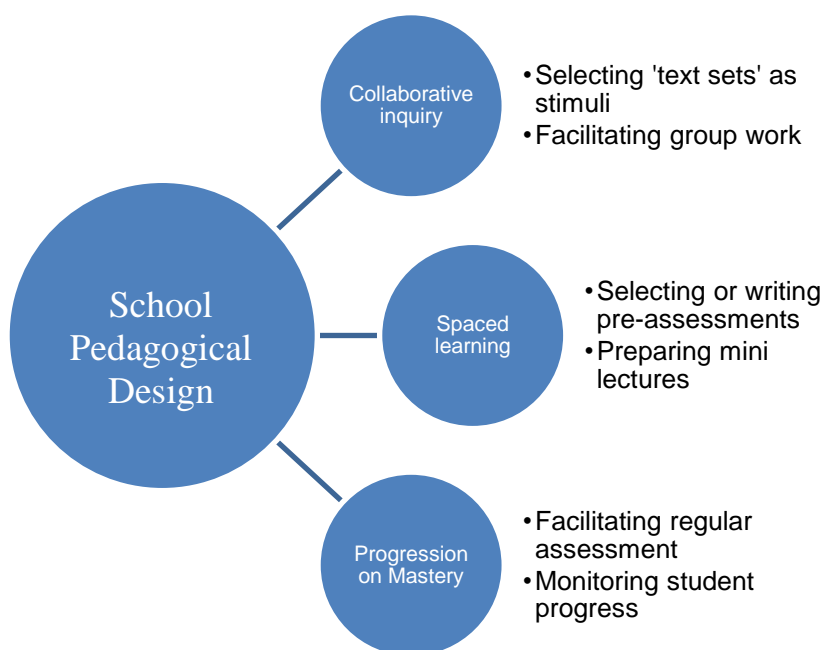
### ***Combining pedagogies into a school design***

When a school has a robust and overarching pedagogical design, it has made a collective decision about the way it will combine several pedagogies to meet multiple educational goals as a community. The advantage of making this decision at the school level is that the power of each pedagogy is strengthened considerably. When teachers are working with the same pedagogical approach, individual teacher planning can be reinforced at the organizational level and teachers can collaborate together more easily, sharing ideas and improving each other’s practice. Students in such schools can transfer the learning approaches they develop in one year or subject area to another. Moreover, the promotion of long-term outcomes is likely to be more successful when carried out across a whole school.

It is still relatively rare for schools to operate with this level of coherence, particularly at the secondary level. There are limits to the extent a pedagogical approach can and should be shared across different disciplines and domains: some pedagogies have been developed specifically to teach the particular core knowledge and skills of different disciplines, and these may shape the bulk of teaching and learning practices. In order to promote personal and social competences, however, some attention to school-wide coherence and developmental pathways seems necessary. To the extent that children and young people move between schools, there is also reason to think about the need for some pedagogical coherence at a

local or even jurisdiction level: for key skills such as oracy and project management, just as with numeracy and literacy, it might be desirable for teachers across a jurisdictions to be able to share common continua and language related to a particular pedagogy, which they would then need to be able to integrate into their individual pedagogical design.

Overall, from the perspective of school pedagogical designs, there are two levels at which we can think about combinations of pedagogies. On the one hand, any given pedagogical approach entails a set of practices which can be refined and improved upon the more they are used. At a more general level, established pedagogical approaches are combined to make up an overarching pedagogical design at the school level, which provides coherence and ensures a balance of discipline-centric and student-centered learning goals.



**Figure 1: Practices combine within approaches, which combine in a school-level pedagogical design**

## Part 2: Examples of combinations

Conceptual models can help to clarify how pedagogical combinations are formed and why. These models are derived in part from looking at what expert practitioners do, and we can learn more from looking at the details. This section features three illustrative examples of how a sample of school networks have combined distinct approaches and practices to generate the experience, learning and outcomes they want for young people.

This section draws on a wider scan of how schools and school networks describe their pedagogical models. A fuller list of examples is included in Appendix B. The cases may be familiar to many educators, but are selected to provide relatively explicit examples of pedagogical combinations, and to show that pedagogical designs can emerge ‘bottom up’ through informal networks and innovation, as well as being cascaded ‘top down’ through the concerted efforts of a school chain or network. A series of conclusions and outstanding questions follows the examples.

### ***High Tech High, San Diego, California, USA***

The High Tech High<sup>39</sup> (HTH) schools began with the founding of one high school in San Diego in 2000. There are now 13 schools in the network, all based in the San Diego area and including elementary, middle and high schools.

The central pedagogy at High Tech High schools is learning through projects. Projects are designed primarily by pairs of teachers who represent two or more disciplines, meaning that they are multi-disciplinary, but focus on core subject content. A project arc will be designed so that periods of time when students are working on their own in groups are interspersed with teacher-led sessions that provide key content or introduce necessary skills. Through projects, HTH seeks to fulfil its four founding ‘design principles’<sup>40</sup>: *personalization, adult world connection, and common intellectual mission, teacher as designer*.

Teachers develop their skills in project based learning through a network-specific initiation (the ‘Odyssey’), as well as ongoing school-based professional development. The network has its own Graduate School of Education which provides teacher education oriented specifically towards the HTH pedagogical design.

The cornerstone of the project-based approach at HTH is public exhibitions: at the end of each project students present or display their work at an event for parents, others students and teachers, and members of the community. These events are well-attended by the community, and act as an important form of motivation and accountability: HTH teachers observe that the level of freedom given to students in how they manage their time and group work across a project is only possible because all students know they have to have something to show for it at the end.

HTH teachers have recognized that not all the necessary learning students need comes naturally through projects or interspersed teacher-led sessions. Portions of the school week are therefore given over to more intensive skills building. For Mathematics, some teachers have adopted an individualizing pedagogy called ‘Judo Math’, originally developed by HTH teacher Dan Theone<sup>41</sup>. Students earn ‘belts’ as they progress through different mathematics topics and skills and demonstrate mastery.

While High Tech High as an organization has resisted spreading geographically, there are a number of HTH-inspired schools around the world. School 21, in London UK has developed a model of project-based learning with support from High Tech High teachers, and combines it with a number of different components to achieve their desired curriculum goals. For example, alongside the emphasis on exhibitions, School 21 promotes the development of communication skills through a unique ‘oracy’ curriculum and drama-based pedagogy. Additionally, amidst longer project lessons, students spend time each day in short, intensive skill-building sessions focused on numeracy and literacy, which adopt a more didactic pedagogy.

### ***Lumiar Schools, Sao Paulo, Brazil***

The first Lumiar school<sup>42</sup> was founded in 2003 in Sao Paulo by entrepreneur Ricardo Semler. The Lumiar Institute<sup>43</sup>, established in 2009, now oversees three schools in the region.

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<sup>39</sup> <http://www.hightechhigh.org/>

<sup>40</sup> <http://www.hightechhigh.org/about/design-principles.php>

<sup>41</sup> <http://hightechhigh.org/projects/?name=Judo%20Math&uid=e143a5b01ae5f9cecd8d38209c8c48e4>

<sup>42</sup> <http://lumiar.org.br/>

The Lumiar pedagogical model is underpinned by a defined view of learning and education. Eduardo Chaves, former President of the Lumiar Institute, described<sup>44</sup> how they see education “as a process of human development”, the end goal of which is to become “a competent and autonomous adult”. According to this view of education as human development, education occurs throughout the life course and through all interactions, but the role of “schools, as formal learning environments” is central, as long as schools and their pedagogies are organised to incorporate and engage with the wider process of development. Consequently, the “learning methodology” of Lumiar schools is based on a picture of what learning looks like in wider life, that “the best way to learn is by acting, doing, transforming projects into reality”. Chaves describes this as an “active methodology”.

The central approach of Lumiar schools is project-based learning, but of a particular kind. Students undertake projects either individually or in small groups, formed around interests. Every two months teachers provide students with a wide range of choices of problems to work on, and shape projects around the student choices. Student suggestions are taken very seriously, and the goal is that as students advance in their education their projects will become increasingly self-determined and important to them. In contrast to some other PBL models, therefore, projects are more likely to track local or current concerns than the mandatory curriculum, although curriculum content will be incorporated. The high level of student choice is enabled by the notion of the ‘mosaic curriculum’: that curriculum should be viewed as a patchwork which students complete in any order they like, as opposed to a mandatory sequence. The core curriculum is built from a ‘matrix of competencies’ which (to the extent to two can be separated) prioritise skills over standardized knowledge.

To provide opportunities for learning knowledge and skills not fully developed through projects, there are two other key components of the Lumiar pedagogical design: workshops and learning modules. Workshops focus on specific content and operate with a studio or apprenticeship pedagogy, where students see skills modelled and have time to practice. Workshops are the method through which students develop necessary skills that are applied in projects.

Learning modules operate with either a didactic or dialogic pedagogy, where teachers are leading a sequence of learning on a specific topic. One learning module all students take is ‘World Reading’, focussed on engaging with international affairs through reading and discussing current newspapers. The topics of learning modules are chosen by the teachers, to ensure students are being exposed to breadth as well as depth of content.

At Lumiar, the teaching role is divided between leaders of projects who are not full-time staff, but supply expertise knowledge and motivation, and the full-time tutors who monitor and guide student learning and progress. Embodying these different skill sets in different staff also gives rise to different pedagogical combinations and variety.

### ***Growing Innovation in Rural Schools, British Columbia, Canada***

Rural schools in British Columbia are networked in an overlapping set of official programs and informal relationships between educators and researchers working in the province and beyond. Over recent years, the sharing of practices has allowed these schools to develop a cohesive set of pedagogies which are highly complementary and aligned with goals to promote social and environmental sustainability and awareness of place. The development of pedagogical practices has been particularly encouraged by the ‘Growing

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<sup>43</sup> <http://www.fundacaoralstonsemmler.org.br/bilingue/home.php?version=eng>

<sup>44</sup> <https://lumiarschool.wordpress.com/2007/10/19/lumiars-pedagogical-proposition/>



Innovation<sup>45</sup> projects in rural schools, funded by the Ministry of Education and facilitated by faculty from the University of British Columbia.

The first and most distinct of these approaches is outdoor or place-based learning. Schools have developed projects and learning sequences specific to their environments, which serve the dual purpose of engaging students in authentic learning and connecting them to the knowledge that is most valuable in their context. A number of sequences have revolved around the development of community gardens or farms, which have subsequently given rise to food technology and cooking programs, and related enterprises. The type of learning experiences and content students have been able to engage with therefore naturally has become more complex as an outdoor learning space grows.

Another variant of outdoor learning focuses on developing students capabilities to engage with uncharted terrain such as mountains or forests, which lends itself to content learning in key areas of science and geography but is also used as inspiration for writing exercises, as well as opportunity to develop students' persistence, self-reflection and social and emotional stability.

These forms of powerful learning experiences lend themselves well to combination with inquiry-based approaches, where outdoor learning provides an initiating point or culmination for periods of inquiry. For example, students planning a hike to a location of particular geological significance are charged with working out where they needed to go, how to get there and what supplies to bring, applying core literacy, numeracy and research skills in the process. In schools where students work on more personal inquiries, an outdoor experience might provide the basis for students to develop new wonderings to pursue, relevant to their context and place.

Alongside inquiry and place-based approaches, the rural education networks have also facilitated the sharing of practices to improve students' reading, writing, questioning and number work, which are all core skills for carrying out inquiries. 'Daily 5s' are a popular method at the elementary level to engage students in practicing these skills, where students chose from one of five activities geared either towards maths or reading and writing. A method found across North America and beyond, it is particularly compatible with inquiry-based learning as it promotes students' self-management.

Another practice which scaffolds inquiry skills is the use of text sets, where teachers put together a selection of books and/or other media resources on a topic from which students select to conduct their research. This practice allows teachers to define the bounds of relevant content for an inquiry, ensures that students are engaging with high quality written material. A parallel activity is possible through the curation of online content, and educators in the network share tips on the use of sites such as National Geographic for Kids<sup>46</sup> or Kiddle<sup>47</sup> (a child-friendly version of google, still undergoing improvements). These new practices around the use of open online resources may emerge as discrete approaches which could be combined with other approaches besides inquiry.

### **3. Hypotheses: creating strong combinations**

How and why do approaches and practices combine – and how can existing combinations inform further innovation? This section extrapolates from the examples above to offer three hypotheses on what can be learned from viewing teaching and learning through the lens of pedagogical combinations. These are proposals to test through the broader project.

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<sup>45</sup> <http://www.ruralteachers.com/growing-innovation-2011>

<sup>46</sup> <http://kids.nationalgeographic.com/>

<sup>47</sup> <http://www.kiddle.co/>

### *1. Depth and balance*

Each of the networks has developed a pedagogical design where teachers draw on a limited number of pedagogical approaches. Successful models seem to be those which balance approaches that maximize opportunities for students' personal and social development, with those which prioritize the development of core skills and knowledge. This finding suggests that the entrenched positions of student-centric and discipline-centric advocates can be overcome: expert educators are drawing on both of these traditions to promote learning that is both rich in new concepts and skills and personally engaging.

### *2. A strong core*

Each model has a single central approach which typically cuts across different subject areas or disciplines, such as project-based learning in the case of High Tech High or inquiry learning in the B.C. rural schools. Teachers view this as a 'core pedagogy' which provides a rhythm to the school day, week and year, for example, the duration of a project leading up to an exhibition, or a cycle of inquiry. This rhythm means that students have a sense of momentum in their work, and learning is shaped meaningfully as opposed to by arbitrary bells and schedules. Both within this structure and in separately allotted times, teachers also adopt subject-specific pedagogies to propel learning in particular domains. The combinations ensures that knowledge and skill development do not lose out amidst the focus on the core pedagogy.

### *3. Network-specific variations*

In most cases, the examples illustrate a distinct version of a more general pedagogical approach, for example, within project-based pedagogies, High Tech High teachers design whole class projects around subject-based inspirations, while the Lumiar approach to projects is more about student choice and a focus on tackling problems. In each case, the network in question provides for teachers a particular 'anchor' or framework for the approach, so that teachers within a school have the same starting point and language. In the best networks, teachers become expert at designing around that frame or anchor.

## ***Outstanding questions for research and practice***

### *1. Balance – across what arc of learning?*

Some schools or networks are in a position to create a pedagogical design that covers the whole duration of formal schooling (or even beyond). Balance discipline-centric and student-centric goals may look different depending on whether one is planning for development over the course of one year, or over a young person's entire school career. Both researchers and practitioners cannot seek to establish general principles of balance and combination without taking into account the situation of students. How to construct that balance is likely to look different depending on the developmental stage of students, and their background experience. Further work on how combinations are created at each stage of education could help inform this question.

### *2. Optimizing – for what?*

This question addresses the tension between different kinds of learning goals. In seeking to identify innovative combinations of pedagogies, it is necessary to have some way of evaluating what makes one combination better than another. But the combinations of pedagogies likely to lead to optimal knowledge outcomes may not be the same as that which leads to optimal personal and social development. For example, project-based approaches geared toward collaboration and student agency require some sacrifice of time that might be spent on content coverage. The study of combinations may be a key opportunity to highlight how higher-order personal and social competences can be produced without sacrificing discipline-centric learning. But this will remain difficult while assessment is primarily geared towards

subjects and a few key skills. External evaluators will need to look to long-term student outcomes, or proxies thereof, as well as impacts on test scores. It is also important to acknowledge that final appraisals of pedagogical choices are value judgments to be made at a class, school or system level.

*3. Less is more, or more is better?*

With the proliferation of network-specific versions of many pedagogical approaches, it is an open question whether it would be desirable to try to combine several of these together – for example, for a model to emphasize both real world challenges and exhibitions, along with best questioning practices, use of rotations, personalized learning plans etc. It might be more desirable for a network to focus on building the best possible capacity around fewer anchors and frames, to create their own ‘core pedagogy’. This question could be explored further through cases of how networks have reached decisions about which practices to make central to their model.

## REFERENCES

- Bloom Benjamin S. and David R. Krathwohl. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals*, by a committee of college and university examiners. Handbook I: Cognitive Domain. New York, Longmans, Green
- Boekaerts, M. Pintrich, P. R. & Zeidner, M. (Eds.) (2000) *Handbook of self-regulation*. San Diego, CA: Academic Press
- Bransford, John D., Anne L. Brown, Rodney R. Cocking, and National Research Council Committee on Developments in the Science of Learning. 2000. *How People Learn: Brain, Mind, Experience, and School*. Washington, D.C.: National Academies Press.
- Bristow, S.F., Patrick, S. (2014). An International Study in Competency Education: Postcards from Abroad, International Association for K–12 Online Learning. CompetencyWorks Issue Brief. Available online at: <http://www.competencyworks.org/wp-content/uploads/2014/10/CW-An-International-Study-in-Competency-Education-Postcards-from-Abroad-October-2014.pdf>
- Cervone, B., & Cushman, K. (2012). *Teachers At Work: Six Exemplars of Everyday Practice* (Students at the Center Series). Boston, MA: Jobs for the Future.
- Claxton, G. (2015). *Intelligence in the Flesh: Why Your Mind Needs Your Body Much More Than it Thinks*. Yale University Press.
- Duckworth, A. L., & Yeager, D. S. (2015). Measurement Matters Assessing Personal Qualities Other Than Cognitive Ability for Educational Purposes. *Educational Researcher*, 44(4), 237–251. <http://doi.org/10.3102/0013189X15584327>
- Dumont, H., Istance, D., & Benavides, F. (Eds.). (2010). *The Nature of Learning: Using Research to Inspire Practice*. Paris: OECD.
- Ericsson, K. A. & Charness, N. (1994). “Expert Performance: Its Structure and Acquisition.” *American Psychologist* 49 (8): 725-747
- Fadel, C., Trilling, B., & Bialik, M. (2015). *Four-Dimensional Education: The Competencies Learners Need to Succeed* (1 edition). CreateSpace Independent Publishing Platform.
- Farrington, C.A., Roderick, M., Allensworth, E., Nagaoka, J., Keyes, T.S., Johnson, D.W., & Beechum, N.O. (2012). *Teaching adolescents to become learners. The role of noncognitive factors in shaping school performance: A critical literature review*. Chicago: University of Chicago Consortium on Chicago School Research.
- Hattie, J. (2011). *Visible Learning for Teachers: Maximizing Impact on Learning* (1 edition). London ; New York: Routledge.
- Haynes, E., Zeiser, K., Surr, W., Hauser, A., Clymer, L., Walston, J., ... Yang, R. (2016). *Looking Under the Hood of Competency-Based Education: The Relationships Between Competency-Based Education Practices and Students’ Learning Skills, Behaviors, and Dispositions* (Nellie Mae Education Foundation). Washington, D.C.: American Institutes for Research. Retrieved from <http://www.nmefoundation.org/getattachment/41f51cb0-81c4-42a5-b40c-50706537829d/CBE-Study-Full-Report.pdf?ext=.pdf>
- Heckman, J. J., & Rubinstein, Y. (2001). The Importance of Noncognitive Skills: Lessons from the GED Testing Program. *American Economic Review*, 91(2), 145–149. <http://doi.org/10.1257/aer.91.2.145>

- Higgins, S., Katsipataki, M., Coleman, R., Henderson, P., Major, L.E., Coe, R. & Mason, D. (2015). The Sutton Trust-Education Endowment Foundation Teaching and Learning Toolkit. July 2015. London: Education Endowment Foundation.
- Immordino-Yang, M.H. & Damasio, A.R. 2007. "We Feel, Therefore We Learn: The Relevance of Affective and Social Neuroscience to Education." *Mind, Brain, and Education*. Vol. 1, No. 1.
- Intrator, S. M., & Siegel, D. (2014). *The Quest for Mastery: Positive Youth Development Through Out-of-School Programs*. Harvard Education Press.
- Jensen, B., Sonnemann, J., Roberts-Hull, K., & Hunter, A. (2016). *Beyond PD: Teacher Professional Learning in High-Performing Systems*. Washington, D.C.: National Center on Education and the Economy. Retrieved from <http://www.ncee.org/wp-content/uploads/2016/02/BeyondPDWebv2.pdf>
- Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist*, 41(2), 75–86. [http://doi.org/10.1207/s15326985ep4102\\_1](http://doi.org/10.1207/s15326985ep4102_1)
- Klieme, E., Pauli, C. & Reusser, K. (2009) The Pythagoras Study: Investigating the Effects of Teaching and Learning in Swiss and German Mathematics Classrooms. in Tomáš, J., & Seidel, T. (Eds). *The Power of Video Studies in Investigating Teaching and Learning in the Classroom*. Munster: Waxmann.
- Lortie, D. C. (2002). *Schoolteacher: A Sociological Study* (2nd edition). Chicago: University of Chicago Press.
- Mehta, J., & Fine, S. (2015). *The Why, What, Where, and How of Deeper Learning in American Secondary Schools* (Students at the Center Series). Boston, MA: Jobs for the Future. Retrieved from <http://www.studentsatthecenter.org/sites/scl.dl-dev.com/files/The-Why-What-Where-How-121415.pdf>
- Meltzoff, A. N., Kuhl, P. K., Movellan, J., & Sejnowski, T. J. (2009). Foundations for a New Science of Learning. *Science*, 325(5938), 284–288. <http://doi.org/10.1126/science.1175626>
- Nagaoka, J. K., Farrington, C. A., Ehrlich, S. B., & Heath, R. D. (2015). *Foundations for Young Adult Success A Developmental Framework* (Concept Paper for Research and Practice). Chicago, IL: The University of Chicago Consortium on School Research.
- National Research Council and the Institute of Medicine. (2003). *Engaging Schools: Fostering High School Students' Motivation to Learn*. Committee on Increasing High School Students' Engagement and Motivation to Learn. Board on Children, Youth, and Families, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.
- OECD (2010), PISA 2009 Results: Learning to Learn – Student Engagement, Strategies and Practices (Volume III). Paris, France: OECD Publishing. DOI: <http://dx.doi.org/10.1787/9789264083943-en>
- OECD (2015), *Skills for Social Progress: The Power of Social and Emotional Skills*. Paris, France: OECD Publishing. DOI: <http://dx.doi.org/10.1787/9789264226159-en>
- Roberts, R. D., Martin, J. E., & Olaru, G. (2015). *A Rosetta Stone for Noncognitive Skills: Understanding, Assessing, and Enhancing Noncognitive Skills in Primary and Secondary Education*. New York: Asia Society.
- Pellegrino, J. W. & Hilton, M. L. (2012) *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century* (Eds.) Committee on Defining Deeper Learning and 21st Century Skills; Wasngton, D.C.: National Research Council
- Peterson, A. (2016). Getting "What Works" working: building blocks for the integration of experimental and improvement science. *International Journal of Research & Method in Education*, 39(3), 299–313. <http://doi.org/10.1080/1743727X.2016.1170114>

- Saavedra, A. R. (2014). The Academic Impact of Enrollment in International Baccalaureate Diploma Programs: A Case Study of Chicago Public Schools. *Teachers College Record*, 116(4).
- Stecher, B. M., & Hamilton, L. S. (2014). *Measuring Hard-to-Measure Student Competencies: A Research and Development Plan*. Santa Monica, CA: RAND Corporation. Retrieved from [http://www.rand.org/pubs/research\\_reports/RR863.html](http://www.rand.org/pubs/research_reports/RR863.html)
- Swann, M., Peacock, A., Hart, S., & Drummond, M. J. (2012). *Creating learning without limits*. Maidenhead: Open University Press.
- Tomáš, J., & Seidel, T. (2009). *The Power of Video Studies in Investigating Teaching and Learning in the Classroom*. Munster: Waxmann.
- UNESCO (2015) Transversal Competencies in Education Policy & Practice (Phase 1 Regional Synthesis Report). Paris, France: UNESCO
- Vander Ark, T. (2016, June 24). Project or Activity? Project-Based Learning and Cousins. Retrieved from <http://gettingsmart.com/2016/06/project-activity-pbl-cousins/>
- Vieluf, S., Kaplan, D., Klieme, E., & Bayer, S. (2012). *TALIS Teaching Practices and Pedagogical Innovations Evidence from TALIS: Evidence from TALIS*. OECD Publishing.
- Zeiser, K., Taylor, J., Rickles, J., Garet, M. S., & Segeritz, M. (2014). *Evidence of Deeper Learning Outcomes (3 of 3)* (Study of Deeper Learning: Opportunities and Outcomes No. 3). Washington, D.C.: American Institutes for Research. Retrieved from <http://www.air.org/resource/evidence-deeper-learning-outcomes-3-3>

## APPENDIX

### NETWORKS WITH INNOVATIVE PEDAGOGICAL DESIGNS

This Appendix provides a wider range of examples of how schools and school networks describe their pedagogical designs. The text is primarily directly extracted from network publications, sourced from an initial search to establish the range of ways pedagogical approaches are described and presented. It is by no means meant to be illustrative of the full range of pedagogical combinations or innovative models in operation today. The search focused only on school *networks*, which often have greater capacity (and need) to codify their pedagogical design as it is being applied across organizational sites. In single schools, a pedagogical design may be just as coherent, but less explicit. This focus on school networks favours systems that have promoted chains or networks of independent public schools, especially the United States, England, and Sweden. Additionally, language limitations restrict the range of the sample. Further work would aim to greatly extend this sample into a wider range of countries.

#### **AltSchool**

<https://www.altschool.com/education#our-approach>

#### ***Personalized learning built on external standards***

*Each student at AltSchool has a personalized learning plan, based on their current knowledge across all academic areas, individual goals, and interests. Through our technology, educators curate relevant individual and group activities that support each student's goals and needs. Educators assess student progress on an ongoing basis to keep students challenged and help them grow. Educators personalize across many dimensions. They continually adjust a student's goals, pace, content by subject, physical environment, and the roles students take on in group projects...*

*Because social-emotional skills are just as important as academics, our educators track them with the same rigor. We also group students of different ages in the same classes so they can experience being leaders, learners, and teammates together.*

*In addition to building skills for how to learn, AltSchool students build competency across core academic domains. Educators assess student work and progress against each student's individual learning objectives and nationally recognized standards, including Common Core English and Math, Next Generation Science Standards (NGSS), and Social Emotional Learning Competencies (CASEL). To build a strong academic foundation, students advance when they have demonstrated competency in an area, not because the class has advanced.*

#### ***Project-based learning***

*Real-world inquiry brings learning to life. Through projects, students put foundational skills directly into practice in an interdisciplinary way. For example, designing an outside patio becomes an opportunity to apply geometry and precise measurement. And submitting a written proposal to City Hall for a permit to build that patio becomes a real-world study of persuasive writing. Such projects provide authentic context to seek out and solve problems, collaborate, and set goals.*

*Each class at AltSchool uses projects to explore interdisciplinary topics. Students have opportunities to investigate topics through field trips, individual and group research, or visits with partners from AltSchool's Expert Network. As a culmination of a particular arc, students plan, produce, and present a project of their own.*

### **Ascend Charter Schools**

<http://www.ascendlearning.org/our-approach/>

[Really quite traditional]

### **Literature Circle**

*An ambitious program where children in kindergarten through fifth grade discover the deepest meaning of outstanding children's literature and become proficient and expressive writers*

### **Number Stories**

*Develops students' skills as mathematical thinkers*

### **Humanities**

*A captivating and intellectually challenging study of multi-cultural literary classics, with a focus on critical-thinking, writing, and public-speaking skills, as well as art and music appreciation.*

...

*Building on the strength of the Humanities Program in grades five through eight, the high school curriculum will **align English and Composition with the History sequence**, where students will study Global History, United States History, Civics, and Economics. Students will graduate confident in their critical reading, writing and public speaking skills, and will have developed the ability to understand, critique, and participate fully in the world around them.*

### **Community service, internships**

*Cementing an understanding of one's place in the world is the full realization of Ascend's liberal arts vision of developing young people who are connected to a purpose and to improving society. To foster this sense of belonging, students will be expected to complete a significant program of community service. **Practical, hands-on experience outside of the school building** is critical for students to explore career paths and navigate the real world. In later years, staff will help connect students to internships.*

### **Advisory**

*Each student at the high school is connected to an advisor, and the **advisees meet as a group with the advisor each morning**. The meeting includes checking in on homework and dress code, ensuring that students are ready for the day, and intentional teaching relating to organization and executive function skills.*

### **Aspire Public Schools**

<http://aspirepublicschools.org/approach/curriculum-instruction/>



### **Teaching Methods**

*All educators at Aspire use a variety of strategies in their teaching practice, depending on how students learn best. Teachers are trained to adapt these strategies to maximize each child's educational experience. The major strategies used include: explicit instruction, academic discourse, group and individualized, problem solving, inquiry, project-based instruction, and apprenticeship.*

### **Clear Learning Goals**

*To establish a foundation for success, we outline three areas of focus:*

- 1. **Basic Skills** Master at least grade level competency in the four core subjects: mathematics, science, social studies, and language arts (including reading, writing, listening and speaking)*
- 2. **Thinking Skills** Be able to apply classroom learning to their real world experiences in a relevant and valuable way, using higher-order thinking skills (including critical thinking, creativity, decision-making, problem solving, reasoning, knowing how to learn)*
- 3. **Life Skills** Have developed personal qualities of individual responsibility, intellectual curiosity, sociability, self-management, confidence, and integrity.*

### **A Balanced Curriculum**

*Aspire combines internally-created curriculum with reliable, nationally-recognized outside sources. Every curricular decision is based on building a clear K-12 system that prioritizes higher-order thinking and life skills..*

### **Blended Learning**

*Over the years, Aspire has become known for our blended learning approach. We have worked to convert existing schools to an integrated model that focuses on enhancing student achievement and supporting teacher effectiveness within current facilities. It was important for us to build on the model that had already proven successful for Aspire - small group learning. Teachers are able to provide small group instruction, while other students are either working on independent reading/problem solving or working on a computer program.*

### **Big Picture Learning**

<http://www.bigpicture.org/>

### **Advisory**

*Each student at a Big Picture Learning school is part of a small learning community of 15 students called an advisory. Each advisory is supported and lead by an advisor, a teacher that works closely with the group of students and forms personalized relationships with each advisee. Each student works closely with his or her advisor to identify interests and personalize learning. The student as the center of learning truly engages and challenges the student, and makes learning authentic and relevant.*

### **Internships**

*Each student has an internship where he or she works closely with a mentor, learning in a real world setting. Parents and families are actively involved in the learning process, helping to shape the student's learning plan and are enrolled as resources to the school community.*

*The result is a student-centered learning design, where students are actively invested in their learning and are challenged to pursue their interests by a supportive community of educators, professionals, and family members.*

‘Advisory structure’ and ‘learning through interests and internships’ are two of the ‘10 Distinguishers’ which unite Big Picture schools around the world. The remaining eight distinguishers are: one student at a time (personalization); parent and family engagement; school culture (student voice and leadership); authentic assessment; school organization (culture of collaboration); leadership (democratic community); post-secondary planning; and professional development (in-house coaching).

*Big Picture Learning’s distinguishers exist as a comprehensive whole. They are interrelated and inform one another – none work in isolation. It is the seamless integration of reflection-based action and the distinguishers that result in the powerful success of the Big Picture Learning design.*

### **Carioca Experimental Gymnasium Network**

<http://www.innovedu.org/en/carioca-experimental-gymnasium-network>

The Carioca Experimental Gymnasium program operates in grade 7-9 in public municipal schools in Rio de Janeiro. The program began in 2011 in ten schools, and now operates in 28 schools. The program is designed to re-engage students and promote agency and autonomous learning.

Alongside the components of ‘directed study, Youth leadership and Elective subjects, a central element of the model is the ‘life project’.

#### ***Life project***

*All students of the Experimental Gymnasia participate in Life Project activities, which seek to improve the human side of the students and to encourage the development of their potential. The course takes place once a week, with reflections on values and the promotion of important attitudes, such as our relationships with others, in sport and in life. Students also perform collaborative activities, which are monitored by their tutor, who provides personalized guidance for each student. The teachers plan the classes together in advance and use new technology and didactic subjects structured by handouts and exercises. Educators and students use the Educopedia platform of digital classes, which supports the teachers by providing class plans, pedagogical games and videos.*

### **Dream School**

<http://dreamschool.eu/what-is-dream-school>

The Dream School model, created by the local school authority in Kauniainen, Finland, is an initiative to re-think the purpose and experience of the school in order to prepare students for ‘jobs that don't yet exist in this fast-changing world’. The project began in 2011 and has spread to 30 schools, a mixture of primary and secondary. They are now working to "open-source" the model by codifying the work for debate and development with others. [Unclear to what extent the work is still developing – only two stories have been written up.]

### ***Student-centric pedagogy***

*Our student-centric pedagogy strives to recognize and harness the real-world knowledge our students bring. The curriculum can incorporate to the knowledge students themselves have to share. This necessitates a re-mapping of the learning environment, the role of the educator and the teacher-student relationship and the school itself. Supporting this is an open-source technology model. The closed models are not only more expensive, but they do not harness the necessary innovation.*

### **Envision Schools**

<http://www.envisionschools.org/our-approach/>

Envision Education is a charter management organization in the United States, operating three schools in the San Francisco Bay area of California. It was founded in 2002 and over several years developed a project based learning and portfolio assessment approach. In 2010 it founded a consultancy division, Envision Learning Partners, which works with schools and teachers across the U.S. to spread their pedagogical approach.

### ***Know, do, reflect***

*Envision Schools' focus is on helping students to not only master academic content, but also to be able to apply that knowledge to other situations. We design our curriculum and model around our "know, do, reflect" approach to make sure that our students excel at the 21st Century skills: thinking critically, collaborating productively, communicating clearly and managing projects effectively and the core competencies (research, inquiry, analysis, and creative expression). This allows Envision Education to accomplish its mission of sending students to college well-prepared to tackle that challenge.*

### ***Portfolio Assessment***

*In addition to using traditional forms of testing, we use an assessment system that emphasizes students' deep understanding of academic disciplines. Students assemble a portfolio of their best work, which they must "defend," dissertation-style, in front of an audience of educators, peers, and community members. Students must present a defense of their work at the end of 10th grade, and, for seniors, passing the college success portfolio defense is a requirement to graduate from an Envision School.*

### ***Real-world projects***

*To ensure that our students are able to apply academic knowledge to new situations, we employ Project-based Learning, a dynamic approach to teaching in which students put their knowledge to work solving real-world problems and challenges. Envision teachers embed academic content in projects that speak to students' life experiences and that have relevance and application in the real world. ... Teachers share their expertise by creating new projects and posting them to our [Project Exchange](#), an open source for rigorous and relevant curriculum.*

### ***Workplace Learning Experience.***

*We include community-based projects and internships at partner organizations and businesses as part of our educational model through the workplace learning experience. During part of their 11th grade year, all Envision students will go to work at an internship site where they learn from an employer mentor and complete a project with measureable outcomes.*

## **Eos Education**

Eos Education is a teaching schools alliance and professional development provider in England, with a focus on immersive and learner-centered pedagogies. It was founded in 2014 on the back of Hartsholme Academy in Lincoln, and now works with teachers and schools around the country.

The core elements of the Eos pedagogical approach include: Immersive classrooms; Exhibitions; and Behaviours for Learning.

Other aspects of the Eos pedagogical approach are presented in the form of principles:

### ***Principles***

- *We place the learner at the centre of all of our activities, continuously reflecting on how effectively our actions are impacting on the outcomes of each individual.*
- *Our curriculum content is relevant to the lives of our learners, ensuring that outcomes are authentic and have an impact on the real world.*
- *We provide learners with the necessary tools and environments to enable them to be flexible, choosing how, where and with whom they work*
- *We ensure learners are engaged in collaborative, self-directed learning with the teachers acting as facilitators.*
- *We strive for staff members to be treated as professionals, ensuring that we place significant emphasis on professional dialogue and time to plan, design and teach in teams for a significant proportion of their work.*
- *We respect and promote the work life balance of employees ensuring that work place systems and schedules encourage a healthy balance. Policies and protocols are regularly reviewed and evaluated to measure their relevance and effectiveness in order to ensure these bureaucratic systems are kept to a minimum.*
- *We provide opportunities to network and collaborate across the whole EOS network and with our wider community, sharing information freely.*
- *We place huge importance on research and on developing new pedagogies and tools to liberate learning from past conventions to connect learners in new and powerful ways.*

## **Expeditionary Learning**

<http://eleducation.org/about/our-approach>

Expeditionary Learning, now called EL Education, formed in 1991 through a collaboration between Outward Bound and the Harvard Graduate School of Education, funded by the New American Schools initiative from the U.S. federal government. There are now over 150 schools in the Expeditionary Learning network. In 2013, EL received a major grant to ‘scale up’ its practice, and now supports many more schools through professional development and curriculum materials.

### ***10 building blocks***

The EL model is based on ‘10 building blocks’, including:

#### ***1. The Primacy of Self-Discovery***

*Learning happens best with emotion, challenge, and the requisite support. People discover their abilities, values, passions, and responsibilities in situations that offer adventure and the unexpected. In EL Education schools, students undertake tasks that require perseverance, fitness,*

*craftsmanship, imagination, self-discipline, and significant achievement. A teacher's primary task is to help students overcome their fears and discover they can do more than they think they can.*

#### **2. The Having of Wonderful Ideas**

*Teaching in EL Education schools fosters curiosity about the world by creating learning situations that provide something important to think about, time to experiment, and time to make sense of what is observed.*

#### **3. The Responsibility for Learning**

*Learning is both a personal process of discovery and a social activity. Everyone learns both individually and as part of a group. Every aspect of an EL Education school encourages both children and adults to become increasingly responsible for directing their own personal and collective learning.*

...

#### **8. The Natural World**

*A direct and respectful relationship with the natural world refreshes the human spirit and teaches the important ideas of recurring cycles and cause and effect. Students learn to become stewards of the earth and of future generations.*

#### **9. Solitude and Reflection**

*Students and teachers need time alone to explore their own thoughts, make their own connections, and create their own ideas. They also need to exchange their reflections with other students and with adults.*

#### **10. Service and Compassion**

*We are crew, not passengers. Students and teachers are strengthened by acts of consequential service to others, and one of an EL Education school's primary functions is to prepare students with the attitudes and skills to learn from and be of service.*

(The additional blocks are Empathy and Caring; Success and Failure; Collaboration and Competition; Diversity and Inclusion).

### ***Expeditions***

Central to the EL model are 'expeditions' – long-term projects which involve *fieldwork* and the creation of *complex, authentic work*, involving *higher-order thinking, multiple perspectives, and transfer of understanding*.

### ***High Quality Work***

The emphasis on *high quality work* and the requirement for students to *demonstrate craftsmanship* means that students produce work through multiple drafts. Student might produce five or six revisions of the same piece of work, building core skills as they practice and refine their efforts, and learn to critique and improve each others' work. This process is showcased through the website Models of Excellence: <http://modelsofexcellence.eleducation.org/>

### ***Fab Labs***

<http://www.fabfoundation.org/fab-education/>

*Fab Lab is the educational outreach component of MIT's Center for Bits and Atoms (CBA), an extension of its research into digital fabrication and computation. A Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. A Fab Lab is also a platform for learning and innovation: a place to play, to create, to learn, to mentor, to invent. To be a Fab Lab means connecting to a global community of learners, educators, technologists, researchers, makers and*

*innovators- -a knowledge sharing network that spans 30 countries and 24 time zones. Because all Fab Labs share common tools and processes, the program is building a global network, a distributed laboratory for research and invention.*

FabEd is a 'network collaboration' being formed to provide support and professional learning opportunities for schools and teachers. FabEd is a collaboration between The Fab Foundation and TIES, the Teaching Institute for Excellence in STEM. FabEd over time may codify the pedagogical approaches suited to STEM learning in the context of a Fab Lab.

### **Galileo Educational Network**

<http://galileo.org/>

Galileo Educational Network is an independent charity based in Canada, which carries out research, professional learning and and partnerships around inquiry-based pedagogy.

Galileo defines inquiry as a pedagogy that cuts across subject areas, and is *a stance that pervades all aspects of life* and is NOT a "method" of doing science, history, or any other subject, in which the obligatory first stage in a fixed, linear sequence is that of students each formulating questions to investigate.

They further define inquiry as: *a study into a worthy question, issue, problem or idea. It is the authentic, real work that that someone in the community might tackle. It is the type of work that those working in the disciplines actually undertake to create or build knowledge.*

Galileo defines the dimensions of inquiry in something akin to a pedagogical model:

#### ***Authenticity***

- *The inquiry study emanates from a question, problem or exploration that has meaning to the students.*
- *An adult at work or in the community might actually tackle the question, problem, issue or exploration posed by the task/s.*
- *The inquiry study originates with an issue, problem, question, exploration or topic that provides opportunities to create or produce something that contributes to the world's knowledge.*
- *The task/s require/s a variety of roles or perspectives.*

#### ***Academic Rigour***

- *The inquiry study leads students to build knowledge that leads to deep understanding.*
- *Students are provided with multiple, flexible ways to approach the problem, issue or question under study that use methods of inquiry central to the disciplines that underpin the problem, issue or question.*
- *The inquiry study encourages students to develop habits of mind that encourage them to ask questions of*
  - *evidence (how do we know what we know?)*
  - *viewpoint (who is speaking?)*
  - *pattern and connection (what causes what?)*
  - *supposition (how might things have been different?)*
  - *why it matters (who cares)*

**Assessment**

- *On-going assessment is woven into the design of the inquiry study providing timely descriptive feedback and utilizes a range of methods, including peer and self evaluation. Assessment guides student learning and teacher's instructional planning.*
- *The study provides opportunities for students to reflect on their learning using clear criteria that they helped to set. The students use these reflections to set learning goals, establish next steps and develop effective learning strategies.*
- *Teachers, peers, adults from outside the classroom and the student are involved in the assessment of the work.*

**Beyond The School**

- *The study requires students to address a semi-structured question, issue or problem, relevant to curriculum outcomes, but grounded in the life and work beyond the school.*
- *The study requires students to develop organizational and self management skills in order to complete the study.*
- *The study leads students to acquire and use competencies expected in high performance work organizations (eg. team work, problem solving, communications, decision making and project management).*

**Use of Digital Technologies**

- *Technology is used in a purposeful manner that demonstrates an appreciation of new ways of thinking and doing. The technology is essential in accomplishing the task.*
- *The study requires students to determine which technologies are most appropriate to the task.*
- *The study requires students to conduct research, share information, make decisions, solve problems, create meaning and communicate with various audiences inside and outside the classroom.*
- *The study makes excellent use digital resources.*
- *Students and parents have on-going, online access to the study as it develops.*
- *The study requires sophisticated use of multimedia/hypermedia software, video, conferencing, simulation, databases, programming, etc.*

**Active Exploration**

- *The study requires students to spend significant amounts of time doing field work, design work, labs, interviews, studio work, construction, etc.*
- *The study requires students to engage in real, authentic investigations using a variety of media, methods and sources.*
- *The study requires students to communicate what they are learning with a variety of audiences through presentation, exhibition, website, wiki, blog, etc.*

**Connecting With Expertise**

- *The study requires students to observe and interact with adults with relevant expertise and experience in a variety of situations.*
- *The study requires students to work closely with and get to know at least one adult other than their teacher.*
- *The tasks are designed in collaboration with expertise, either directly or indirectly. The inquiry requires adults to collaborate with one another and with students on the design and assessment of the inquiry work.*

### ***Elaborated Communication***

- *Students have extended opportunities to support, challenge, and respond to each other's ideas as they negotiate a collective understanding of relevant concepts. Students have opportunities to negotiate the flow of conversation within small and large group discussions.*
- *Students have opportunities to choose forms of expression to express their understanding.*
- *The inquiry provides opportunities for students to communicate what they are learning with a variety of audiences.*

### **High Tech High**

[See chapter text]

### **International Baccalaureate**

<http://www.ibo.org/programmes>

The International Baccalaureate Organization (IBO) supports and authorizes schools to provide the IB programmes: the primary years programme (3-12), middle years programme (11-16), diploma programme and careers programme (both 16-19).

Each of the programmes is essentially a curriculum and approach to assessment, but the curricula are designed to work with certain ways of teaching. Schools aiming to become IB schools have to go through particular professional development, meaning that IB curricula are taught with an emphasis on particular pedagogies.

For example, the primary years programme is presented in the form of:

- [\*The written curriculum\*](#), which explains what PYP students will learn
- [\*The taught curriculum\*](#), which sets out how educators teach the PYP
- [\*The assessed curriculum\*](#), which details the principles and practice of effective assessment in the PYP

The central element of the pedagogical approach in the PYP is structured, purposeful inquiry.

#### ***Structured, purposeful inquiry***

*The PYP is committed to structured, purposeful inquiry that engages students actively in their own learning. The programme supports students' efforts to construct meaning from the world around them by:*

- *drawing on their prior knowledge*
- *providing provocation through new experiences*
- *providing opportunities for reflection and consolidation.*

*This approach respects students' developing ideas about how the world works. It encourages them to question, consider and refine their understanding of the social and natural world.*

The Middle Years Programme adds additional pedagogies:

#### ***Interdisciplinary units***

*Students demonstrate interdisciplinary understanding when they bring together concepts, methods, or forms of communication from two or more disciplines or established areas of expertise so that they can*



*explain a phenomenon, solve a problem, create a product, or raise a new question in ways that would have been unlikely through a single discipline.*

*In each year of the programme, MYP schools are responsible for engaging students in at least one collaboratively planned interdisciplinary unit that involves at least two subject groups. In MYP schools, collaborative planning is vital. Time for collaborative planning must be managed systematically and effectively, and it must involve all teachers. Meeting time is especially important for developing horizontal and vertical articulation of the curriculum.*

### ***Long-term project***

*MYP projects encourage students to reflect on their learning and the outcomes of their work – key skills that prepare them for success in further study, the workplace and the community.*

*Students who complete the MYP in Year 3 or Year 4 complete the community project. All students who complete the MYP in Year 5 complete the personal project. The community project provides an important opportunity for students ages 13-14 to collaborate and pursue service learning. Schools register all MYP Year 5 students for external moderation of the personal project, promoting a global standard of quality.*

*MYP projects are student-centred and age-appropriate, and they enable students to engage in practical explorations through a cycle of inquiry, action and reflection.*

Additionally, the over-arching approach to teaching and learning in the MYP is articulated in terms of the following concepts:

### ***Teaching and learning in context***

*Students learn best when their learning experiences have context and are connected to their lives and their experience of the world that they have experienced.*

*Using global contexts, MYP students develop an understanding of their common humanity and shared guardianship of the planet through developmentally appropriate explorations of:*

- *identities and relationships*
- *personal and cultural identity*
- *orientations in space and time*
- *scientific and technical innovation*
- *fairness and development*
- *globalization and sustainability.*

### ***Conceptual understanding***

*Concepts are big ideas that have relevance within specific disciplines and across subject areas. MYP students use concepts as a vehicle to inquire into issues and ideas of personal, local and global significance and examine knowledge holistically. The MYP prescribes sixteen key interdisciplinary concepts along with related concepts for each discipline.*

### ***Approaches to learning***

*A unifying thread throughout all MYP subject groups, approaches to learning (ATL) provide the foundation for independent learning and encourage the application of their knowledge and skills in unfamiliar contexts. Developing and applying these social, thinking, research, communication and self management skills helps students learn how to learn.*

### ***Service as action, through community service***

*Action and service have always been shared values of the IB community.*

*Students take action when they apply what they are learning in the classroom and beyond. IB learners strive to be caring members of the community who demonstrate a commitment to service—making a positive difference to the lives of others and to the environment.*

*Service as action is an integral part of the programme, especially in the [MYP community project](#).*

## **Kunskapsskolan**

<http://www.kunskapsskolan.com/thekedprogram.4.52155b18128a87c7cfd80009543.html>

Kunskapsskolan is a school chain that originated in Sweden, and now also runs schools in England. The pedagogical approach is described as the ‘KED Program’.

### ***Personalized education***

*The KED program is a concept for personalized education. This means that students, with the guidance of their coach, set and work towards their own personal goals, with the ambition of achieving high final results. Students allocate their study time based on their previous educational experience as well as their individual strengths and weaknesses.*

*Personalized education should not be confused with students being left on their own without guidance or teaching.*

The program has several key elements:

### ***Strategies for learning***

*[On entering the school] the student is assessed to determine what level she will start on and accordingly what strategies she will need to reach her long-term goals. The strategies are not only a list of hours that need to be spent or pages that has to be read. It is also a choice of lectures, lessons, assignments and every thing else that can support the learning. This provides everyone with a working plan, which will be divided into medium-term goals for the semester and short-term goals for the week to come. Each step is followed up in the student’s weekly coaching sessions with her personal learning coach. In progress reviews and development discussions - whenever needed or at least every six months- progress is tracked and the goals and their strategies are reviewed.*

### ***Individual goals and ongoing documentation***

*Through the Educational Documentation System (EDS) on the Learning Portal, families — as well as the student and the teacher - get a real time insight into how learning is progressing.*

*Setting up individual goals and strategies to reach them creates meaning and motivation in school... The ability to set up goals and strategies, to break them down into smaller steps and to experience that sometimes strategies need to be revised, is knowledge that has a life-long value.*

As well as the EDS, the tools underpinning the model include the individual study plans, the Learning Portal (a web-based set of courses and learning continua), and a logbook maintained by each student.

### ***Coaching***

*The personal coaching method is based on thinking from several areas, such as motivational- and developmental psychology, but also from pedagogy and cognitive psychology. The theory of multiple intelligences has inspired our way of working to help students develop personalized learning strategies. Personal coaching contributes to the student’s personal development as the student’s learning is structured, supported, assessed, and followed up. Through personal coaching, students learn to set clear*

*and realistic, but still challenging, goals for their studies and to work in a goal-driven manner. The Personal coaching is not limited to scheduled talks to discuss the student's coaching and development — it is a continuous dialogue between the student and the coach. This dialogue is characterized by closeness and concern. The coach is responsible for ensuring that the students assume the responsibility they can manage — and no more. The content of the one-on-one tutorials varies, as in all coaching, depending on the student's level of maturity and needs. In the beginning, the students receive mainly help and support with procedures — to accomplish their personal planning and understand the working methods. The focus gradually shifts to reflections on the student's own learning process, where the students reflect on their goals, work, strategies and results. As students deepen their studies, they assume greater responsibility and receive additional coaching towards new challenging goals.*

### **NAF Academies**

<http://naf.org/about>

NAF, originally the National Academy Foundation, is a U.S. organisation that brings together schools and businesses to create *STEM infused industry-specific curricula and work-based learning experiences*. Founded in 1982, NAF partners with high schools to create small learning communities known as NAF academies within existing schools (sometimes more than one in a school). Each academy is structured around a growing industry, such as finance, hospitality & tourism, information technology, engineering, or health sciences. Almost 89,000 students now attend one of 716 NAF academies, located in 482 different high schools, across 36 U.S.states.

The *NAF Educational Design* is described in terms of *four essential elements of practice*: the Academy Development & Structure (small, focused learning communities), Curriculum & Instruction (career-themed curriculum and project based instruction), Advisory Board (providing a bridge between schools and the work place), and Work-Based Learning.

### **Work-inspired projects**

*The NAF curricula is created in partnership with industry professionals and designed around projects that help students acquire valuable workplace skills and see their education as a step toward long-term career options. NAF empowers teachers to expand the boundaries of the classroom in non-traditional ways that ensure lessons have real-world application to growing industries.*

### **Work-based learning**

*Work-based learning brings the classroom to the workplace and the workplace to the classroom. This instructional strategy provides students with a well-rounded skill set that goes beyond academics and includes the soft skills needed to succeed in college and the working world. NAF's approach to work-based learning is centered on a continuum of work-based learning experiences beginning with career awareness activities, progressing to career exploration activities, and culminating in career preparation activities, including internships. Businesspeople guest speak in classrooms, host college and career skills workshops, and take part in mock interviews. Students have the opportunity to tour worksites, network with, and shadow business professionals. Work-based learning culminates in an internship that allows students to apply their classroom skills and learn more about what it takes to succeed.*

## **New Tech Network**

New Tech Network (NTN) is a non-profit organization that supports schools to move towards project based learning and other deeper learning pedagogies. It operates across the U.S. and partners with both individual charter schools and school districts.

There are a number of elements core to the pedagogical approach of the network:

### ***Project-based learning***

*Project-based learning (PBL) is at the heart of our instructional approach. In PBL, learning is contextual, creative, and shared. Students collaborate on meaningful projects that require critical thinking, creativity, and communication in order for them to answer challenging questions or solve complex problems. By making learning relevant to them in this way, students see a purpose for mastering state-required skills and content concepts.*

*Students aren't just assessed on their understanding of academic content, but on their ability to successfully apply that content when solving authentic problems. Through this process, project based learning gives students the opportunity to develop the real life skills required for success in today's world.*

### ***Problem-based learning***

*New Tech Network schools also use Problem-based learning. PrBL is a form of inquiry-based instruction used primarily in Mathematics that places the students in several smaller Problem scenarios rather than a single, large Project scenario. Supported by NCTM and the NSF, much of what makes PBL so successful is present in a PrBL environment, including Entry Events, the Need-to-Know (NTK) process, and student-centered scaffolding.*

### ***Individual Assessments of Knowledge and Thinking***

*Assessments that call for students to demonstrate authentic skills are frequently referred to as "performance assessments" and project based learning is typified by these sorts of assessments. ... Over the past several years, we have put special attention on the design of disciplinary strong individual performance tasks initial termed "literacy tasks" and now labeled Individual Assessments of Knowledge and Thinking (IAKTs) as a curriculum embedded element of strong PBL.*

### ***College Readiness Assessments***

*College Readiness Assessments (CRAs) are curriculum-embedded performance assessments used to assess students' mastery of Knowledge and Thinking and Written Communication outcomes. The Knowledge and Thinking rubrics are specific to each core discipline and assess the key knowledge and skills necessary for college readiness in a particular content area against an externally validated standard. CRAs allow teachers to integrate individual tasks aligned to external standards for quality into larger, authentic projects. ...NTN CRAs are derived from a performance assessment process developed by Envision schools and the Stanford Center for Assessment, Learning, and Equity (SCALE), and aligned to the Common Core State Standards. The assessments allow schools to calibrate around a "college ready" level of performance in each of the core academic areas on the kinds of tasks students are typically expected to perform in college. Over the past year, we have collaborated with Envision and SCALE to adapt their processes and rubrics for use in NTN schools.*

### **Connection through technology**

*The smart use of technology supports our innovative approach to instruction and culture. All classrooms have a one-to-one computing ratio. With access to Web-enabled computers and the latest in collaborative learning technology, every student becomes a self-directed learner who no longer needs to rely on teachers or textbooks for knowledge and direction. We use Echo, an [online learning management system](#) to create a vibrant network which helps students, teachers, and parents connect to each other, and to student projects across the country.*

### **Quest to Learn**

<http://www.q2l.org/about/>

Quest to Learn, in New York City, and Quest to Learn Chicago are schools developed by the Institute of Play, which practice game-based learning

### **Game-Based Learning**

*At Quest, we define games as carefully designed, student-driven systems that are **narrative-based**, structured, **interactive** and **immersive**.*

*Why games? In the past decade or so, leading educational researchers have discovered that games allow for some of the richest learning experiences.*

- *Games ask us to collaborate with others and learn by doing.*
- *Games let us know if we are failing or succeeding at a moment's notice and allow us to retry, or "iterate," after a failure or loss.*
- *Unlike traditional educational systems, failure is a necessary and integral part of the "game." It creates a context for students to be motivated to try again and succeed.*
- *Learning experiences in games don't feel like spoon-fed education. Learning experiences feel like play.*

*At Quest to Learn, **learning happens by doing**.*

*Game-based learning takes a variety of forms at Quest to Learn. For instance, in ninth grade Biology, students spend the year as workers in a fictional bio-tech company, and their job is to clone dinosaurs and create stable ecosystems for them. By inhabiting the role of biotech scientists, the students learn about genetics, biology and ecology.*

*Educational games are at the core of Quest's curriculum. Sixth graders use **Dr. Smallz**, where they play the role of designers, scientists, doctors and detectives as they explore cellular biology and the human body. And ninth graders use **Storyweavers**, a collaborative storytelling role-playing game. These games not only engage students in the learning process, but also allow teachers to assess students in real time and provide feedback on learning experiences immediately.*

Game-based learning at Quest is supported by a learning platform called PupilPath.

The Institute of Play provides '[design packs](#)' on Systems Thinking, Games and Learning, Curriculum Design, and School Design which articulate broader aspects of their model.

The Chicago Quest school also emphasizes *connected learning*, a pedagogical approach that has been promoted in the Chicago area and beyond by the work of the MacArthur Foundation.

### **Connected Learning**

*Connected Learning is a [researched approach](#) that leverages the potential of social and digital media to integrate young people's interests, peer culture, and academics. CICS CQ uses these principles to connect students to real-world contexts, through partnerships with local organizations (e.g. [Hive Chicago](#)), programs that take students beyond the classroom (e.g. 8th grade externship, Upper School internships), and our immersive [Boss Level](#) experience*

*Game-based learning and connected learning are combined into one pedagogical model in examples such as the 'boss level' at [Quest to Learn NYC](#), where students spend two weeks working on particular challenges to be presented to the community: <http://connectedlearning.tv/>*

### **Reggio Emilia/Reggio-inspired schools**

<http://www.aneverydaystory.com/beginners-guide-to-reggio-emilia/main-principles/>

The Reggio Emilia Approach originated in the town (and surrounding areas) of Reggio Emilia in Italy where the community developed a particular manner of early childhood education. The Approach is not a codified method but a substantial number of schools, preschool and home schools in Europe, North America and beyond now call themselves 'Reggio-inspired'.

The individuality of the child and the importance of the community is central to the Reggio approach, and therefore no set of practice or model looks the same, but some key elements of the Reggio Approach are articulated in the form of 'Fundamental Principles':

*Children are capable of constructing their own learning. They are [driven by their interests](#) to understand and know more.*

*Children form an understanding of themselves and their place in the world through their interactions with others. There is a strong focus on social collaboration, working in groups, where each child is an equal participant, having their thoughts and questions valued. The adult is not the giver of knowledge. [Children search out the knowledge through their own investigations.](#)*

*Children are communicators. Communication is a process, a way of discovering things, asking questions, using language as play. ...Children are listened to with respect, believing that their questions and observations are an opportunity to learn and search together.*

*The environment is the third teacher. [The environment is recognised for its potential to inspire children.](#) An environment filled with natural light, order and beauty. ...The space encourages collaboration, communication and exploration. The space respects children as capable by providing them with [authentic materials & tools.](#) The space is cared for by the children and the adults.*

*The adult is a mentor and guide. [Our role as adults](#) is to observe (our) children, listen to their questions and their stories, find what interests them and then provide them with opportunities to explore these interests further. The Reggio Emilia Approach takes a child-led project approach. The projects aren't planned in advanced, they emerge based on the child's interests.*

*An emphasis on documenting children's thoughts. You'll notice in Reggio and Reggio-inspired settings that there is an emphasis on carefully displaying and documenting children's thoughts and progression of thinking; [making their thoughts visible](#) in many different ways: photographs, transcripts of children's*

thoughts and explanations, visual representations ([drawings](#), sculptures etc.), all designed to show the child's learning process.

*The Hundred Languages of Children. Probably the most well-known aspect of the Reggio Emilia Approach. The belief that children use [many many different ways](#) to show their understanding and express their thoughts and creativity. ...Through [drawing](#) and [sculpting](#), through dance and movement, through [painting](#) and pretend play, through [modelling](#) and music, and that each one of these [Hundred Languages](#) must be valued and nurtured.*

### **Riverside School**

<http://schoolriverside.com/philosophy>

Riverside school was founded 14 years ago and has developed what it called a 'user centered curriculum' with a focus on 'quality of learning AND student well being'.

Some central aspects of the Learning approach include

- Conglom (starting the day)
- Agenda setting and closing the loop (daily routines which set the 'tone and pace of work', and 'determine what has been accomplished')
- Assembly (once a week presentations of work or other)
- Assessment and Evaluation ('students are assessed throughout the learning process')
- Buddy interaction (with children of different age groups)
- Learning embedded in real life
- Making Learning Visible
- Peer and public scrutiny
- Parent Partnership
- Reflection (evaluating ones own progress?)
- Revisiting (similar to the above?)
- Student led conferences
- Thinking routines

From Key Stage 3, activities are added:

- Global Exchange (exchanges with partner schools)
- Persistence ('developing leadership and perseverance for social courses' – student planned civic activities)
- Learning Hub (once a year, designing a cross-stage, cross-curricular experience for peers)
- Rural exposure (experiencing a different way of life, optional)
- Sports coaching
- Nights out (spending the night with friends on the school campus)
- Prom
- Graduation Ceremony

Riverside views all of these components – both curricula and extra-curricular – as central to the learning approach and the way students develop.

### **Steve JobsSchool**

<http://stevejobsschool.world/differences-with-a-regular-primary-school/>

Steve JobsSchools is a small chain of private primary schools in the Netherlands, founded in 2014. As well as flexible school hours, there are several distinctive aspects to the pedagogical model.

### **Core groups**

*A Steve JobsSchool does not have classes of children in the same age group, but core groups of approximately 25 children with a maximum difference in age of 4 years, in which the older children are stimulated to help the younger ones. The children start their day in their core group. The first half hour is intended to work on the social emotional development of your child and is usually characterized by a group discussion of recent events or of things that the children have on their minds. The core group meets again for half an hour at the end of each school day.*

### **Coaches and subject specialists**

*Just as in secondary school, your child will get their instruction from subject professionals instead of from one permanent teacher. Your child will have a permanent coach for the junior years and then another one for the senior years. This coach has a number of functions. For starters he or she is the permanent contact person and the permanent counsellor for you and your child. Besides that, the coach also keeps track of the performance of your child and evaluates these every 6 weeks, together with you and your child using the Individual Development Plan of your child.*

*On an average day, 10.30-12pm is given to 'instruction', in the Language studio, the Math studio and the World studio. At their own level and at their own speed.*

### **Workshops, projects, independent work, sports, etc.**

*In the afternoons children may choose from a number of workshops and activities and they practise learning materials independently on the Quiet plaza. They are required to finish among others 60 calculation and 60 language exercises.*

### **String Theory Schools**

<http://stringtheorieschools.com/our-model/>

String Theory is a U.S. charter management organisation which currently has four campuses in Philadelphia, all with some kind of focus on performing arts, which together form a K-12 continuum. One of those schools was 'entrusted' to String Theory Schools as part of the School District of Philadelphia's [Renaissance Schools](#) initiative. They have a goal to rapidly expand the network on the basis of their technology-based model.

### **Key components of the pedagogical model include:**

#### ***Creation: The Imagination at Work***

*The vision of String Theory Schools is to provide the opportunity for students to **explore their interests** in the arts, language, science and /or technology that will prepare them for postsecondary studies or for a faster entry into related occupations through a proven model of excellence. The balance between **artistic development and academic preparation** is at the heart of our philosophy.*

#### ***iTunes U***

*We have said goodbye to the limitations of the textbook and hello to the creative, rigorous and boundless resources of iTunes U ... Our teachers have become course designers, creative problem solvers, better researchers, collaborative team members, and authorities about instructional strategies and best practices for delivering content as it relates to curriculum standards and student needs...The iTunes U course becomes a collection of resources, the textbook of sorts, and students retrieve all of their materials from*



*this one location... Collectively, students and teachers determine workflows using apps for writing, reading, creating, solving and more. Our classroom teachers do not ask students to rely on information from just one source, the textbook. Instead, teachers guide instruction and ask students to research, analyze, evaluate and draw conclusions. Our students are learning how to be content curators, resource creators, and designers in best practices. Most importantly, they have a better understanding through collaboration.*

### **Majors (at High school level)**

*All students continue to deepen their knowledge and expertise within their Major, as 1 block per day is devoted to the pursuit of content and practices in that Major. ... **Our art-infused curriculum places a premium on both academic and performance excellence.** Each Major program delves deeply into the subject, and students develop an immense skill set at the conclusion. As students develop within their Majors, internships and other opportunities exist to work with professionals in their chosen fields.*

### **Studio Schools**

<http://studioschoolstrust.org/what-studio-school>

NB The First Studio School opened in 2010. There are now around 40, with more set to open.

*The Studio School is a new concept in education, which seeks to address the growing gap between the skills and knowledge that young people require to succeed, and those that the current education system provides. Studio Schools pioneer a bold new approach to learning which includes teaching through enterprise projects and real work. This approach ensures students' learning is rooted in the real world and helps them to develop the skills they need to flourish in life. For detailed information, please read the Studio Schools Brochure.*

*Studio Schools are designed for 14-19 year olds of all abilities. They are small schools for 300 students; and with year-round opening and a 9-5 working day, they feel more like a workplace than a school. Working closely with local employers, Studio Schools will offer a range of academic and vocational qualifications including GCSEs in English, Maths and Science, as well as paid work placements linked directly to employment opportunities in the local area. Students will gain a broad range of employability and life skills through the **CREATE skills framework**, and will have the option to go on to university, further training, and into employment.*

#### *Enquiry-based learning*

*All students are taught English, Maths and Science at GCSE [English qualifications at age 16] via enquiry-based learning (EBL) ...By working with educational experts, our local partners, and a range of employers, the Studio Schools Trust has developed a framework for the delivery of innovative multidisciplinary Enterprise Projects which enable EBL to take place, and also encourage the development of CREATE employability skills. Often commissioned by local employers, the projects take education out of the traditional classroom setting. When they work in this way to produce tangible and useful end-products, students' learning becomes relevant to them and rooted in the real world.*

#### **CREATE framework**

*The unique CREATE skills framework has been designed specifically for Studio Schools and is comprised of a wide range of employability and life skills. CREATE stands for Communication, Relating to people, Enterprise, Applied skills, Thinking skills and Emotional intelligence. As well as being developed through the Studio Schools Trust multi-disciplinary Enterprise projects, CREATE skills will underpin all activities in the Studio School and will be used by coaches to encourage and track students' development. The CREATE framework is grounded in a wide range of skills typologies and has been developed specifically*

*for Studio Schools in order to equip young people with the key employability skills that they need to flourish in life.*

### **Success Academies**

<http://www.successacademies.org/our-approach/>

Success Academies is a charter management organization operating primarily elementary and middle schools (and one high school) in New York City.

At the elementary level, the *Approach to Learning* is summarized by the following:

#### ***Learning through doing***

*We believe deeply that doing is at the core of learning. Therefore, scholars receive only 80 minutes of direct instruction (teacher up front) every day. Our school leaders and teachers work tirelessly to make each of these minutes count. The rest of the day is devoted to small group instruction and hands on learning. ...Beginning in kindergarten, scholars receive hands-on, inquiry-based science five days a week with a dedicated science teacher.*

#### ***Project Based Learning***

*Project Based Learning is an intensive, multidisciplinary study of one topic – exploring a topic in such depth brings history to life and allows scholars to develop their own deep insights. During our Brooklyn Bridge study, 2nd grade scholars conduct experiments to learn the engineering principles behind bridge construction, read about how Emily Roebling became the project’s chief engineer, and visit the bridge to record their own observations and interview pedestrians.*

#### ***Field Studies***

*Through frequent field studies, scholars discover New York City and experience all this great city has to offer! Recent field studies have included the American Museum of Natural History, Alvin Ailey American Dance Theater, Queens County Farm Museum, and the Big Apple Circus. And not all field studies take place outside our schools! During the 2012-2013 school year, Chess Grandmaster Garry Kasparov visited our schools and scholars enjoyed assemblies featuring jugglers, dancers, musicians, and more.*

#### ***Reading & Writing - THINK Literacy***

*Our approach to teaching literacy stems from our belief that if a child loves reading and reads exceptionally well, she can teach herself anything! Throughout all aspects of our THINK Literacy curriculum we introduce scholars to great literature and emphasize critical thinking and the thoughtful discussion of ideas. THINK Literacy prepares scholars for any reading or writing challenge they will encounter throughout their education.*

#### ***Math - activity-based investigations***

*At Success Academy, we blend conceptual understanding with a push for precision and accuracy. The math program is centered on **activity-based investigations**, which encourage scholars to think creatively and develop their own approaches to problem-solving and work cooperatively.*

Additionally, chess is a compulsory part of the learning program for all students from kindergarten up, and computer science is added at the middle school level.

## Summit Public Schools

<http://www.summitps.org/approach>

Summit Public Schools are a charter management organization which now operates 8 schools in California (3 middle, and 5 high schools), and 3 in Washington state (2 high schools, one unknown soon to open). Summit is currently partnering with Facebook to ‘scale personalized learning’ by making its Personalized Learning Plan Platform (PLP) freely available to schools across United States.

The Summit approach is described in terms of the following elements: College Readiness, High Impact Teaching, Professional Development, and Culture of Innovation.

### **‘High Impact Teaching’**

*Each Summit teacher plays a three-pronged role - as teacher, leader and mentor. They support individual needs, facilitate deeper learning, and encourage students in their development of cognitive skills and Habits of Success.*

**Teacher:** *Summit teachers know their students well and understand where and how they need to develop in order to become self-directed learners. Teachers use data—quantitative and qualitative—to diagnose student needs and use their professional skills and shared knowledge of best practices to personalize learning for every student. Through project-based learning, Summit teachers focus on developing cognitive skills with their students.*

**Mentor:** *At Summit, faculty members know each student personally. And through the mentor-mentee relationship, Summit takes its commitment to personalized learning one step further: each student is paired with a faculty member, who meets multiple times each week with the student in small-group settings and one-on-one. Mentors know how each student is progressing toward their goals and coach students in their development of Habits of Success. Mentors get to know their mentees’ families, and they understand what is happening with their students outside the classroom that could be affecting the student's learning.*

**Leader:** *Summit teachers understand the value of collaboration. They understand that common language and expectations are essential for student learning. They share best practices across the network, observe one another in the classroom, and work as a team to provide their students with the high-quality education that will prepare them for success. Teachers have the opportunity to take on a variety of leadership roles within these collaborative structures at Summit.*

A ‘day in the life’ at Summit entails:

### **Project Time**

*Students develop deeper thinking and life skills through project-based learning. They have Project Time for all of their core courses in English, History, Math, Science, and Spanish (in high school). In this picture, a student explores the nature of sound for a physics essay. Summit projects mimic real-world work experiences. Students use problem-solving, critical thinking, and communication skills to tackle challenging problems....They regularly present their analysis, recommendations, and projects because public speaking is a key life skill. ...Many projects require teamwork. Students are graded on their ability to work well with others, listen, and participate*

### **Summit Reads**

*Every student reads every day for at least 30 minutes...Through our online reading programs, students choose from a variety of approved books. We help students find the “just right book”. The book that is challenging enough to keep students learning, but not so challenging that it’s discouraging. Depending on their individual needs, students will read in groups, independently or with a teacher.*

### **Personalized Learning Time**

*Students learn the content knowledge they need for all of their courses. They learn through a combination of online playlists (diverse learning resources including texts, videos, presentations, exercises), peer-to-peer coaching, and one-on-one tutoring from their teachers. Students learn the facts and information they need to become college ready.*

*Students move at their own pace and learn how they learn best. A diverse array of educational resources give students exactly what they need, when they need it. Every student has an online Personalized Learning Plan (PLP). Students use the PLP to set goals, access learning resources, submit work, and track their progress. Teachers provide one-on-one tutoring. At the Tutoring Bar, students receive targeted support and coaching. Collaboration is encouraged. Through peer-to-peer coaching, students support and learn from each other.*

### **Summit Solves**

*Students practice math problems for at least 30 minutes a day. ...Students practice math problems on Khan Academy. Each student has personalized goals. Students are assigned specific exercises and practice problems based on their individual skill level. Teachers coach students through problems. They support students individually or in small groups to provide targeted feedback. ...We encourage students to write out problems so that they can see their mistakes and repeat successes.*

### **Mentor Time**

*Mentors support students in achieving their college and career goals. Our mentoring program is one of the most unique aspects of Summit. Each student is assigned a teacher mentor who is the student’s coach, college counselor and advocate, and supports them to excel both inside and outside the classroom. Mentors meet weekly with their mentees. Students lead these check-in’s, reflecting on the week, and discussing their goals and plans for the coming week. Mentors push students to become self-directed learners who can set and achieve goals and seek new challenges. Mentors will help students reflect on their challenges and successes so that they can learn from both. The mentor and family work together to support a student’s goals and academic success.*

### **Community Time**

*Every student at Summit is assigned a mentor and community group. Community Time is a safe space for students to bond with their classmates and mentor, express their thoughts and feelings, and build meaningful relationships....Every student spends at least 1 hour per week with their Community Group. Summit high schools end each day with their group.*

Additionally, for four two-week sessions per year, students engage in Expeditions:

**Expeditions**

*For four 2-week sessions throughout the school year, students take a break from their core courses and immerse themselves in energizing and engaging electives where students explore and develop their passions. Students discover and deepen their passions*

*When students find their passion, it sparks an internal drive to succeed and creates a fulfilling and enriching life. We have Expeditions in the Arts, STEM (Science, Technology, Engineering, Mathematics), Physical and Emotional Well-Being, Leadership & Society, and College & Career Readiness. Students gain real-life experiences. Expeditions are taught by teachers and community partners who are experts in their field like in this Engineering class.*

*High school students can intern in different fields. Some high school seniors learn professional workplace skills and explore real career options through internships.*

## **TECHNOLOGY-ENHANCED PEDAGOGICAL INNOVATIONS FOR LEARNING AT SCALE AT DIFFERENT LEVELS: CHANGE**

**Nancy Law**

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### **Abstract**

This paper presents a multilevel, multi-scale model for Technology-Enriched Pedagogical Innovations (TEPIs), showing how it can be applied in innovation-focused school networks. It begins with a brief review of the relative lack of impact of decades of innovations in learning technology on pedagogical practices in classrooms in general. On the other hand, there are also recent examples of TEPIs that have scaled at a system level over a sustained period of time in widely different education systems and cultural backgrounds following different pathways of change. By definition, TEPIs are new or alien species within their existing contexts. Hence, for them to be scaled, there must be fundamental changes in the educational and socio-cultural ecosystem such that these innovations can gain traction and become the norm.

This paper begins with an analysis of the interdependencies in the changes that needs to take place at different levels of an education system for scalable change. It then puts forward the argument that the mechanisms for change at each level should most appropriately be conceived as learning, and that the key to scalable change is in the appropriate design of a system of learning that supports (1) learning collaborative inquiry at each level, and (2) interdependent learning across multiple levels. The final part of the paper presents the outcomes of an analysis of three system level cases where TEPIs have been launched for over a decade using this multilevel multiscale model of scalable change to examine the explanatory power of this theoretical model.

### **Scaling Technology-Enhanced Innovative Pedagogy: the Challenge**

From the 1990s, many countries have launched their ICT in education masterplans, often in conjunction with major education reform initiatives (Plomp, Anderson, Law, & Quale, 2003) (Plomp, Anderson, Law, & Quale, 2009). These national Technology-Enhanced Learning (TEL in short) initiatives generally involve major investments in furnishing schools with the necessary computing devices, internet connectivity, extensive training and professional development of teachers, as well as providing schools with resources to hire technology support staff and digital learning resources. The rationale for such extensive efforts and investment is often connected with the expectation that learning *through* the use of ICT use would be able to transform the learning process (Pelgrum & Law, 2003) to achieve 21<sup>st</sup> century outcomes such as collaboration, communication, creativity and critical thinking (Partnership for 21st Century Skills, 2009).

Given the high expectations and scale of investment involved, it is not surprising that the IEA Second Information Technology in Education Studies (SITES) conducted in 1998 (Pelgrum & Anderson, 1999) and in 2006 (Law, Pelgrum & Plomp, 2008) showed a huge improvement in the ICT infrastructure in all the countries that participated in both studies. Of the 22 education systems participating in SITES 2006, with the exception of South Africa, nearly 100% of the schools surveyed reported having computers for use by grade 8 students (which was the target grade level for the survey) for teaching and learning purposes; and in 20 of the surveyed systems, over 90% of the schools reported having access to the Internet. On the other hand, the percentage of principals indicating that the use of ICT was very important for achieving various pedagogical goals were low, and the percentages were particularly low for principals in economically developed countries with high computer:student ratios and high levels of Internet access.

The SITES 2006 survey results from the grade 8 mathematics and science teachers further show that the percentages reported using ICT in their teaching varied from about 14% to almost 50% (not including South Africa because of its low level of ICT access). Further, most of the pedagogical practices teachers reported using ICT for were traditional instructional activities such as completing worksheets or answering tests.

More worrying than the rate of pedagogical uptake of ICT use in classrooms is the impact of ICT use on students' learning outcomes. The PISA 2009 (OECD, 2011) results show that access to ICT at school may not bring about heightened digital literacy. For example, Hong Kong students scored 533 on the print reading scale but only 515 on the digital reading scale. Results from PISA 2012 (OECD, 2015) show marked increases in the percentage of students reporting using ICT for various learning activities in school reported in all countries between 2009 and 2012. However, students reporting higher frequencies of computer use in schools had lower achievement scores in most learning outcomes even after adjusting for demographic differences. While different explanations have been put forward to account for such observations, further research is needed to reach a better understanding. On the other hand, it is well documented in the research literature that use of digital technology per se may not bring about enhanced learning outcomes, as much depends on the pedagogy adopted (Watson, 2001; Fisher, 2006). In fact, for e-Learning to bring about the kinds of 21<sup>st</sup> century outcomes often mentioned in policy documents requires deep pedagogical transformation (Law, 2008a; Somekh & Davis, 1997).

The recognition that pedagogical innovations are needed to realize the potential of ICT to bring about desired learning outcomes stimulated studies of technology-enhanced pedagogical innovations (or TEPI in short). The first such large-scale international comparative study was SITES-M2 (Kozma, 2003), which found exemplars of innovative pedagogy even in economically less developed countries with low computer:student ratios. (Law, Yuen & Fox, 2011) identified six dimensions of innovativeness from the SITES-M2 case studies, and found that among those six, the roles played by the teacher and by the students in the learning process were the two most highly correlated with the innovativeness (i.e. non-traditional nature) of the learning outcomes achieved. Further, the pedagogical innovativeness of the case studies had no correlation with the sophistication of the learning technologies adopted.

There are two noteworthy observations from the SITES M2 study. First, notwithstanding the decades of university-led TEL research and development projects, none of the 174 TEPIs identified by the national research teams in the 26 participating countries mentioned any of the innovation studied to have been initiated from University-led projects. Instead, the cases were generally identified as initiated within the schools concerned, either by the teachers or the school leaders. This result could be related to two of the criteria used in the case selection as stipulated by the Study: evidence of sustainability and scalability of the TEPI. Another observation is that the pedagogical approaches pioneered in these innovations, e.g. collaborative inquiry and learning from authentic problems involving the participation of members of the community, are still rare in classroom practices in countries around the world as revealed by large international studies conducted more than a decade later, such as ICILS 2013 and the PISA 2012 study. These findings point to the importance of school-based agency and ownership as well as the significant challenge in scaling up TEPIs.

Research evidence gathered in the second decade of the new millennium shows more examples of systemic improvement efforts that have scaled. The collection of papers in section 2 of the *Second International Handbook of Education* (Hargreaves, Lieberman, Fullan & Hopkins, 2010) on systemic changes in education that has taken place in countries around the world testifies to the progress made in this area. In comparing seven case studies of technology-enhanced learning innovations (which is another name for TEPIs) that have achieved some level of scale collected in Europe and Asia (Law, Kamylyis & Punie, 2013) find that in general, the innovations implemented at larger scales tend to have less ambitious

educational goals as a common strategic basis for participation, requiring lower levels of innovativeness in the pedagogical practices. On the other hand, the level of innovativeness does not necessarily determine the scale of implementation. In particular, the study found the Singapore ICT masterplan 3 (mp3) to have achieved a scale higher than expected given the level of innovativeness it was targeting, while the scale achieved by the e-Learning Pilot Scheme in Hong Kong and the e-Textbook project in South Korea were both lower than expected in comparison.

The comparative study of European and Asian TEPIs that scaled show that while scaling TEPIs is challenging, it has been achieved to different extents in countries that differ widely in their culture, socio-political and education systems. (Law, Kampylis & Punie, 2015) further show that there are multiple pathways to scaling TEPIs.

### **Need for a Model that Addresses Mechanisms of Change at Multiple Levels for scalability**

This section reviews some key theories of change and educational innovation to examine what insight these might bring to understanding the conditions for scalability of TEPIs. Before discussing the different models of change, there is a need to clarify the meaning of scalability. Here we take our point of departure (Clarke & Dede, 2009)'s five dimensional model of scalability, which are depth, sustainability, spread, shift and evolution (the first four dimensions were proposed by (Coburn, 2003). We find the evolution dimension, i.e. that the adopters adapt and revise the innovation for their own innovation contexts, to be the most important as we can see from the TEPI literature that evolution over time to be an important feature of those that were scaled.

#### *Diffusion models of innovation adoption*

The most often cited model for scaling innovations is Roger's diffusion model (Rogers, 2003). The model highlights that even for innovations that are effective, they may not be adopted by those who would benefit from it. The model is grounded on a theory of communication, the efficacy of which depends on the channels of communication available as well as the features of the social system involved. This model is popularly adopted in studies of education technology adoption studies as it provides an apt description of the bell-shaped distribution with regard to the positions taken by people in response to an innovation: innovators, early adopters, early majority, late majority and laggards. However, this model takes innovations as ready solutions that only need to be implemented. On the other hand, technological tools and resources are only the media for the realization of the innovative pedagogical ideas in the TEPIs. The technologies in the TEPIs are not ready solutions as in the case of boiling water to ensure that the drinks made are safe. The "adoption" of a new pedagogy, which is the core of the innovation, requires a constructive process of interpretation and adaptation on the part of the teachers and the schools concerned.

Another drawback of Roger's (2003) model is that the physical process of diffusion is a unidirectional process, which cannot be reversed once triggered, and will necessarily achieve an ultimate state of uniform density. This means, taken literally, a diffusion model would predict that ultimately an innovation would spread. The only significant variation is in the time taken to reach uniform adoption. TEPIs, on the other hand, can just have a transient presence in the adoption schools in the same way that non-indigenous species introduced into a foreign ecology may simply go extinct (Law et al., 2011). A model for understanding the scalability of TEPIs needs to include mechanisms for evolution and change in the innovation adoption process.

#### *Design-Based Research: Teachers as co-designers in TEPIs*



As pointed out earlier, TEPIs require deep changes in teachers' practices and roles in the classroom, thus requiring new knowledge, skills as well as beliefs about the goals and processes of learning (Law, 2008a). Literature on teacher learning for TEL implementation has shown that training models focusing on imparting knowledge and skills are not effective in bringing about change in pedagogical practice. Models that report successful change are similar in providing experiential, action oriented learning involving teachers collaborating in communities of practice (Looi, Lim & Chen, 2008). In particular, collaborative design of curricular materials has been found to be an effective form of teacher professional development as it provides a situated context for the learning, agency for change by the teachers, and a cyclical mode of learning for continuous improvement and change (Voogt et al., 2015). (Cviko, McKenney & Voogt, 2014) further show that engaging teachers as co-designers in the design and implementation of technology-enhanced learning activities result in the greatest extent of integration of technology-rich activities in the teachers' practices compared to engaging them as re-designers or simply as executors of designed activities. In fact, engaging teachers as co-designers is a commonly adopted methodology of working with teachers in design-based research (Cobb, Confrey, Lehrer & Schauble, 2003) in the learning sciences community to explore the implementation of more effective models of learning and teaching in classroom settings.

While co-design has been shown to be an effective form of teacher professional learning activity for change, the implementation of TEPIs requires change not only at the teacher level. Classrooms as sites of teachers' pedagogical practices are nested within schools, within school districts, state/ regional/national education systems and influenced by the wider educational ecology constituted by commercial, political, bureaucratic, and professional organizations at local, national and international levels and their interactions (Davis, 2008). Models of scaling TEPIs through supporting *Teachers as co-designers of TEPIs* offer an effective model for innovation focused learning at the teacher level, but do not address the complex interplay of factors at other levels.

In order to understand the wider contexts within which TEPIs emerge and develop, the SITES-M2 study collected information about school, regional and national level contexts pertaining to each case study of TEPI in addition to the in-depth descriptions of the pedagogical innovations at the classroom level (Kozma, 2003). The Study findings (ibid.) show that school level factors such as leadership involvement and school culture had important influence on the initiation and development of the TEPIs studied. In a further secondary analysis of these case studies, (Law, 2008b) found school leadership engagement to be a strong contributing factor to the sustainability of the innovations. Cases where the school leadership supported teacher collaboration and the establishment of teacher communities of practice connected with the TEPI showed higher sustainability, as these provided mechanisms for sustained teacher learning. The transferability of the SITES-M2 innovation cases was found to be influenced by both school level ICT policy and system level education policy (ibid.). Where the system level policy encouraged and supported cross-school, multi-stakeholder collaboration networks around pedagogical innovations, the cases were more likely to have been scaled up within the same school and/or to other schools. Clearly, models of scalable TEPIs need to take account of the interdependence between teacher learning and conditions at the other levels within the educational ecosystem.

### *Models of change as theories-in-action of system level actors*

Another important line of research into the scalability of educational reform comes from scholars involved in studying and guiding system level changes. Many of the researchers in this community have been in close collaboration with policy makers in driving change, either as a member of the reform team or as a consultant at the system level. (Fullan & Hargreaves, 2009) and (Hargreaves et al., 2010) provide rich accounts and analyses of system level change that took place in different parts of the world.

Hargreaves (2009) provides a succinct overview of the four ways of implementing education reform goals by policy makers in the Anglo-Saxon world since the 1960s. The First Way was characterized by a focus on supporting professional freedom and flexibility, and the result was great diversities in outcome due to the lack of leadership for consistency in effort or impact. Standards-based reforms were subsequently launched to create coherence. Unfortunately, the reform goals could not be achieved simply through the stipulation of common educational standards. The Second Way (from mid '90s to mid-2000s) attempted to enforce the standards through various market mechanisms such as league tables, standards-based accountability, competition, prescription and punitive actions. This resulted in alienation of the teaching profession as well as damaged innovation and creativity.

The Third Way was described as the post-standardization response from policy makers characterized by three possible strategic foci: tighter regulation and market competition, strengthened statistical surveillance to monitor progress, or encouraging laterally driven improvement processes through peer-driven networks (e.g. setting up mentor schools) and resource incentives for innovation initiatives. It is clear from the description of the three ways that this body of literature, while also grounded very much on practice, but it is practice as experienced by people driving/implementing change at the policy level, and is very different from the practice of those driving/implementing change at the classroom level. Here, learning at student, classroom and teacher levels are considered as solutions to be implemented. How do individuals and groups learn, and the finer details and complexities of instituting change and learning at these lower levels are not considered as important in policy decisions for change at the system level beyond the general principles of motivation, support, incentives, and accountability.

Fullan (2009) proposes that a theory of action is needed to realize whole system improvement in education, and that such a theory needs to satisfy three criteria: (1) can address the needs of a whole system and not just a selection of schools; (2) will result in sustained improvement; and (3) motivating to different actors. Hargreaves (2009) describes the “theory-in-action” of the Fourth Way as comprising three sets of principles to guide the strategic actions of policy makers: five pillars of purpose and partnership (highlighting the importance of having an inspiring vision, partnership and corporate responsibility as well as adequate resource provisions), three principles of professionalism (highlighting the importance of professional learning through communities, and having teachers as their own custodians of professional standards), and four catalysts of coherence (emphasizing the need for leadership to be distributed, knowledgeable about learning, non-controlling, focusing on responsibility rather than accountability and supporting coherent bottom-up improvement initiatives).

The *Theory of Action for System Change* (TASC) that Fullan (2009) put forward is similarly a set of guiding principles with six components. The first, direction and sector engagement, parallels Hargreaves's (2009) five pillars of purpose and partnership, but puts into sharp focus the need for a guiding coalition of key leaders (politicians) from the very top of the system, and not just the minister of education, as well as leaders at other levels of the system. The second and third components are similar to Hargreaves' (ibid.) principles of professionalism and leadership characteristics needed to serve as catalysts of coherence. The three other components in Fullan's (2009) TASC are guidelines for managing the change process: managing the distractors, continuous evaluation and inquiry, and two-way communication describe the need for having mechanisms that provide feedback and communication mechanisms to help maintain focus and bring alignment while navigating change in large complex systems.

In summary, there is emerging from this rich body of literature deepening understanding of the complexities of change and a move towards developing a theory of change that takes account of the need for alignment at different levels of the system, and that professional learning is of paramount importance.

*Building architecture for learning to support pedagogical innovations at multiple levels*

Reform agendas stipulated at the policy level needs to be enacted by teachers at the classroom level in order that the envisioned impact on students' learning outcomes can be realized. However, unlike the contexts studied in design-based research, where the participating teachers are generally innovators or early adopters since scale is not a focal issue, system change requires buy-in from the majority of teachers to change their practices. For change to be implemented at scale throughout an entire system, the reform agenda has to be operationalized through the different levels of the system, usually involving district education offices and schools. Hence, our understanding of the nuances involved in scaling pedagogical innovations can be enriched by literature on the implementation of pedagogical change at school and district levels, focusing on the role of school and district level leadership.

In a study of how school leadership in four demographically different schools, particularly the school principals, mediated the implementation of curriculum policy by the teachers, (Spillane, Parise & Sherer, 2011) observe the creation of organizational routines as “coupling mechanisms” to change teachers' practices. The use of the term organizational routines is as defined by (Feldman & Pentland, 2003), and refers to “a repetitive, recognizable pattern of interdependent actions, involving multiple actors” (p. 95). These routines serve to connect specific elements of the policy regulation to the formal structure and administrative practice of the school in order to achieve greater alignment between the teachers' practices and the core policy concerns. For example, the Five Week Assessment routine set up in one of the schools coupled the government curriculum standards with regular five-week cycles of tests to measure student progress and indirectly to monitor teachers' teaching, as well as provide the focus for staff meetings to review the test outcomes. By creating mechanisms and expectations for teachers to regularly share important aspects of their practice such as content coverage and grading criteria of student work, the organizational routines also make these practices more transparent and subject to monitoring.

In some educational systems, there are intermediary levels of jurisdiction, such as school districts, that are responsible for the implementation of system level policy. (Stein & Coburn, 2008) studied how two school districts went about implementing a new mathematics curriculum in their schools. Adopting a theoretical lens that view implementation and alignment challenges as learning challenges, and that learning takes place through appropriate forms of engagement, then the work of the districts in curriculum implementation can be conceptualized as one of designing the conditions conducive to meaningful learning by teachers. There are different stakeholder groups, which can also be referred to as communities, involved in the implementation process: district leaders, district math leadership team and instructional specialists, principals, math coaches and teachers, each with their own practices. Successful implementation requires effective channels of *influence* across community boundaries, such that there can be interactions not only among teachers within the same school, but also interactions of teachers with other communities within and outside their own school within the district.

They adopted Wenger's (1998) concept of “architectures for learning”, which refers to the organizational environments that foster teacher learning through communities of practice, to investigate the differences in the conditions for learning available to the teachers in different schools in the two school districts studied. They found that the most significant variation in outcomes were between the two districts rather than between schools within each of the districts. The more successful district provided more organization structures for cross-level and cross-school interactions through a variety of strategies such as sharing the coaching role between two math teachers instead of having one single math coach in each school, and meetings. It should be noted here that the concept of organizational routine as used by (Spillane et al., 2011) is one example of architecture for learning (Wenger, 1998), which pertains to specific organizations. Architecture for learning, on the other hand, is more generic and can be applied across levels and organizational units of a system.

It can be seen that research on change and leadership at the school and local (district) levels provides an important link between studies of change at the system level and classroom level changes. Further, some of the work in this area conceptualizes the process of implementation and change as a learning process, providing a parsimonious continuity to studies of teacher and student learning.

### In Search of Multilevel Interdependencies for TEPI Success

In the previous section, we reviewed literature on models of change at different levels of the education system. On the other hand, education systems are complex systems characterized by interdependencies across and within units at each level. Studies on the scalability of TEPIs would not be adequate without exploring such interactions and interdependencies. Hence, similar to other large-scale international comparative studies (e.g. TIMSS) and national evaluation studies, ICILS 2013 also collected data at student, teacher, school and system levels. Figure 1 shows the framework adopted by ICILS to conceptualize the relationship between the various contextual factors (referred to as antecedents), the learning process and students' outcomes. And, as is common with the design of such studies, the contextual factors at the various levels are grouped together, as is the case with learning processes that are affected by contextual factors located at different levels.

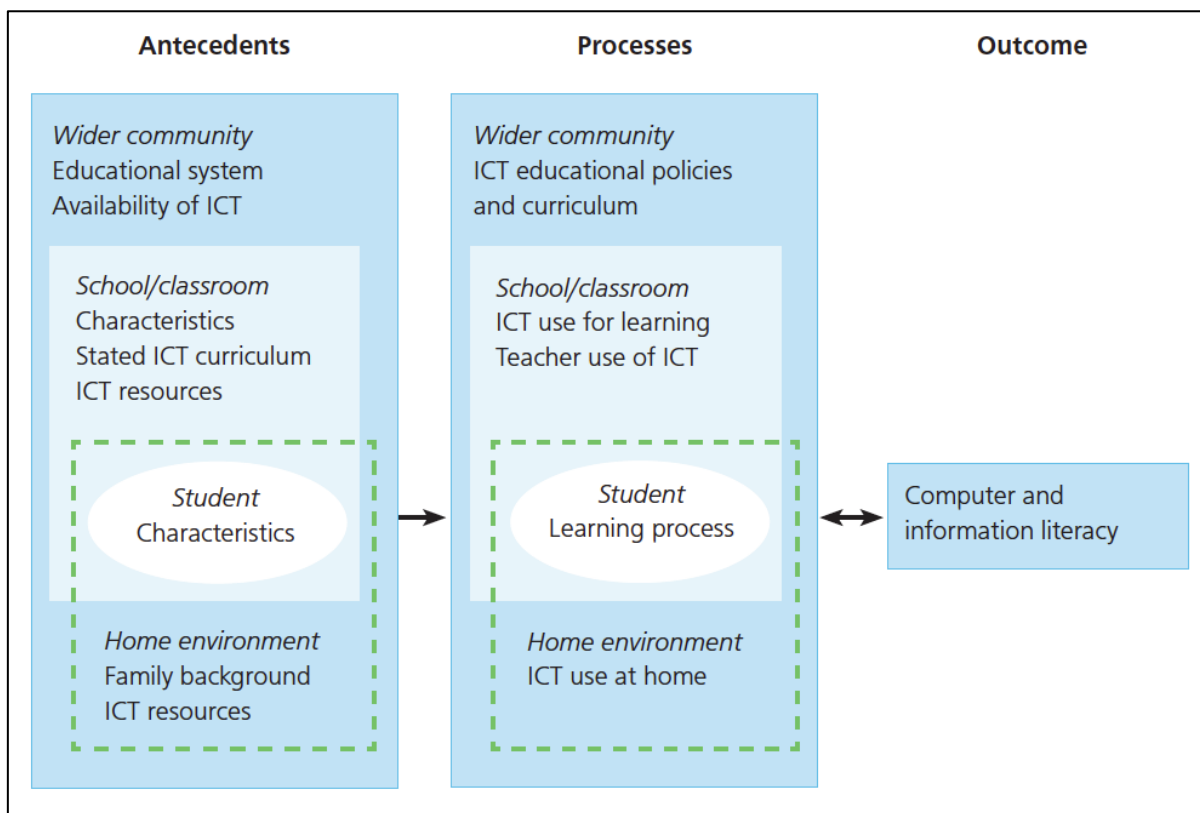
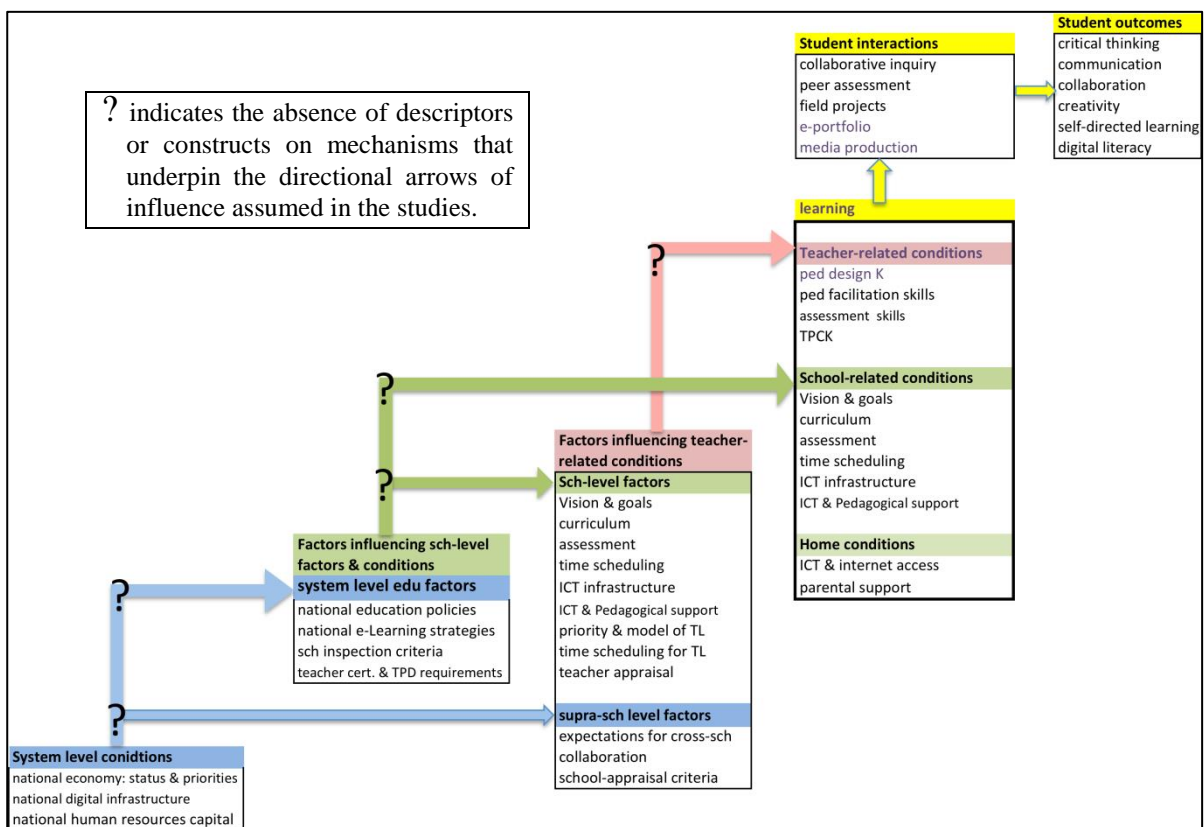


Figure 1. Conceptual framework adopted by ICILS 2013 relating contextual factors to learning outcomes. (Fraillon, Schulz, Friedman, Ainley, & Gebhardt, 2015), p. 37.

There is a need to unpack the intricate interdependencies in order that the massive amounts of contextual data collected can be used to provide valuable information about how school and classroom level factors influence students' learning outcomes. (Drent, Meelissen & van der Kleij, 2013) report on a carefully constructed meta-study of published secondary analysis studies on TIMSS data up to March 2010 (i.e. including TIMSS 1995, 1999, 2003, 2007), focusing on the contributions these studies made to

understanding the relationship between the characteristics of school and classroom contextual factors with student achievement. The study found relatively few papers that met basic quality criteria actually reported significant findings between these contextual factors and students' cognitive outcomes in science or mathematics, and where significant findings were reported, these are often inconsistent across countries. In addition to issues of whether important scales and parameters have been included in the design (ibid.), and the limitations of the cross-sectional design of these studies (Goldstein, 2004), there is a need for research designs to take account of the nuances of the multilevel dependences of these various factors. To do so, this paper first unpacks the interdependencies implicit within the model underpinning the ICILS 2013 study, represented in Figure 2:



**Figure 2. Schematic showing the constructs pertaining to different levels of the education system commonly included in ICILS 2013.**

1. *Factors influencing the learning interactions.* The nature and attainment level of students' learning outcomes are very much dependent on the learning opportunities available, which are represented under "student interactions" in Figure 2. The kinds and quality of learning opportunities available are dependent on a number of factors at the teacher level related to his/her pedagogical capacities and practices (e.g. whether the teacher has the requisite pedagogical design knowledge, facilitation skills and technological, technological content knowledge (TPCK) to organize collaborative inquiry activities for students), and at the school level (e.g. the vision and goals of the school, the curriculum and assessment policies of the school practices adopted, ICT infrastructure and pedagogical support available), as well as on home and personal factors.
2. *Factors influencing the teachers' classroom practices.* The school-related conditions that affect students' learning opportunities such as the school vision and curriculum also affect the priorities

teachers give to different kinds of pedagogical and assessment practices. Furthermore, where teachers are expected to engage in active collaboration with other schools, such engagement may also influence their classroom practices.

3. *Factors influencing school level conditions.* System level education policies and strategies would influence the school leaders' formulation of school level vision, goals, curriculum, assessment as well as TEL implementation strategies, which may support or pose obstacles to teachers' ICT-using classroom practices in their schools.
4. *General system level factors.* The national survey, which was generally completed by a knowledgeable person from the Ministry of Education nominated by the National Research Coordinator, provides information about the country's education system and structure, as well as curriculum related policies. The ICILS 2013 national survey included questions about the state of ICT development in the country as reflected by the broadband penetration in family homes and ICT development index of the country, in addition to policies related to ICT use in the school curriculum and its implementation in schools, such as provisions of ICT infrastructure, digital learning resources, as well as teacher professional development requirement and opportunities.

There are a number of ? marks in Figure 2, which indicates the black box approach in the conceptualization of the interactions across the different levels of factors. The assumption is that these are causal influences from one level to the next (and essentially top-down, from higher to lower levels). In recent years, there is research that points to the need for dynamic models of studying educational effectiveness to more appropriately inform policy and practice (Creemers & Kyriakides, 2008; Creemers & Kyriakides, 2010), and makes explicit assumptions about the interactions.

### **A Multi-Level Multi-Scale (MLMS) Model of Learning for Scalable TEPIs**

Building on work that argues for multilevel, longitudinal and dynamic models of understanding how contextual factors at different levels influence student learning outcomes, this paper puts forward a model for studying the interdependencies using a parsimonious learning framework. A dynamic model focuses on the changes that happen at each of the levels. At the core of this proposed framework is to view change at each of the levels as requiring learning, and that the learning within and across levels are interdependent. The efficacy and scalability of change depend on the efficacy and scalability of the interdependent learning systems involved. A diagrammatic representation of this model is presented in Figure 3, and the key postulates (or principles) of this model are described below.

*Changes at each level are conceptualized as learning.* The core concept here is that the conditions or factors at different levels of the system influencing student learning should be conceptualized as learning outcomes at the respective levels. Hence, teachers' TPACK and assessment skills are learning outcomes at the teacher level; the organizational structures, curricula, assessment and appraisal systems of schools are the learning outcomes at the school level; and national education policies, e-Learning strategies, teacher certification requirements and school inspection criteria are learning outcomes at the system level. By adopting a learning model, we highlight the importance of *pedagogical design* (i.e. designing the learning environment and learning interactions within and across these different levels) in achieving the targeted outcome goals at these different levels. In the educational change literature, as reviewed in an earlier section, mechanisms for change are often conceptualized primarily from the vantage point of a particular level within the system.

Diffusion models and design-based research literature focus on change at the teacher and classroom level, and the latter does adopt a learning model in conceptualizing change, but primarily at the teacher level. For those researching change at the system level, the focus is at the strategic level in ensuring focus and alignment during the process of navigating change in large

complex systems (e.g. Fullan & Hargreaves, 2009). While these models of managing change do recognize the importance of supporting professional learning, they do not perceive change at the system level as learning. Research on architecture for learning in the literature on change and leadership at the school and district levels (Spillane et al., 2011; Stein & Coburn, 2008) shows that organizational environment and organizational routines have major impacts on teacher learning due to the different channels of communication and influence that these provide to foster interactions among different professional communities, and hence contribute importantly to different outcomes in terms of changes in teachers' practices. These findings provide crucial support to the model being proposed here.

*Tangible and conceptual artifacts as learning outcomes.* There are three sets of constructs related to each level: learning outcomes, learning interactions and conditions for learning, which are colour-coded in Figure 3 (yellow, pink, green and blue for student, teacher, school and system levels respectively). Our main focus for learning outcomes at the student level is on 21<sup>st</sup> century abilities such as critical thinking, collaboration and communication, which are best fostered through collaboration in solving authentic problems. Likewise, at the other levels, particularly at the school and system levels, the outcomes are generally policy and implementation decisions, which should ideally be outcomes arising from collaborative problem solving interactions.

*Scale matters: peer collaboration and inquiry as core mechanisms for effective learning at all levels.* Peer collaboration and inquiry have been identified as key pedagogical characteristics of classroom practices that are successful in fostering 21<sup>st</sup> century learning outcomes at the student level. In the process of implementing TEPI, stakeholders at each level have to generate the learning outcomes as described above through a process of authentic problem solving in the change process. Hence, these stakeholders themselves have to engage in 21<sup>st</sup> century learning. Thus collaborative inquiry must be designed as core to the design for learning at higher levels: teacher, school leadership learning and policy-maker (system) levels.

In Figure 3, the arrows connecting the learning interactions and learning outcomes at each level are bi-directional, highlighting the importance for the stakeholders at each level to review and reflect on the outcomes of their learning to iteratively improve the learning process. Furthermore, idea diversity is an important knowledge building principle (Scardamalia & Bereiter, 2003) as a pre-requisite for idea improvement through the collaboration process. Hence, the learning at each level would benefit tremendously from interacting with peers from outside of the specific unit, whether it be the school, the district or education system.

One important implication of this principle is that scale matters in scalability of TEPIs. Models of scaling that start with pilot projects involving one or very few schools to develop and refine innovation prototypes before further dissemination and scaling are generally less successful as compared to those that start as innovation networks (Law, Kankaanranta & Chow, 2005). As pointed out by (Law et al., 2011), pedagogical practices identified as innovations are by definition alien species within their education ecology. Hence, the concept of "innovation adoption" is a misleading misnomer if taken literally, since any "adoption", if successful in becoming sustainable, has to bring about changes in the local ecology, which implies that it has to engage stakeholders at different levels of the local ecology in a process of learning and innovation. The outcomes of scalable "adoptions" should be products of evolution (Clarke & Dede, 2009) and hence would rarely be high fidelity replications of the original. eTwinning, a Europe-wide initiative to promote intercultural awareness across classrooms in different European countries through the provision of an online collaboration platform to connect classrooms, became a wellspring of technology-enhanced learning innovations (Kampylis & Punie, 2013) when additionally supported by national/regional strategies to encourage teachers to engage in

experimentation in these directions. This is prime example of how TEPIs may evolve through the provision of an effective network infrastructure for connecting potential innovation units at scale.

1. *Architectures for multilevel stakeholder engagement and participatory decision-making.* In Figure 3, there are three pairs of adjacent levels that are clearly marked along the diagonal: student-teacher, teacher-school and school-system. For each of these pairs, there are two sets of one-directional arrows representing between-level learning feedback that can be leveraged to achieve cross-level alignment. For example, the school level outcomes constitute the immediate, direct conditions affecting teachers' learning interactions, which should in turn affect the school-level decision-making if there are channels for the leadership to understand where tensions and obstacles to teachers' learning lie in realizing the schools' e-Learning goals. Conditions for learning at different levels such as classroom and school routines, staff appraisal criteria, national curriculum and assessment methods, etc. are interdependent. For the innovation to develop and scale requires that these conditions can organically and interdependently evolve over time through self-organizing learning interactions across the different levels. This in turn depends on whether there are appropriately crafted channels of communication and mechanisms for participatory decision-making involving multilevel stakeholders (i.e. architecture for multilevel learning) to ensure systemic alignment during the process of innovation implementation.

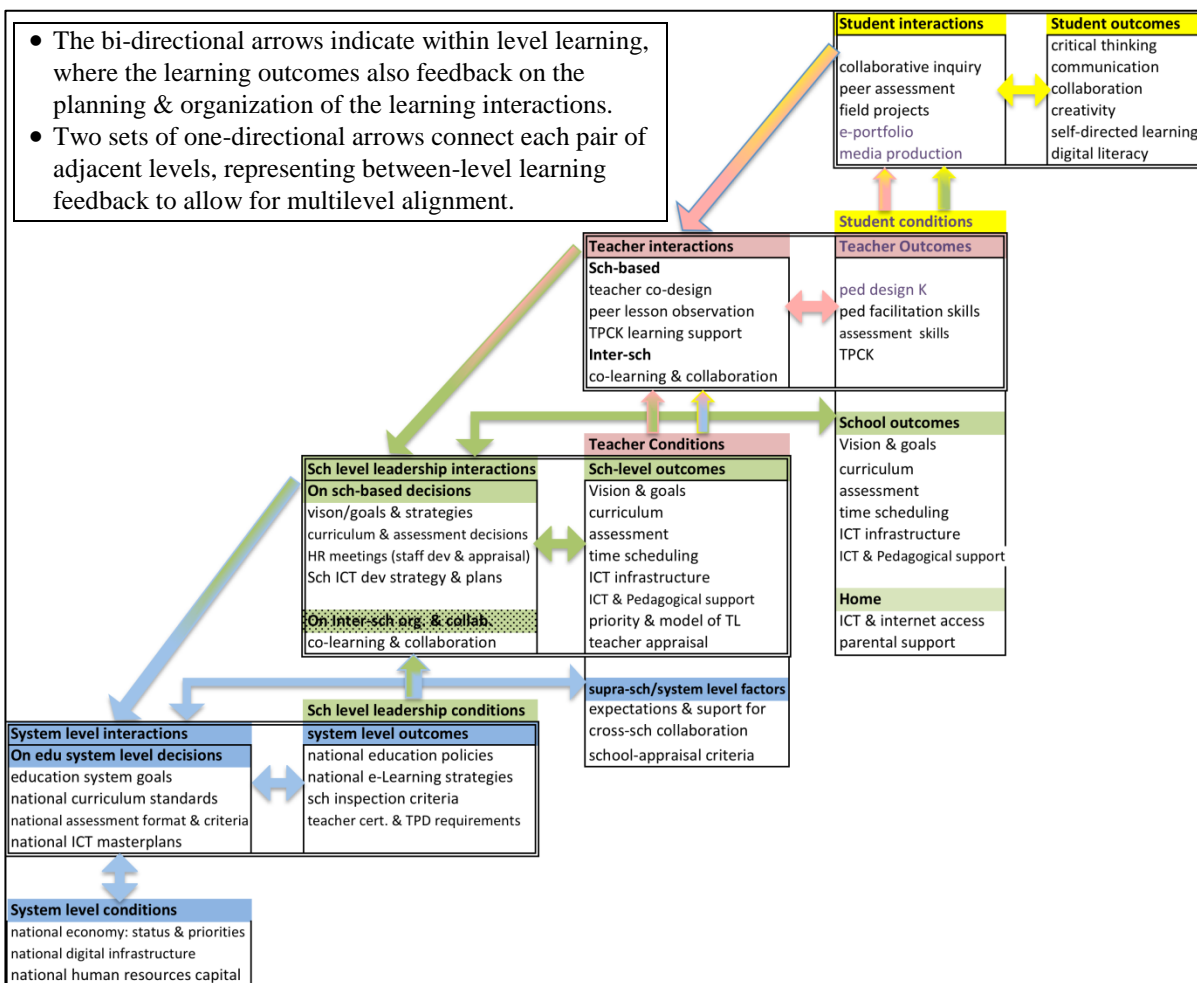


Figure 3. Schematic showing two types of feedback loops connecting the constructs within and across levels throughout the different levels of the education system.



## Implications of the Multi-Level Multi-Scale Model for Scalable TEPI

Taking the model of MLMS learning as the core mechanisms for scaling TEPI, there are a number of implications we can derive from the principles described above.

### *Scaling TEPI*

One important advantage of conceptualizing the process of change in implementing TEPIs as MLMS learning is that it can guide change strategies for scalability. TEPIs are not static formulations to be copiously followed, but are dynamic systems. As depicted in Figure 3, change may be initiated at any level, but the change agents need to undertake intentional design learning interactions within each level and across the different levels, to provide opportunities for dynamic, self-organizing alignment, to achieve gradual changes to the education ecosystem that favour the long term sustainability of the TEPI.

### *R&D on pedagogical designs for MLMS learning*

Human beings learn through experience and reflections on those experiences, which may not be associated with institutionalized or intentional learning settings. In the same way, teachers, schools and societies learn (i.e. change) without conscious planning or design. However, without intentional planning and design, the learning outcomes are likely to replicate what has always been the case within the particular ecosystem if there are no changes in the environment. Given the rapid technological and socio-economic changes and pace of globalization, such laissez-faire policy is recognized by many policy makers to be untenable, and hence the emergence of educational reform and various IT in education initiatives and masterplans. While such initiatives are generally accompanied by research on curriculum and pedagogical designs for classroom learning, and increasingly also on teacher learning, the same is rarely available for learning at school level, system level and across levels. The MLMS learning model can provide a theoretical framework for much needed R&D in these areas to advance the theory and practice of scaling TEPIs.

### *Evaluation of TEPI plans and implementations*

An advantage of conceptualizing change at each level as learning is that one can distinguish between surface learning and deep learning. If the learning outcome is only the result of rote learning without understanding, the outcomes may not be able to withstand the test of time, or be “sustainable” when the context for application of the knowledge or skill is changed. Similarly, policy decision at school or system levels may not be understood or supported by the professionals, students or the community even though they may be decided upon and implemented. In some cases, decisions made could be reverted when there is strong dissent from stakeholders. Hence, while MLMS learning can serve as an intentional design framework for scalability, it can also serve as a powerful lens for the examination of TEPI implementation projects/plans to gauge its likelihood of successful scalability.

Many countries have invested enormous resources and efforts to launch education reforms and ICT in education masterplans since the end of the last century. These efforts are often designed and implemented as a standalone, one-off efforts to achieve a set of well laid-out goals, objectives, and conditions in much the same way as depicted in Figure 2. Given the intrinsic flaws as described in the previous section, particularly the lack of understanding that the changes needed at the various levels are not to be achieved in one step, and has to be negotiated through multilevel, interdependent learning. TEPI plans and implementation strategies that do not address and make provisions for multilevel multiscale learning and alignment are intrinsically deficient in scalability and long term sustainability.

*Predicting the scalability of change (formative evaluation of TEPIs)*

In education, we are familiar with the need to specify learning outcomes, pedagogical and assessment designs so that we can appropriately evaluate the outcomes and the efficacies of the designs and appropriateness of the intended learning outcomes. Further, there have been much research in recent years on *assessment as learning*, which are design principles and designs for learning activities that would also reveal the status of the learning progression for individual learners so that the learning designs can be appropriately adjusted according to the learners' needs. If student level learning which typically takes place within a time scale of days and weeks needs formative feedback during the process of learning, designs for formative feedback is even more important for MLMS learning at organizational and system levels. Learning outcomes at the school level (e.g. school routines, staff appraisal and incentive systems, assessment methods, staff competence) and at the system level (e.g. national education policies, school inspection criteria, teacher certification criteria) typically takes months and years to accomplish, and for the effects of these changes to have measurable impacts on student learning would take even longer.

Hence, it is even more important to design mechanisms to assess the alignment of the learning outcomes within and across levels, and for the findings to feedback formatively to the learning (i.e. management of change) process. In particular, there needs to be research on be methodologies to identify key interdependencies, the state of alignment, and effective mechanisms for self-organizing alignment. A preliminary proposal for the design of a multilevel system of quality technology-enhanced learning and teaching indicators based on the MLMS model of learning was discussed at the EDUsummIT 2015 (Law, Niederhauser, Shear & Christensen, 2015) and further elaborated in (Law, Niederhauser, Christensen, & Shear, 2016).

## **Conclusions and Discussion**

As the empirical studies on TEPIs in Europe and Asia (N. Law, Kampylis, et al., 2015) (Law et al., 2013) reveal, agency for change can be various, and sometimes multiple, depending on the specific contexts. Socio-political and education systems differ, and change strategies need to pay attention to the local ecological contexts to build architectures for MLMS learning. Learning outcomes include not simply beliefs, knowledge or skills. Organizational structures, decision-making mechanisms and processes, rules and regulations, physical and digital infrastructures, etc. affect the efficacy of learning. Artifacts, social, physical and digital infrastructure and organizational routines are important learning outcomes at different levels in this model. This conception of learning outcomes lies at the core of the MLMS learning model, and is very important from theoretical, policy and practice perspectives.

Based on this MLMS model, existing conditions for learning within and across each of the levels can be identified, and whether changes are needed as targeted learning outcomes can be explicitly explored. Structures and mechanisms for interactions and decision-making can be intentionally designed to foster self-organized learning towards the overarching vision and goals for student learning. There are always variabilities and imbalances as the system moves forward, and this model highlights the need for building within- and cross- level learning interactions for alignment and dynamic systemic advancement. This proposed can be used to guide pedagogical and assessment design, feedback and evaluation of MLMS learning for scalable TEPI. It does not prioritize a particular model of change, but provides a framework to guide policy-makers, practitioners and researchers in the identification of research findings and models of learning from the literature to guide their efforts in the planning and implementation of TEPIs for scalability.

## REFERENCES

- Clarke, J., & Dede, C. (2009). Design for Scalability: A Case Study of the River City Curriculum. *Journal of Science Education and Technology*, 18, 353-365. doi:10.1007/s10956-009-9156-4
- Cobb, P., Confrey, J., Lehrer, R., & Schauble, L. (2003). Design experiments in educational research. *Educational researcher*, 32(1), 9-13.
- Coburn, C. E. (2003). Rethinking scale: Moving beyond numbers to deep and lasting change. *Educational Researcher*, 32(6), 3-12.
- Creemers, B. P., & Kyriakides, L. (2008). *The dynamics of educational effectiveness: A contribution to policy, practice and theory in contemporary schools*. London: Routledge.
- Creemers, B. P. M., & Kyriakides, L. (2010). Using the dynamic model to develop an evidence-based and theory-driven approach to school improvement. *Irish Educational Studies*, 29(1), 5-23.
- Cviko, A., McKenney, S., & Voogt, J. (2014). Teacher roles in designing technology-rich learning activities for early literacy: A cross-case analysis. *Computers & Education*, 72, 68-79.
- Davis, N. (2008). How May Teacher Learning be Promoted for Educational Renewal with IT? In J. Voogt & G. Knezek (Eds.), *International Handbook of Information Technology in Primary and Secondary Education* (pp. 507-519): Springer
- Drent, M., Meelissen, M. R., & van der Kleij, F. M. (2013). The contribution of TIMSS to the link between school and classroom factors and student achievement. *Journal of Curriculum Studies*, 45(2), 198-224.
- Feldman, M. S., & Pentland, B. T. (2003). Reconceptualizing organizational routines as a source of flexibility and change. *Administrative Science Quarterly*, 48, 94-118.
- Fisher, T. (2006). Educational transformation: Is it, like beauty? in the eye of the beholder, or will we know it when we see it? *Education and Information Technologies*, 11(3), 293-303.
- Fraillon, J., Schulz, W., Friedman, T., Ainley, J., & Gebhardt, E. (2015). *International Computer and Information Literacy Study 2013 technical report*. Amsterdam, the Netherlands: International Association for the Evaluation of Educational Achievement (IEA).
- Fullan, M. (2009). Have Theory, Will Travel: A Theory of Action for System Change. In M. Fullan & A. Hargreaves (Eds.), *Change Wars*. Bloomington, IN: Solution Tree Press.
- Fullan, M., & Hargreaves, A. (Eds.). (2009). *Change Wars*. Bloomington, IN: Solution Tree Press.
- Goldstein, H. (2004). International comparative assessment: how far have we really come? *Assessment in Education: Principles, Policy and Practice*, 11(2), 227-234.
- Hargreaves, A. (2009). The fourth way of change: Towards an age of inspiration and sustainability. In M. Fullan & A. Hargreaves (Eds.), *Change Wars* (pp. 11-44). Bloomington, IN: Solution Tree Press.
- Hargreaves, A., Lieberman, A., Fullan, M., & Hopkins, D. W. (Eds.). (2010). *Second International Handbook of Educational Change*. Dordrecht: Springer.
- Kampylis, P., & Punie, Y. (2013). Case report 1: eTwinning - the community for schools in Europe. In P. Kampylis, N. Law, & Y. Punie (Eds.), *ICT-enabled innovation for learning in Europe and Asia: Exploring conditions for sustainability, scalability and impact at system level* (pp. 21-35). Luxembourg: Publications Office of the European Union.
- Kozma, R. (Ed.) (2003). *Technology, Innovation, and Educational Change: A Global Perspective*. Eugene, OR: ISTE.
- Law, N. (2008a). Teacher Learning Beyond Knowledge for Pedagogical Innovations with ICT. In J. M. Voogt & G. A. Knezek (Eds.), *International Handbook of Information Technology in Primary and Secondary Education* (pp. 425-434). New York: Springer.

- Law, N. (2008b). Technology-supported pedagogical innovations: the challenge of sustainability and transferability in the information age. In C.-H. Ng & P. Renshaw (Eds.), *Reforming Learning: Issues, Concepts and Practices in the Asian-Pacific Region* (pp. 319-343). New York: Springer.
- Law, N., Kamylyis, P., & Punie, Y. (2013). Towards a policy framework for understanding and upscaling ICT-enabled learning innovations: Synthesis and Conclusions. In P. Kamylyis, N. Law, & Y. Punie (Eds.), *ICT-enabled innovation for learning in Europe and Asia: Exploring conditions for sustainability, scalability and impact at system level* (pp. 115-135). Luxembourg: Publications Office of the European Union.
- Law, N., Kamylyis, P., & Punie, Y. (2015). Multiple Pathways to Enhance Multilevel Learning for Scaling Up Systemic ICT-Enabled Learning Innovations: Lessons from 7 European and Asian Cases. In C. K. Looi & L. W. Teh (Eds.), *Scaling Educational Innovations* (pp. 197-223). Singapore: Springer.
- Law, N., Kankaanranta, M., & Chow, A. (2005). Technology-supported Educational Innovations in Finland and Hong Kong: A Tale of Two Systems. *Human Technology*, 1(2), 176-201.
- Law, N., Niederhauser, D. S., Christensen, R., & Shear, L. (2016). A Multilevel System of Quality Technology-Enhanced Learning and Teaching Indicators. *Journal of Educational Technology & Society*, 19(3), 72-83.
- Law, N., Niederhauser, D. S., Shear, L., & Christensen, R. W. (2015). Thematic Working Group 7: Indicators of Quality Technology--Enhanced Learning and Teaching. In K. W. Lai (Ed.), *Technology Advanced Quality Learning For All: EDUsummIT 2015 Summary Report* (pp. 47-53): EDUsummIT 2015.
- Law, N., Pelgrum, W. J., & Plomp, T. (Eds.). (2008). *Pedagogy and ICT in schools around the world: findings from the SITES 2006 study*. Hong Kong: CERC and Springer.
- Law, N., Yuen, A., & Fox, B. (2011). *Educational Innovations Beyond Technology: nurturing leadership and establishing learning organizations* New York: Springer.
- Looi, C. K., Lim, W. Y., & Chen, W. (2008). Communities of Practice for Continuing Professional Development in the 21st Century. In J. M. Voogt & G. A. Knezek (Eds.), *International Handbook of Information Technology in Primary and Secondary Education* (pp. 489-505). New York: Springer.
- OECD. (2011). *PISA 2009 Results: Students on Line: Digital Technologies and Performance* Paris: OECD.
- OECD. (2015). *Students, Computers and Learning: Making the Connection*. Paris: PISA, OECD Publishing.
- Partnership for 21st Century Skills. (2009). *P21 Framework Definitions*. Retrieved from [http://www.p21.org/storage/documents/P21\\_Framework\\_Definitions.pdf](http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf)
- Pelgrum, W. J., & Anderson, R. E. (Eds.). (1999). *ICT and the Emerging Paradigm for Life Long Learning*. Amsterdam: IEA.
- Pelgrum, W. J., & Law, N. (2003). *ICT in education around the world: trends, problems and prospects*. Paris: UNESCO: International Institute for Educational Planning.
- Plomp, T., Anderson, R. E., Law, N., & Quale, A. (Eds.). (2003). *Cross-national Information and Communication Technology Policies and Practices in Education*. Greenwich, CT: Information Age Publishing.
- Plomp, T., Anderson, R. E., Law, N., & Quale, A. (Eds.). (2009). *Cross-national Information and Communication Technology Policy and Practices in Education* (2nd ed.). Greenwich, CT: Information Age Publishing Inc.
- Rogers, E. M. (2003). *Diffusion of Innovations* (5th ed.). New York: Free Press.
- Somekh, B., & Davis, N. (1997). *Using information technology effectively in teaching and learning : studies in pre-service and in-service teacher education*. London ; New York: Routledge.
- Spillane, J. P., Parise, L. M., & Sherer, J. Z. (2011). Organizational Routines as Coupling Mechanisms Policy, School Administration, and the Technical Core. *American Educational Research Journal*, 48(3), 586-619.

- Stein, M. K., & Coburn, C. E. (2008). Architectures for learning: A comparative analysis of two urban school districts. *American Journal of Education*, 114(4), 583-626.
- Voogt, J., Laferrière, T., Breuleux, A., Itow, R. C., Hickey, D. T., & McKenney, S. (2015). Collaborative design as a form of professional development. *Instructional Science*, 43(2), 259-282.
- Watson, D. M. (2001). Pedagogy before Technology: Rethinking the Relationship between ICT and Teaching. *Education and Information Technologies*, 6(4), 251-266.
- Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems thinker*, 9(5), 1-5.

## ATTUNING PEDAGOGIES TO “NEW LEARNERS”: CONTEXT

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### Introduction

The learner should be at the centre of teaching concerns. It follows that as learning is influenced by learner characteristics, then teaching must attune to these characteristics to be effective (Dumont, Istance, and Benavides, 2010). This does not mean that schools should give up on their essential objectives and curricula, but rather to adjust pedagogies in order to get closer to their students and better address their educational needs. Policies cannot be designed and implemented in a vacuum, and should be sensitive to the learner factor as it is a crucial aspect of the classroom context. Pedagogical innovation should be informed by learners’ interests and needs so as to reshape and optimise teaching. In this paper, we present “new learning” general tendencies that might help design and implement innovative pedagogies.

The next sections present the notion of “new learners” as they have been depicted in the literature, discussing possible new learning trends of young people, analysing their implications for pedagogy, and examining their potential benefits and drawbacks for learning. This includes digital technology use for teaching and learning; multimedia materials; multi-tasking and interactive teaching and learning environments; gaming in educational settings; and collaboration and the use of Web 2.0 tools in teaching and learning.

### “New learners”

Some have asserted that there is a new type of learner with specific characteristics that impact on the way they learn. Many labels have been used for them: digital natives (Prensky, 2001), the netGeneration (Tapscott, 2009), the iGeneration (Rosen, Carrier and Cheever, 2010), New Millennials (Howe and Strauss, 2000), and many others. Although each term implies a specific delineation, they all assume that young people growing up with technology have acquired distinctive ways of learning as a result. According to Prensky (2001), digital natives are those born after 1980 as the “first generation” that grew up surrounded by technology. Those born after 1990 are the “second generation” of digital natives (Wang et al., 2014), shaped by the likes of Google, iPods, e-mail and chat rooms. A “third generation” of digital natives would be those born after 2000, in a world of widespread use of cell phones, tablets, cloud-computing tools and social networking.

These depictions of “new learners” coalesce around the following suppositions (Thompson, 2013):

- *Constantly using technology*: Digital technology is part of young people’s landscapes, immersed in a digital world and daily using different technologies for many purposes, including learning.
- *Using multimedia or multimodal materials mixing the verbal and non-verbal*: Verbal codes can be text or spoken words, and the non-verbal can be illustrations, photos, videos or animation. The young learners are supposed to prefer visual representations (e.g., videos or animation) over text, and to like materials combining verbal and non-verbal codes (e.g., video clips).

- *Multi-tasking in non-linear and interactive environments*: young people are supposed to like to multi-task (i.e., perform more than one task at the same time, or constantly switch between tasks), with a preference for non-linear materials where the user can choose different paths or jump from one part of the document to another (e.g., clicking on different webpage links while looking for certain information). Young learners are supposed to behave that way in highly interactive environments which respond differently according to the learner's actions (e.g., giving certain feedback depending on their activity).
- *Being active and using gaming environments*: the young learners are supposed to prefer active roles in learning (e.g., hands-on tasks), to engage in video games, and to seek entertainment.
- *Social and collaborating*: the supposed preference is for being constantly connected with peers in activities that often require collaboration.

### ***Sharpening a blurred image***

Empirical studies, however, commonly yield mixed evidence on the existence of a distinct generation showing that the simple picture is actually far more complex (Bennett and Maton, 2010). Some critics point out that studies tend to offer decontextualised images, and their conclusions, drawn from mainly US and European research, are not necessarily applicable elsewhere (Cabra and Marciales, 2009). Differences in, for instance, Internet use between older and younger generations are not unbridgeable (Helsper and Eynon, 2010). The younger generations are actually heterogeneous regarding technology usage and cannot be assumed to be digitally competent (Kennedy et al., 2010; Li and Ranieri, 2010; Margaryan, Littlejohn and Vojt, 2011).

Concepts such as “new learners” may help to evoke a memorable image, but are misleading when used as clichés or stereotypes (Organisation for Economic Co-operation and Development –OECD, 2012). Such labels often lead to a determinism that is ill-matched with the diversity and plurality of young people. Searching for a prototype of the “new learner” presupposes unrealistically that there is homogeneity among youth across nations and cultures (van den Beemt, Akkerman and Simons, 2011). Another misleading assumption is that the younger generations’ distinctive features are the result of intensive technology use (Carr, 2010; Prensky, 2001; Tapscott, 2010), instead of attributing them to wider social and cultural change (including technology).

Some claim (Prensky, 2001) that differences reflect biological, unmodifiable characteristics such that the brain structures and physiology of digital natives are depicted as different from digital immigrants through being exposed to technology from an early age. Instead, such tendencies may be developed by anyone who is daily exposed to technology-rich environments (e.g., Small et al., 2009).

In this chapter we assume that beyond the debate about distinct generations of learners and their labels, what matters is if learners show any new learning tendencies likely to impact school teaching and learning. We propose to focus the analysis on the “new learning” trends rather than the “new learners”. While we can assert that some international research informs that today's young learners generally show the tendencies depicted in the previous section, we cannot assume by any means that this phenomenon is homogeneous across the globe.

Reshaping pedagogies to better meet new learning needs and interests requires a clear picture of what those needs are. Research and more informal classroom observation or community-based studies can provide precious information to inform pedagogy design at the micro-level, taking account of changing learner

needs and priorities. Large-scale studies only take us so far, and practitioners and education managers need to verify how far those conclusions apply in their local contexts.

## **Technology use**

### ***Supporting learning through new tools***

Information and Communication Technology (ICT) is ever more pervasive in our societies. Young people access it ever earlier and spend ever more time using it (OECD, 2015a). Households have invested in ICT to access a wider and faster wealth of services, mainly for leisure purposes (OECD, 2013). Outside school, teenagers spend on weekdays an average of two hours using computers for leisure, especially browsing the Internet for fun and participating in social networks (OECD, 2015a). Likewise, increased smartphone penetration and intensity of use make those activities ever more mobile (OECD, 2015b). There is, however, no easy transition between the informal uses of technology as described above, and those commonly proposed in formal schooling.

An argument now frequently put forward in the literature for using ICT in the classroom is that it can enhance human learning; yet alongside this an also-frequent conclusion of the literature is that ICT does not automatically bring about learning improvement as it is only a tool in the service of instructional goals (Tamim et al, 2011). To bring about improvement it needs to be used in certain ways and hence the challenge is to find out those “certain ways”.

Meta-studies conducted over recent years have generally yielded modest positive results in favour of using technology in classrooms. Tamim et al. (2011) review 25 meta-analyses from the past 40 years to conclude that the average student in a classroom with technology will perform 12 percentile points higher than a student in a traditional setting without ICT. The effect size is higher when technology is used to support students to achieve learning (e.g., the use of simulators or text processors to create documents), rather than for delivering content (e.g., Computer-Based Instruction).

Kulik and Fletcher (2016) meta-analysis suggests that a specific technology known as “Intelligent Tutoring Systems” can be perfectly effective for content delivery. In the same vein, Gerard et al. (2015) show that the use of automated adaptive environments can improve learning results as long as they imitate the guidance typically given by expert teachers.

Meta-research on the use of mobile devices suggest a moderate positive effect on learning (Sung, Chang and Liu, 2016), especially when they are used with inquiry-based pedagogies and outside the school environments. In the same vein, meta-studies on one-to-one computer programmes in schools show some evidence of increased academic achievement –mostly in science, writing, mathematics and English, as well as technological competences, although that evidence is still weak (Fleischer, 2012; Zheng et al., 2016). Computers are used mainly in those programmes for exploration (information seeking), communication (mail and instant messaging), and expression (typing and multimedia authoring).

Likewise, meta-analyses of technology and reading outcomes (Cheung and Slavin, 2012) conclude that ICT can support reading instruction - even more so when it is integrated into face-to-face teaching, assisting teachers but not trying to replace them. Similarly, a meta-analysis by Li and Ma (2010) shows that computer technology has statistically significant positive effects on mathematics achievement. The best results are achieved with the adoption of “constructivist” pedagogical approaches that, for instance, help students to construct their mental models or their own knowledge through small-group activities. Another meta-analysis shows that ICT can be used to improve learners’ reflection in different ways, as long as technology is appropriate for the instructional context (Kori et al., 2014).



Nevertheless, analyses from the Programme for International Student Assessment (PISA) suggest that learning outcomes have not improved in countries that have heavily invested in technology (OECD, 2015a); furthermore, ICT may even be detrimental to learning if it is not appropriately integrated into the educational setting.

### ***Pedagogies that harness the power of technology for learning***

ICT may lead to positive learning outcomes, although the effect size of such increase is not dramatic according to meta-research. Overall, it seems that technology may be more beneficial when it is conceived as an amplifier of teaching to be used in combination with teachers' and peers' support, rather than a tool to be used in isolation. In fact, the research largely concludes that successful teaching experiences rely precisely on how teachers integrate technology into their daily relations with students.

Teachers can make the most of technology when it is used to diagnose the student's progress and difficulties, and accordingly provide tailored assistance to encourage the student moving forward. It comes as no surprise that the applications that yield the more encouraging results are those that activate the complex cognitive processes involved in deep and meaningful learning such as interacting with simulations, communicating and discussing with peers and educators, and solving complex tasks. It is precisely through these complex processes that revealing information can be gathered by educators to grasp their students' performance and to inform an adjusted instructional response.

We may thus conclude that a whole range of pedagogical approaches can be used to harness the power of technology, as long as it is used to complement and amplify the teacher's role. Pedagogical approaches that are likely to make the most of technology are those that encourage discussion and collaboration, that give students an active role, and that promote complex cognitive processes like analysing and solving complex and authentic tasks.

Another important technological potential is its capacity to promote learning engagement and motivation. For instance, students' self-reports used in research on one-to-one computer projects show that learners feel more motivated when they use those computers (Fleischer, 2012; Zheng et al., 2016). Likewise, Li and Ma (2010) conclude that one of the ingredients that explains the positive effects of technology on mathematics learning is increased student engagement. However, those authors also assert that shorter programmes of less than 6 months are more successful than longer ones, the reason given being that students might feel attracted by the technological novelty and not by the mathematical contents or learning tasks.

Students' motivation to master different subjects can be fostered so long as pedagogies seek to motivate students *through* technology and not *to* technology. This relates to the distinction between intrinsic and extrinsic motivation (Ryan and Deci, 2000). Intrinsic motivation means students learn because they find it inherently interesting or enjoyable such as in wanting to master a subject, or in wanting to feel more capable. Extrinsic motivation means the student pursues something separate from the learning itself such as a prize or reward, or in order to avoid negative sanctions. Intrinsic motivation is associated with high-quality learning. Using technology simply as a novelty to attract students will not be enough as that might well rely on extrinsic motivation. Pedagogies should seek to increase student interest in the contents and the competences being promoted, making students aware of the value of learning them, and the potential satisfaction that accompanies mastering them.

Yet motivating students *to* technology makes sense when the aim is acquiring digital literacy. One of the most popular assumptions about young learners is that they are "technology savvy" because they have grown up surrounded by technology. This has been widely rejected by empirical research (Kennedy et al., 2010; Li and Ranieri, 2010; Margaryan, Littlejohn and Vojt, 2011). Gu, Zhu and Guo (2013) find that

although the young learners feel more digitally competent than their teachers and adopt technology at an earlier age, in terms of duration and frequency they do not use more ICT than their teachers. Similar results are found by Wang et al. (2014): school-age learners are not more technology savvy than their teachers and indeed teachers' use of technology, inside and outside the classroom, surpasses that of the students.

The myth of the learners as tech savvies is harmful as it assigns them a competence for using ICT for learning purposes that they might not have. Using technology for social or leisure purposes, and for life-long learning are two different experiences that involve different competences. Overrating their digital competence can result in omitting digital literacy in the curriculum, and/or leaving students to work with technology on their own ("because they already know how to use it").

The meta-analysis by Winters, Greene and Costlich (2008) concluded that for students to exploit computer-based learning environments, they must have reasonable prior skills and knowledge for using technology. Such skills and knowledge relate to general strategies like planning or monitoring their own learning, and prior knowledge about contents. Students must also have prior technological competence, and they generally benefit from training on how to use those technological environments beforehand.

Leaving students to interact with technology regardless of their prior competences will likely have detrimental consequences for their learning. Digital environments can foster learning so long as students have the minimum abilities to start the learning process. Digital literacy is an important ingredient of the so-called 21<sup>st</sup> century competences and it is not simply acquired through engagement with ICT at an early age.

Finally, technology is under-used when it is simply associated with the presentation of contents by teachers. Teachers using technology with the only aim of transmitting information to students will get among the worse results of ICT classroom integration. One of the pitfalls of ICT classroom integration is that teachers adopt traditional pedagogical strategies and become more concerned about how they will use ICT, than about the benefits of technology for their students (Fleischer, 2012).

When designing and implementing pedagogy, practitioners should focus on how both teachers and students can make the most of it. Meta-research highlights the potential of computers to implement student-centred scenarios by using pedagogies like project-based learning (Zheng et al., 2016). Students perform better in digital environments when they use active strategies - e.g., coordinating different sources of information or making inferences - than the passive strategies of copying, summarising, and note-taking (Winters, Greene and Costlich, 2008). Pedagogies must avoid teachers monopolising the technology and avoid assigning learners with a merely passive role. This is especially important to counteract the habits learners often develop outside school (Kennedy et al., 2010), in which many use technology passively in their daily lives as consumers rather than actively through producing or mixing artefacts.

The following table summarises the advantages and drawbacks of technology use, together with pedagogical implications:

**Table 1: Pedagogical implications of technology use**

| Advantages   |  | Challenges   |   |
|--|--|--|---|
| Technology can improve learning outcomes   | Technology can improve learning engagement and motivation  | Young learners may not be technology savvies   | Technology may reproduce traditional pedagogies   |
| How pedagogies can help  |  |  |   |
| * Pedagogies use technology as a complement of teaching and not as a substitute of it<br>* Pedagogies give learners an active role and promote collaboration, while teachers use information to adjust support | * Pedagogies motivate learners "through technology" and not "to technology"<br>* Pedagogies promote intrinsic motivation and avoid reliance on "novelty" | * Pedagogies promote digital literacy<br>* Pedagogies assess that students have the prior competence to engage with digital environments | * Pedagogies avoid transmission practices with teachers monopolising the technology<br>* Pedagogies push students towards active strategies in using technology |

## Multimedia

### *Conditions for the effective use of multimedia environments*

Children spend more time than ever in on-screen activities such as watching television, surfing the web and playing games on computers, tablets and cell phones (Bus, Takacs and Kegel, 2015; Courage and Howe, 2010; Wartella, Richert and Robb, 2010). One of the common features of those activities is the combined verbal and non-verbal information in the same environment (photos, animation, spoken words, text, etc.). Children's books are changing from traditional paper books to electronic formats on phones, tablets and e-readers (Burnett, 2010). Such e-books enable new features like listening to the story, looking at animated pictures, listening to background sounds and music, etc. This poses a challenge to schools in which the main medium of instruction has traditionally been text alone.

The cognitive theories of multimedia learning establish that humans have independent auditory and visual channels and a limited capacity for processing information such that one channel might get overloaded (Moreno and Mayer, 2007; Schöler, Scheiter and van Genuchten, 2011). However, learning may be enhanced when those two channels process different sorts of media at the same time, such as images being processed through the visual channel, while words are being processed through the auditory channel. Research has shown that the different media may enhance learning, but only if certain conditions are met.

Takacs, Swart and Bus (2015) conduct a meta-analysis of technology-enhanced storybooks to find a small but positive effect of the multimedia on story comprehension and expressive vocabulary learning. Learning is leveraged only when non-verbal information such as animated visualizations, background sounds and music are congruent with, and support, the narration. The advantage of multimedia materials is not the presence of illustrations along with other information, but such features as animated pictures, sounds and

music. According to another meta-analysis (Berney and Bétrancourt, 2016), animations are found to benefit multimedia learning when they are accompanied by oral information instead of text.

Likewise, Kalyuga (2012) conducts a meta-analysis of the instructional benefits of spoken words along with pictorial information. When pictures are not self-explanatory, then words must be used. Spoken words must be used when information is complex. For instance, if such explanations are displayed on PowerPoint slides and simultaneously narrated by the instructor, the learner needs to relate on-screen text with the oral explanations, and also pay attention to the pictorial information. Eliminating or reducing on-screen text would improve learning (Kalyuga, 2012).

On the other hand, when pictures are intelligible by themselves, then the studies suggest not using words. For instance, when pictorial information is clear enough through maps, pie-charts etc., there is no need to add verbal information. Only when the learner requires it, educators should adjust and provide verbal explanation of pictures.

Some studies conclude that multimedia environments are more effective when they imitate the performance of expert teachers (Moreno and Mayer, 2007): for instance, by providing guidance through animated agents, promoting reflection through posing challenging questions, or providing rich feedback especially for learners with less prior knowledge or skills. Eitel and Scheiter (2015) conclude in their meta-review that learners may benefit from multimedia environments that present contents sequentially, but only when less complex information is presented first, and then information of increasing complexity and detail. This facilitates the understanding especially of learners with less prior knowledge. Likewise, Richter, Scheiter and Eitel (2016) conclude in their meta-analysis that meaningful learning is fostered when learners are able to relate verbal and pictorial information; this can be facilitated through signalling cues like using the same colour for corresponding words and pictures. This strategy benefits especially learners with low prior knowledge.

### ***Pedagogies taking advantage of multimedia materials***

In summary, the use of multimedia materials may bring moderately better learning outcomes, provided that practitioners and designers follow some specific principles. Multimedia materials embrace a wide range of products - from a PowerPoint presentation, to a videogame, a storybook, or a simulation – and are compatible with a wide range of pedagogies. Their power to enhance the comprehension of narrations can make them a good vehicle to aid mastery of complex skills of oral comprehension and reading. Likewise, their potential to represent and simulate different phenomena - natural, chemical or physical processes, as well as social or historic ones – means they can foster insight on different subjects across the curriculum. Pedagogies based on the use of narrative, such as “learning through storytelling”, can take advantage of multimedia materials, so long as they follow sound instructional designs such as making sure the student is presented with increasingly complex and rich contents.

Multimedia materials may also be a resource for powerful learning when students have to *produce* a multimedia artefact (“multimedia authoring”). The evidence is scattered in this regard but multimedia authoring has the potential to support higher-order thinking skills (McFarlane, Williams and Bonnett, 2000). As learners engage in building and refining their artefacts, they also can modify and perfect their conceptual representations (Yuen and Liu, 2011). Moments when students experience disequilibrium - encountering unexpected responses or opposed and conflicting ideas - can highlight misconceptions and help to address them. Thomas (2012) finds that multimedia authoring gives the learner the personalised opportunity to express themselves and with varying degrees of sophistication. A challenge lies in balancing the teacher’s attention between effectively fostering understanding of contents while promoting the skills to build such complex artefacts.

One of the most studied multimedia products are concept maps. Nesbit and Adesope (2006) conclude through meta-analysis that, although the evidence is quite heterogeneous, concept mapping is more effective than reading passages, attending lectures or studying text passages or lists, and is useful for teaching in a wide range of educational settings. Pedagogies should consider them both as activity, where students have to produce them, and as pre-constructed objects to support teaching and individual study.

Multimedia artefacts are produced and read differently from texts in classic format, resulting in an ongoing reformulation of grammar to describe the confluence of words, images and sounds (Mills, 2010). Reading and writing using words on paper are necessary but not enough for communicating through multimedia products. Multimedia authoring is certainly a good opportunity to promote such competence. Multimedia authoring may lead to the construction of artefacts by students to master specific knowledge and skills (Papert, 1993). Several pedagogical approaches have come to highlight this principle such as “learning by design” (Kolodner et al., 1998), where students work on the design challenge of creating an artefact that requires some critical knowledge and skills to be learned. Another is the “maker movement” and “learning by doing” (Martinez and Stager, 2013), where learners use technology to make or repair useful artefacts using knowledge from different disciplines.

On the other hand, multimedia materials have some risks too. If those materials are not well designed and used, they may become a source of distraction. According to Schweppe and Rummer (2014) the most important criterion for designing multimedia learning materials is ensuring that they promote the focus on relevant information and away from “extraneous” information. Some meta-studies conclude that games and extra-animations embedded in multimedia materials can be extraneous material that does not integrate with the relevant story content (Mayer and Moreno, 2002; Bus, Takacs and Kegel, 2015). This diminishes children’s language and story comprehension, especially if they are incidental to the story line. If they have a choice, children prefer to play rather than listen to the story and read it. Very young children and learners at risk are especially vulnerable to such distractions. Features like games and extra-animations might enhance learner engagement with the story, but with diminished language acquisition and story comprehension. The authors consider that time spent with screen media cannot replace time spent with print books, unless children are explicitly guided by educators to focus on the reading experience before engaging with any other activities.

Pedagogies should consider that distractions in multimedia experiences may be detrimental for learning. Scaffolding the acquisition of important skills like reading is a complex process that cannot be completely delegated to multimedia technological environments, although some may include functions that imitate the guidance of human experts. That scaffolding process should include designing the learning experience, providing tailored support according to the learner’s performance, and appraising performance until the learners are judged capable of performing on their own. Guidance in using multimedia materials should also help learners to focus on the relevant contents, and make sure that any extra-features contribute to the overall learning experience.

Another potential drawback is cognitive overload. It may occur: first, when multimedia information is presented in a way unsuited for the human capacities for processing it, e.g., using lengthy text and spoken words in addition to pictures when presenting complex information (Kalyuga, 2012); second, when the learner engages with interactive elements like games or hotspots, and tries to read or listen to them at the same time (Takacs, Swart and Bus, 2015). Either way, the experience reduces the learner’s resources to understand the contents. This effect again seems to be more intense in young children and learners at risk who are less skilled in controlling their attentional focus. School pedagogies should pay attention to these risks and seek to minimise them. Instructional designers and practitioners should be sensitive to their learners’ capabilities to process new information. They should pay close attention to how the verbal and non-verbal information is displayed, and ensure that the contents can be understood.

Pedagogies can take advantage of certain interactive features because they appeal to learners. Practitioners should follow a clear instructional sequence that helps the learners to achieve the intended goals, clarifying the objective of multimedia tasks before engaging with them. Likewise, the instructional design should avoid parallel activities likely to overload the students' capacity of understanding. The learning sequence should ensure that the learner has enough prior knowledge and skills to engage with whichever multimedia materials are selected.

**Table 2: Pedagogical implications of multimedia materials**

| Advantages   |   | Challenges   |  |
|--|---|--|--|
| Multimedia materials can improve learning outcomes   | Students can engage in multimedia authoring   | Multimedia materials can create distraction  | Multimedia materials can create overload   |
| How pedagogies can help  |   |  |  |
| * Pedagogies use sound instructional designs and adequately integrate them<br>* Pedagogies take advantage of their power to represent narratives | * Pedagogies focus on promoting multimedia literacy especially in the construction of artefacts | * Pedagogies accompany the learner and scaffold their use of the materials<br>* Pedagogies focus on relevant contents and productively integrate multimedia extra-features | * Practitioners make sure that multimedia contents can be understood by learners<br>* Practitioners clarify the use of multimedia features and ensure that learners are able to use them |

### Multi-tasking, non-linear and interactive environments

Research shows that the average number of online activities per user has increased in OECD countries, especially in younger people (OECD, 2016a). This suggests that young people are regular multi-taskers – constantly switching or performing different tasks at the same time: watching videos, reading, playing videogames, listening to music, texting, etc.. Some “internal” factors behind this include the desire to stay connected with others and the “fear of missing out”, addiction to the Internet or cell phone, or the wish to change from doing a task viewed as boring. “External” factors include technological devices calling for attention through beeps or pop-up signals, and the in-built technological facilitation of multi-tasking through the possibility to open multiple windows or tabs, and to work on different applications simultaneously (Carrier et al., 2015).

Research using laboratory experimental data generally shows that multi-tasking is less efficient than single-task performance whether in terms of time invested or accuracy achieved (Cardoso-Leite, Green and Bavelier, 2015; Carrier et al., 2015; Courage, 2015). Tasks that involve responses requiring conscious control such as having a conversation or reading a text, or that involve verbal information, are especially affected when multi-tasking. Young children in particular are subject to the limitations associated with multi-tasking since their immature attention processes make it particularly difficult (Courage et al., 2015; Rothbart and Posner, 2015). Multi-tasking necessitates control over attentional focus, switching between tasks, avoiding distractions and pursuing goals. The underlying executive function that enables such behaviours is only slowly acquired by children and young people from age 3 onwards.

Some claim that young learners have developed more effective multi-tasking skills but this is not supported by evidence whatever young people themselves might think (Kirschner and van Merriënboer, 2013). Young people who frequently multi-task are no more capable of avoiding distraction than those who multi-task only occasionally (Carrier et al., 2015). Coaching on task-switching and better grasping tasks might enhance multi-tasking but there is little or no transfer of those benefits to other tasks performed at the same time (Cardoso-Leite, Green and Bavelier, 2015; Rothbart and Posner, 2015).

Research findings contradict the popular assumption that multi-tasking damages attentional and learning brain circuits. It is not extended exposure to technological environments *per se* that shortens children's attention or causes attention deficit, but rather that children with such deficits get their required level of stimulation through those media (Courage et al., 2015). Likewise, the amount of time devoted to screen media may correlate negatively with academic outcomes, not because it is damaging in itself, but because it displaces time for other activities such as reading or studying.

As for interactive and non-linear materials, meta-studies show that learners generally benefit from being able to control the information appearance pace and choose their own learning path (Moreno and Mayer, 2007; Wouters, Tabbers and Paas, 2007). Likewise, meta-research shows that these environments are generally more effective when they provide elaborated feedback like giving an explanation, instead of simple feedback as in informing on the correctness of the answer (Van der Kleij, Feskens and Eggen, 2015). However, these interactive features are not always advantageous for learners because (Scheiter and Gerjets, 2007):

- Learners experience “usability problems” such as disorientation, distraction, and cognitive overload.
- Learners have poor prior knowledge and skills, or inadequate abilities to regulate their own learning, or negative attitudes towards learning.
- The interactive environments might lack a clear design based on sound pedagogical approaches.

### ***Pedagogies relevant to multi-tasking and interactive environments***

The daily use of technology inside and outside the classroom tends to produce multi-tasking and yet multi-tasking generally adds very little to learning, unless it is carried out for very specific instructional purposes. Some media multi-tasking may support the learning activity in specific circumstances, such as when learners gather data and analyse them on-the-fly, but many forms of multi-tasking are clearly detrimental to learning and to be discouraged, such as the student answering unrelated texts during a lecture. Since younger learners are especially vulnerable to distraction and cognitive overload, designers and practitioners need to factor this into the technological environment, and be able to monitor the children's learning to ensure the appropriate use of technology.

Multi-tasking is nowadays pervasive and it is liable to occur whenever someone uses fixed or mobile technologies, whether at school or university, the workplace, or during social or leisure activities. While multi-tasking at school might be said to better prepare young learners for life, its potential negative effects on task performance poses the challenge of promoting awareness of the implications of multi-tasking in a world full of distraction. Learners must be capable of judging by themselves the consequences of multi-tasking in different tasks and contexts, to test its consequences, and find effective ways to control their learning or work performance (Carrier et al., 2015).

The ability of learners to judge the consequences of multi-tasking, to deliberately handle it, and stay on-task requires capacities of self-control - the executive function - that are only slowly acquired during the primary school years. This developing capacity should be recognised in different pedagogies. So long as learners consider that multi-tasking is productive and necessary, and so long as they are not aware of its potential negative consequences, they will keep doing it.

On the other hand, certain pedagogies may depend on technological environments where learners can follow their own learning path or control information appearance. Such environments need to be designed and implemented according to sound pedagogical approaches such as the web-based inquiry science approach where students engage in projects to design scientific solutions to problems, debate science controversies, and critique scientific claims (van den Broek, 2012). Students collect evidence and articulate their ideas, test their predictions, get feedback, and reflect on their progress. Effectiveness is not so much about the technology as about the promotion of high quality learning.

Pedagogies should especially take account of learner characteristics: the learner must have the knowledge, skills and attitudes to engage with the contents and follow a clear path towards learning. Practitioners should choose the environment according to their learners' characteristics and pedagogical approaches, and technological environments should be flexible enough to adapt to different learning profiles (Wouters et al., 2007).

Pedagogies may also take advantage of data automatically gathered on student's performance ("learning analytics") (Sharples et al., 2014). Teachers may use data to make adjustments in the instructional design or provide more assistance to struggling students. Before engaging with interactive environments, students can also benefit from specific training either on the environment characteristics or contents knowledge (Moreno and Mayer, 2007).

Pedagogical design also needs to take account of the so-called "butterfly defect" (Kirschner and van Merriënboer, 2013). Learners may behave like "butterflies fluttering across the information on the screen, touching or not touching pieces of information (i.e., hyperlinks), quickly fluttering to a next piece of information, unconscious to its value and without a plan" (p. 171). Having the possibility of jumping from one piece of information to another might offer the chance for students to quickly connect different pieces of information, to establish connections between contents of different fields, and to build richer and wider networks of knowledge in their minds. To achieve such benefits, they must have relevant prior knowledge to understand the information, the skills to relate them to familiar frameworks, and consequently to analyse their value. When students use interactive learning environments they must have other key skills such as being aware of the task goal, being able to delineate a plan, follow a procedure, and evaluate when they have achieved the goal.

Pedagogies should incorporate knowledge frameworks so that students can interpret the information they are presented with. Practitioners can help students to "activate" or use what they already know in order to understand new information. Without such frameworks, students will not understand what they find and will activate strategies that lead to poor learning (e.g., copying and pasting irrelevant information), or "flutter" endlessly on the web. Teaching should promote the capacity to make connections between ideas from different fields that may seem unrelated, and ensure that students have sufficient skills to "regulate" their navigation through the technological environment. Teachers should make students aware of the goals and the task requirements, assisting in the creation of a plan, and supervising its success.



**Table 3: Pedagogical implications of multi-tasking and interactive environments**

| Advantages   |   | Challenges  |  |
|--|---|---|--|
| Teaching can prepare students for a world of distractions  | Interactive and non-linear environments can support learning  | Multi-tasking can be detrimental to learning  | Interactive and non-linear environments can encourage the “butterfly defect”   |
| What pedagogies can do   |   |   |  |
| * Pedagogies promote awareness of multi-tasking and its consequences<br>* Pedagogies foster self-control and judicious use of multi-tasking in the classroom | * Environments are designed and implemented according to sound pedagogical approaches<br>* Designers and practitioners ensure that environments are suitable for learners | * Pedagogies actively address harmful multi-tasking<br>* Pedagogies are especially careful about multi-tasking regarding younger learners | * Pedagogies promote use of knowledge frameworks by learners<br>* Pedagogies ensure that learners have sufficient competence to navigate the environment |

## Active learning and gaming environments

### *In search of the right conditions to use videogames in learning*

Popular claims about young learners generally assign them a preference for playing active roles in daily activities and the need for constant rewards and positive feedback if they are to persist in tasks. They are depicted as students who prefer to carry out hands-on activities and make artefacts, rather than being passive such as attending lectures. On this view, it follows that learners should prefer to play games, especially video games. On these propositions there is less evidence than assertion though it is clear just how popular games are among young people: US research found nearly three-quarters of teenagers play video games on a computer, game console or portable device like a cell phone. They are considered by teenagers as entertainment and a form of socialising, so that the pedagogical challenge is to take advantage of gaming for learning purposes (Lenhart et al., 2015).

There are two main educational responses to this challenge so far:

- *The Game-Based Learning approach* - using videogames, either entertainment or specifically educational ones, in school settings. There is growing use of video games across different curricular areas, mostly in secondary and higher education, and most notably in health, business and social subjects (Connolly et al., 2012). In primary education they are mainly used in mathematics, science, languages and social areas (Hainey et al., 2016).
- *The Gamification approach* which does not involve videogames themselves but uses game elements such as rewards, points, and top-score leader boards in classroom activities (Domínguez et al., 2013).

Video games may enhance students’ learning outcomes, although results from some meta-analyses are limited in effect sizes, restricted to some subjects and type of outcomes, and very much depending on the

instructional conditions under which those games are used. Jabbar and Felicia's (2015) meta-analysis of digital and analogue games concludes that role-playing instils a sense of immersion that supports engagement and learning improvement. However, students might not be really motivated to learn but just to play and to compete against peers. Complex games might hinder content learning as they call on more cognitive resources simply to play the game. Clear goals, unambiguous feedback and a sense of control by students are key for experiencing game conflicts in a positive fashion.

Clark, Tanner-Smith and Killingsworth's (2016) meta-analysis concludes that digital games can enhance students' learning compared with non-game conditions. Games that have been enhanced for educational purposes show particular benefits. Sitzmann (2011) asserts on the basis of another meta-analysis that digital simulations may enhance learners' declarative and procedural knowledge, retention and self-efficacy. Connolly et al. (2012) conclude that the use of entertainment and serious games generally yield positive outcomes. Serious games generally result in positive knowledge acquisition, and the use of entertainment games results in positive affective and motivational processes. Serious games may be more effective than conventional instruction in terms of knowledge retention, but not in motivation (Wouters et al., 2013). Hainey et al. (2016) show that innovation in primary education is more focused on serious games of genres like strategy, puzzle and role-playing, rather than entertainment games. Their literature review suggests that serious games impact especially knowledge acquisition, although they do not provide quantitative meta-analyses.

On a more sceptical conclusion to meta-analysis of serious games, Young et al. (2012) report improved students' outcomes only for language games and, to a lesser degree, physical education games. They conclude that instructional design must assure that game and learning objectives align. Teachers need to promote learning transference to other contexts and reflection on the game experience. The authors conclude that the keys to learning effectiveness are less features of the game and more the wider pedagogical context in which it is used.

As for the gamification approach, there has been less meta-research. Hamari, Koivisto and Sarsa (2014) conclude that although the majority of studies on gamification and learning yields positive outcomes, there are important caveats: the role of the wider instructional context may play a more decisive role than the gamified activity itself; likewise, some cognitive and affective personal features of the learners might importantly contribute to success. Faiella and Ricciardi (2015) point out that the literature on the topic is not yet solid enough to explain specifically how gamified elements work in education and we need to know more about how gamified elements interact with learner characteristics.

### ***Video gaming to support learning***

Evidence suggests that video games may be educationally valuable, provided that other key factors are met. The most important element is an adequate pedagogical integration of the game into the instructional context (Arnab et al., 2012). The game play must help students to achieve the learning objectives (Young et al., 2012). Likewise, the teacher plays a fundamental role in helping to exploit the potential benefits of the gaming experience. Additional structured activities developed before, during and after the game may help: presenting the objectives and contents before playing; mediating and assisting learners during the game play when they experience difficulties; fostering post-game discussions and reflections; and promoting transference of learning to other contexts. Collaborative learning can be used in game play, where students share resources and solutions in the pursuit of the game and learning objectives. Likewise, some meta-research suggests that video games can foster better engagement when learners are allowed to play for longer and more adequately spaced sessions (Clark, Tanner-Smith and Killingsworth, 2016; Young et al., 2012).

Many pedagogical approaches seem suitable to lead the use of videogames in schools. For instance, case-based instruction or scientific inquiry-based approaches may make the most of immersive “virtual worlds” (Dede, 2014). Students assume the role of real professionals (e.g., scientists) and explore a natural phenomenon occurring in the virtual environment, gather data, and analyse them in order to answer certain research questions. These digital environments may help students to master abstract principles and skills through exploration and analysis of real-world situations through authentic simulations. Authentic simulations give learners the chance to visualise processes and manipulate representations that would be difficult to replicate in the real world (e.g., the chemical processes involved in the greenhouse effect). Such digital games are typically serious games designed for educational purposes - – or, at least, they are entertaining games that have been augmented to allow learners to work precisely on a particular phenomenon such as an historical, social, natural or physical process, or an artistic movement.

Meta-research on the use of video games nevertheless reveals some potential drawbacks. Video games, especially entertainment video games, usually provide unnecessary contents and procedures for mastering the intended knowledge and skills. While rich narratives and visual complexity might be appealing for young people, meta-research shows that games with no narratives might be more effective than those with an elaborate narrative (Clark, Tanner-Smith and Killingsworth, 2016). Students might be attracted for these reasons, not to the tasks and contents to be learnt. Likewise, the student might be motivated to earn rewards and having fun with other students rather than focusing on the learning. Hence, the use of video games might result in the promotion of extrinsic motivation, as the student ends up being more interested to achieve aspects unconnected to learning itself. An adequate selection of simplified video games could help the student to focus on essential learning elements. Likewise, the teacher may play an important role in highlighting the importance of the learning objectives and focusing the student’s attention on those aspects.

When the game involves complex rules and procedures, the learner may also allocate significant cognitive resources to playing the game, at the expense of reasoning and understanding contents (Jabbar and Felicia, 2015; Young et al., 2012). While video games can engage students, when there is a mismatch to their abilities and they are perceived as too difficult, they may cause frustration. Games need simple mechanics and narratives to ensure that the learner can engage. Pedagogies that embrace video games have to ensure adequate learner support and feedback during the gaming experience to reinforce persistence in the learning task. Student’s own knowledge, expectations, and skills should be taken into account in the instructional design to facilitate correspondence between the student’s learning capacity and the gaming experience. Video games that are highly adaptable to different learner profiles are likely to prevent mismatches.

**Table 4: Pedagogical implications of gaming environments**

| Advantages  |  | Challenges  |  |
|---|--|---|--|
| Gaming can yield positive learning outcomes   | Gaming can promote authentic learning  | Gaming can promote extrinsic motivation   | Gaming can cause overload and frustration  |
| What pedagogy can do  |  |   |  |
| * Pedagogies ensure sound integration of video games into the instructional context<br>* Pedagogies promote complementary structured activities to maximise the gaming experience | * Pedagogies ensure exploration and manipulation of realistic scenarios<br>* Designers and practitioners ensure access to high quality digital games | * Practitioners focus students' attention on essential elements of learning<br>* Pedagogies rely on simpler video games | * Pedagogies provide useful feedback to the learner<br>* Pedagogies match the learner profile with the gaming experience |

## Collaboration and social activities

### *Research on social, collaborative activities and Web 2.0 tools*

Young learners are often assigned the tendency of needing to maintain constant connectivity with peers - communicating, texting each other, and sharing information. This image is grounded in the pervasive teenage use of social media, the popularity of social networking sites, and the omnipresence of mobile devices. 89% of young learners across the OECD countries use social networking sites, ranging from 53% in Mexico to 97% in Iceland (OECD, 2016b). A more particular related suggested tendency is their preference to do school work through social contact and collaboration. The evidence for this, however, is not robust. Some studies have identified a preference by some for collaborative settings and technology rich-environments (e.g., Bekebrede, Warmelink and Mayer, 2011), but so much depends on cultural environment, personal characteristics, and the specificities of the learning activities in question.

This new learning tendency is associated with “Web 2.0” tools. The evolution of the Internet is commonly defined by three consecutive stages (Berners-Lee, Hendler and Lassila, 2001; Raffl et al., 2008):

- Web 1.0 was when information was presented in a way that allowed the user to navigate and consume it – the ‘read-only’ web.
- Web 2.0 (O’Reilly, 2005), is commonly framed as a communication web, or “read-write web”, allowing the person also to *produce and share* information with others through applications like blogs, wikis, podcasts, virtual worlds or social networking sites (Harris and Rea, 2009; Naik and Shivalingaiah, 2008).
- Web 3.0 is foreseen as the next phase, defined by concepts such as the “semantic web”, where the web will “understand” the users and adapt to them.

Hew and Cheung (2013) review 27 studies where secondary education students use Web 2.0 tools such as podcasts, wikis, blogs, virtual worlds, or social networks like Twitter. The authors conclude that the evidence is still weak and cannot determine causal relationships between the use of such tools and student achievement gains. However, they see the use of web 2.0 tools to be usually associated with a positive

impact on students' outcomes. Again, the key is not the use of the technologies themselves but how they are integrated within the educational activity and support the learning process. This happens as, for instance, podcasts provide the students with supplementary or more comprehensive learning contents, when blogs provide relevant scaffolding, or when Twitter gives a platform for productive conversation between students and teachers.

The use of social media in schools is still a relatively new phenomenon. An understanding of how these technologies can be utilised in the educational field is still lacking, with few conclusions about their impact on students' learning to be drawn to date (Blazer, 2012; Kidd, Carpenter and Stephen, 2014; Manca and Ranieri, 2013).

### ***Harnessing Web 2.0 tools for collaborative learning***

How can we take advantage of the enthusiasm of learners to use technology for communicating and sharing with peers, in order to promote social and collaborative learning? Collaborative learning has been shown to be effective for increasing student outcomes (Kyndt et al., 2013; Slavin, 2010). It can be supported by technological environments that adapt their functional characteristics to learner needs. Such responses include using artificial intelligence, by providing tailored support during the problem-solving process, and Web 2.0 techniques to enable students to produce artefacts and share them online. A meta-analysis of these types of "adaptive environments" concludes that they can support content knowledge and collaboration skills acquisition (Magnisalis, Demetriadis and Karakostas, 2011).

Although evidence is still not extensive, research to date suggests that for Web 2.0 tools to be effective in schools, certain fundamental pedagogical aspects need to be present. It is not so much about integrating Web 2.0 tools in the classroom, but about implementing the underpinning *principles of Web 2.0 activities*, namely, students:

- being authors and agents of their own learning;
- deciding the course of their own projects according to their interests;
- interacting and collaborating;
- making and sharing their own materials;
- engaging each other and exchanging constructive feedback.

It is the "Web 2.0 pedagogy" that is important, with blogs, podcasts, social networking sites and virtual worlds as tools to realise this approach.

Such pedagogical approaches demand that teachers adopt a mentor role and foster competence for self-regulated learning. Teachers as mentors should be compatible with the (pro-) active and collaborative role of learners. One such approach is teacher "orchestration" (Dillenbourg and Jermann, 2010; Hämäläinen and Vähäsantanen, 2011): learners are assisted and guided by their teachers when they "orchestrate" the social and collaborative activity. The orchestration metaphor highlights that it is the students who "play the music" of learning. The teacher orchestrates the learning process, finding a balance between structuration (scripting activities and giving routines), and improvisation in collaborative processes (allowing students to take their own course of action). Orchestration is based on three main ingredients:

- Bringing about task structuration through providing sound educational design and guidelines for developing the learning activity;
- Promoting students' interaction, such as through fostering collaboration showing routines, scripts and giving assistance;
- Providing resources, whether external resources, such as books and technological devices, or activating internal resources such as students' prior knowledge and interests.

When Web 2.0 tools are implemented under traditional pedagogical approaches, tensions and issues arise: “educational practice does not seem to be easily bringing these elements into an expected alignment” (Crook, 2012: 64). For instance, transmission based on the teacher providing all the contents is ill-matched to a technological environment full of information and multiple voices. Students need to deal with informational complexity and uncertainty, and gain competences in searching and analysing information. Pedagogical approaches that relegate the student to a passive role or to automatise routines, are not the most promising avenues for promoting the construction of personal artefacts and collaboration in solving complex problems. Neither is the omnipresent use of texts in schools which does not suit the receptivity of young people to the multimedia information embedded in Web 2.0 tools. And, the traditional school conception of individual and sole authorship does not suit the practices characterised by producing, mixing, re-mixing, and sharing materials.

If pedagogies want to make the most of collaborative and social activities that use Web 2.0 tools they have to face a common problem, namely student distraction when they encounter unrelated contents, when they socialise otherwise than for learning purposes, and when they face disruption (Blazer, 2012). Working in “real” open technological environments like social networking sites can bring distraction. Those environments blur boundaries between contexts, and the learner is likely to come across content and others from outside the school network. Students need the abilities to self-regulate their learning process and to keep focused. Teachers would do well to monitor their student’s learning and work with students in advance to prevent and avoid distraction.

Addressing those downsides requires time and energy but the benefits of exploiting collaborative and participatory settings with popular technologies may be considerable. Using daily tools for learners to support collaborative learning might help the student, not only to improve their teamwork competences, but also to learn new and more productive ways of using those tools for collaboration. Young learners might be experts in using Web 2.0 technologies like social media for socialising, but their use for formal collaboration and learning is less common. Using technologies for networking outside the school and extending learning beyond the classroom walls is key for becoming life-long learners.

**Table 5: Pedagogical implications of collaborative and Web 2.0 environments**

| Advantages  |  | Challenges  |  |
|---|--|---|--|
| Web 2.0 tools need to be implemented through adequate pedagogies  | Common Web 2.0 tools can be harnessed to improve collaboration competences   | Web 2.0 tools used with traditional pedagogies gives rise to issues and tensions  | Web 2.0 tools can cause distraction  |
| What pedagogy can do  |  |   |  |
| * Implement the “Web 2.0 principles”<br>* Practitioners adopt a mentor role and support self-regulated learning (e.g., orchestration) | * Pedagogies use “real” tools to show new venues and ways of collaboration<br>* Learning goes outside the classroom and students gain competences for life-long learning | * Avoid transmission approaches and the automatization of routines<br>* Avoid the omnipresence of text and traditional conception of authorship | * Practitioners promote abilities to self-regulate the learning activity and stay on task<br>* Practitioners and students work together to prevent and avoid common distractions |

## Conclusions

Pedagogical innovation should be sensitive to context. Students' learning inclinations should not be left out of the classroom; they should be naturally incorporated as part of the classroom context if we judge that they have potential to support learning improvement. In this chapter we have seen that new learning tendencies and priorities offer potential leverage to teaching innovation.

Practitioners and policy makers need more and clearer data about the profile of young learners and their tendencies. Macro data generated by central and regional governments, and by external research, can help sharpen a clearer picture of what those learning tendencies are, and to what extent they apply to local learners. Local authorities and schools can complement this by generating more detailed learner profiles and learning histories, assuming appropriate privacy safeguards.

Five broad trends and features have been identified and reviewed: the use of technologies; multimedia materials; multi-tasking and non-linear and interactive environments; games; and collaborative activities using Web 2.0 tools. The review shows that all hold positive possibilities but also disadvantages for learning - their encouragement in schools will not automatically lead to better learning outcomes. The key to making the most of these trends while minimising the pitfalls is the pedagogical practices of teachers with deep integration into the instructional context.

There is still only a limited number of relevant studies. The meta-analyses that exist support an optimistic view of the use of computers and other technologies in the classroom, the utilisation of multimedia materials, video gaming, and collaborative activities. Those studies also usually conclude that outcomes improvement effects tend to be small, and they conclude negatively about multi-tasking. Therefore, innovation can seek to incorporate the main trends and directions while mindful of the drawbacks of multi-tasking.

Since the pedagogical approach is key for exploiting the characteristics of new learning trends, policies should focus especially on teacher learning and practices. Professional learning should look to enhance teachers' technological *pedagogical* content knowledge (Harris, Mishra and Koehler, 2009), as well as empower them to generate educational innovation. The goal is not to learn how to run technological devices in the classroom, but to design and implement suitable *pedagogies* that use technology to better meet student needs. Encouraging and supporting professional learning where practitioners form learning communities and share materials and best practices is pivotal. Investing resources in technology is not enough, if teachers do not have the competence to use them in a pedagogically sound fashion; otherwise, the extensive use of technology in the classroom can even have detrimental consequences (OECD, 2015a).

The goal should be to design and implement innovative and powerful school pedagogies that match new learning priorities and interests. If schools do not meet young learners "halfway", students will feel that their expectations and preferences are being ignored, causing disengagement and detachment.

Leveraging new learning trends can activate educational areas associated with innovative learning eco-systems (OECD, 2015c):

- *Promoting high levels of learners' motivation and engagement* through pedagogies that match the needs and interests of young learners. Pedagogies foster motivation *through* technology, not to technology, and should avoid extrinsic motivations to persist on task.

- *Promoting learner agency and voice*, with pedagogies revolving around learners' priorities and needs. Teachers will often adopt a mentoring role with pedagogies promoting self-regulation of young people's own learning and minimising distraction.

- *Using mixed, personalised pedagogical practices* in order to make the most of the positive features of the new learning trends. Adjusting teaching to the learner's needs and interests is a strategy that enables personalisation; it does so at two different levels: identifying learning tendencies on a macro level (e.g., at a national or regional level), and on a micro level (e.g., individual tendencies that might differ from student to student in a classroom).
  
- *Encouraging the development of curriculum and new learning materials*, creating and using video games, multimedia and highly interactive environments. These materials are carefully designed and embedded in sound instructional approaches, with students able to exploit them across many learning activities with the support of teachers and peers.
  
- *Using digital applications and social media*: pedagogies pursue the use of new digital applications and tools to encourage social and collaborative learning. Students are introduced to new avenues for collaboration, and learn new ways of using popular technologies for pedagogical purposes. Learners construct social networks that embed the formal and the informal, and gain competence for lifelong learning.



## REFERENCES

- Arnab, S. et al. (2012), "Framing the adoption of serious games in formal education", *Electronic Journal of e-Learning*, Vol. 10/2, pp. 159-171.
- Bekebrede, G., H.J.G. Warmelink and I.S. Mayer (2011), "Reviewing the need for gaming in education to accommodate the net generation", *Computers & Education*, Vol. 57/2, pp. 1521-1529.
- Bennett, S. and Maton, K. (2010), "Beyond the 'digital natives' debate: Towards a more nuanced understanding of students' technology experiences", *Journal of Computer Assisted Learning*, Vol. 26/5, pp. 321-331.
- Berners-Lee, T., J. Hendler and O. Lassila (2001), "The semantic web", *Scientific American*, Vol. 284/5, pp. 28-37.
- Berney, S. and Bétrancourt, M. (2016), "Does animation enhance learning? A meta-analysis", *Computers & Education*, Vol. 101, pp. 150-167.
- Blazer, C. (2012), *Social Networking in Schools: Benefits and Risks; Review of the Research; Policy Considerations; and Current Practices*, Information Capsule, Volume 1109, Research Services, Miami-Dade County Public Schools.
- Burnett, C. (2010), "Technology and literacy in early childhood educational settings: A review of research", *Journal of Early Childhood Literacy*, Vol. 10/3, pp. 247-270.
- Bus, A.G., Z.K. Takacs and C.A.T. Kegel (2015), "Affordances and limitations of electronic storybooks for young children's emergent literacy", *Developmental Review*, Vol. 35, pp. 79-97.
- Cabra, F. and G.P. Marciales (2009), "Mitos, realidades y preguntas de investigación sobre los 'nativos digitales': Una revisión" [Myths, realities and research questions about the 'digital natives'], *Universitas Psychologica*, Vol. 8/2, pp. 323-338.
- Cardoso-Leite, P., C.S. Green and D. Bavelier (2015), "On the impact of new technologies on multi-tasking", *Developmental Review*, Vol. 35, pp. 98-112.
- Carrier, L.M. et al. (2015), "Causes, effects, and practicalities of everyday multi-tasking", *Developmental Review*, Vol. 35, pp. 64-78.
- Carr, N. (2010), *The Shallows: What the Internet is Doing to our Brains*, W.W. Norton and Company, New York.
- Cheung, A.C. and R.E. Slavin (2012), "How features of educational technology applications affect student reading outcomes: A meta-analysis", *Educational Research Review*, Vol. 7/3, pp. 198-215.
- Clark, D.B., E.E. Tanner-Smith and S.S. Killingsworth (2016), "Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis", *Review of Educational Research*, Vol. 86/1, pp. 79-122.
- Connolly, T.M. et al. (2012), "A systematic literature review of empirical evidence on computer games and serious games", *Computers & Education*, Vol. 59/2, pp. 661-686.
- Courage, M.L. (2015), "Translational science and multi-tasking: Lessons from the lab for the everyday world", *Developmental Review*, Vol. 35, pp. 1-4.
- Courage, M.L. et al. (2015), "Growing up multi-tasking: The costs and benefits for cognitive development", *Developmental Review*, Vol. 35, pp. 5-41.
- Courage, M.L. and M.L. Howe (2010), "To watch or not to watch: Infants and toddlers in a brave new electronic world", *Developmental Review*, Vol. 30/2, pp. 101-115.
- Crook, C. (2012), "The 'digital native' in context: Tensions associated with importing Web 2.0 practices into the school setting", *Oxford Review of Education*, Vol. 38/1, pp. 63-80.
- Dede, C. (2014), *The Role of Digital Technologies in Deeper Learning*, Students at the Center: Deeper Learning Research Series, Jobs for the Future, Boston, MA.
- Dillenbourg, P. and P. Jermann (2010), "Technology for classroom orchestration", in M.S. Khine and I.M. Saleh (eds.), *New Science of Learning: Cognition, Computers and Collaboration in Education*, Springer, New York.

- Domínguez, A. et al. (2013), “Gamifying learning experiences: Practical implications and outcomes”, *Computers & Education*, Vol. 63, pp. 380-392.
- Dumont, H., D. Istance and F. Benavides (eds.) (2010), *The Nature of Learning: Using Research to Inspire Practice*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264086487-en>
- Eitel, A. and K. Scheiter (2015), “Picture or text first? Explaining sequence effects when learning with pictures and text”, *Educational Psychology Review*, Vol. 27/1, pp. 153-180.
- Faiella, F. and M. Ricciardi (2015), “Gamification and learning: A review of issues and research”, *Journal of e-Learning and Knowledge Society*, Vol. 11/3, pp. 13-21.
- Fleischer, H. (2012), “What is our current understanding of one-to-one computer projects: A systematic narrative research review”, *Educational Research Review*, Vol. 7/2, pp. 107-122.
- Gerard, L. et al. (2015), “Automated, adaptive guidance for K-12 education”, *Educational Research Review*, Vol. 15, pp. 41-58.
- Gu, X., Y. Zhu and X. Guo (2013), “Meeting the ‘Digital Natives’: Understanding the acceptance of technology in classrooms”, *Journal of Educational Technology and Society*, Vol. 16/1, pp. 392-402.
- Hainey, T. et al. (2016), A systematic literature review of games-based learning empirical evidence in primary education, *Computers & Education*, Vol. 102, pp. 202-223.
- Hämäläinen, R. and K. Vähäsantanen (2011), “Theoretical and pedagogical perspectives on orchestrating creativity and collaborative learning”, *Educational Research Review*, Vol. 6/3, pp. 169-184.
- Hamari, J., J. Koivisto and H. Sarsa (2014), “Does gamification work? – A literature review of empirical studies on gamification”, In *Proceedings of the 47th Hawaii international conference on system sciences*, 6–9 January 2014, Hawaii, USA.
- Harris, J., P. Mishra and M. Koehler (2009), “Teachers’ technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration reframed”, *Journal of Research on Technology in Education*, Vol. 41/4, pp. 393-416.
- Harris, A.L. and A. Rea (2009), “Web 2.0 and virtual world technologies: A growing impact on IS education”, *Journal of Information Systems Education*, Vol. 20/2, pp. 137-144.
- Helsper, E.J. and R. Eynon (2010), “Digital natives: Where is the evidence?”, *British Educational Research Journal*, Vol. 36/3, pp. 503–520.
- Hew, K.F. and W.S. Cheung (2013), “Use of Web 2.0 technologies in K-12 and higher education: The search for evidence-based practice”, *Educational Research Review*, Vol. 9, pp. 47-64.
- Howe, N. and W. Strauss (2000), *Millennials rising: The next great generation*, Vintage Books, New York.
- Jabbar, A.I.A. and P. Felicia (2015), “Gameplay Engagement and Learning in Game-Based Learning: A Systematic Review”, *Review of Educational Research*, Vol. 85/4, pp. 740-779.
- Kalyuga, S. (2012), “Instructional benefits of spoken words: A review of cognitive load factors”, *Educational Research Review*, Vol. 7/2, pp. 145-159.
- Kennedy, G. et al. (2010), “Beyond natives and immigrants: Exploring types of net generation students”, *Journal of Computer Assisted Learning*, Vol. 26, pp. 332–343.
- Kidd, T.T., I.I. Carpenter and B. Stephen (2014), “Rethinking Educational Spaces: A Review of Literature on Urban Youth and Social Media”, *Journal of Educational Multimedia and Hypermedia*, Vol. 23/2, pp. 189-208.
- Kirschner, P.A. and J.J. van Merriënboer (2013), “Do learners really know best? Urban legends in education”, *Educational Psychologist*, 48(3), 169-183.
- Kolodner, J.L. et al. (1998), “Learning by Design from Theory to Practice”, *Proceedings Third International Conference of the Learning Sciences*, [www.cc.gatech.edu/projects/lbd/htmlpubs/lbdtheorytoprac.html](http://www.cc.gatech.edu/projects/lbd/htmlpubs/lbdtheorytoprac.html) (accessed 9 October 2016).
- Kori, K. et al. (2014), “Supporting reflection in technology-enhanced learning”, *Educational Research Review*, Vol. 11, pp. 45-55.
- Kraut, R. (2013), *Policy Guidelines for Mobile Learning*, UNESCO Publications, Paris.

- Kulik, J.A. and J.D. Fletcher (2016), Effectiveness of Intelligent Tutoring Systems: A Meta-Analytic Review, *Review of Educational Research*, Vol. 86/1, pp. 42-78.
- Kyndt, E. et al. (2013), “A meta-analysis of the effects of face-to-face cooperative learning. Do recent studies falsify or verify earlier findings?”, *Educational Research Review*, Vol. 10, pp. 133-149.
- Lenhart, A. et al. (2015), *Teens, Technology and Friendships*, Pew Research Center, <http://www.pewinternet.org/2015/08/06/teens-technology-and-friendships/> (accessed 9 October 2016).
- Li, Y. and M. Ranieri (2010), “Are ‘digital natives’ really digitally competent?—A study on Chinese teenagers”, *British Journal of Educational Technology*, Vol. 41/6, pp. 1029-1042.
- Magnisalis, I., S. Demetriadis and A. Karakostas (2011), “Adaptive and intelligent systems for collaborative learning support: A review of the field”, *Learning Technologies, IEEE Transactions on*, Vol. 4/1, pp. 5-20.
- Manca, S. and M. Ranieri (2013), “Is it a tool suitable for learning? A critical review of the literature on Facebook as a technology-enhanced learning environment”, *Journal of Computer-Assisted Learning*, Vol. 29/6, pp. 487-504.
- Margaryan, A., A. Littlejohn and G. Vojt (2011), “Are digital natives a myth or reality? University students’ use of digital technologies”, *Computers & Education*, Vol. 56/2, pp. 429-440.
- Martinez, S.L. and G. Stager (2013), *Invent to Learn: Making, Tinkering and Engineering in the Classroom*, Constructing Modern Knowledge Press, Torrance, CA.
- McFarlane, A., J.M. Williams and M. Bonnett (2000), “Assessment and multimedia authoring - A tool for externalising understanding”, *Journal of Computer Assisted Learning*, Vol. 16, pp. 201-212.
- Mills, K.A. (2010), “A review of the ‘digital turn’ in the new literacy studies”, *Review of Educational Research*, Vol. 80/2, pp. 246-271.
- Mayer, R.E. and R. Moreno (2002), “Animation as an aid to multimedia learning”, *Educational Psychology Review*, Vol. 14/1, pp. 87-99.
- Moreno, R. and R. Mayer (2007), “Interactive multimodal learning environments. Special issue on interactive learning environments: Contemporary issues and trends”, *Educational Psychology Review*, Vol. 19, pp. 309-326.
- Naik U. and D. Shivalingaiah (2008), “Comparative study of Web 1.0, Web 2.0 and Web 3.0”, In *Proceedings of the International Convention on Automation of Libraries in Education and Research Institutions*, 28 February–1 March 2008, Caliber, Allahabad, India.
- Nesbit, J.C. and O.O. Adesope (2006), “Learning with concept and knowledge maps: A meta-analysis”, *Review of Educational Research*, Vol. 76/3, pp. 413-448.
- OECD (2016a), *Trends Shaping Education 2016*, OECD Publishing, Paris. [http://dx.doi.org/10.1787/trends\\_edu-2016-en](http://dx.doi.org/10.1787/trends_edu-2016-en)
- OECD (2016b), *Society at a Glance 2016: OECD Social Indicators*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264261488-en>
- OECD (2015a), *Students, Computers and Learning: Making the Connection*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264239555-en>
- OECD (2015b), *OECD Digital Economy Outlook 2015*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264232440-en>
- OECD (2015c), *Schooling Redesigned: Towards Innovative Learning Systems*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264245914-en>
- OECD (2013), *Trends Shaping Education 2013*, OECD Publishing, Paris. [http://dx.doi.org/10.1787/trends\\_edu-2013-en](http://dx.doi.org/10.1787/trends_edu-2013-en)
- OECD (2012), *Connected Minds: Technology and Today's Learners*, OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264111011-en>
- O’Reilly, T. (2005), *What is Web 2.0?* <http://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html> (accessed 9 October 2016).
- Papert, S. (1993), *Mindstorms: Children, Computers, and Powerful Ideas*, Basic Books, New York, NY.
- Prensky, M. (2001), Digital Natives, Digital Immigrants, *On the Horizon*, Vol. 9/5, pp. 1-12.

- Raffl, C. et al. (2008), "The web as techno-social system. The emergence of web 3.0", In R. Trappl (ed.), *Cybernetics and Systems*, Austrian Society for Cybernetic Studies, Vienna.
- Richter, J., K. Scheiter and A. Eitel (2016), "Signaling text-picture relations in multimedia learning: A comprehensive meta-analysis", *Educational Research Review*, Vol. 17, pp. 19-36.
- Rosen, L.D., L.M. Carrier and N.A. Cheever (2010), *Rewired: Understanding the iGeneration and the Way they Learn*, Palgrave Macmillan, NY.
- Rothbart, M.K. and M.I. Posner (2015), "The developing brain in a multi-tasking world", *Developmental Review*, Vol. 35, pp. 42-63.
- Ryan, R.M. and E.L. Deci (2000), "Intrinsic and extrinsic motivations: Classic definitions and new directions", *Contemporary Educational Psychology*, Vol. 25, pp. 54-67.
- Scheiter, K. and P. Gerjets (2007), "Learner control in hypermedia environments", *Educational Psychology Review*, Vol. 19/3, pp. 285-307.
- Schüler, A., K. Scheiter and E. van Genuchten (2011), "The role of working memory in multimedia instruction: Is working memory working during learning from text and pictures?", *Educational Psychology Review*, Vol. 23/3, pp. 389-411.
- Schweppe, J. and R. Rummer (2014), "Attention, working memory, and long-term memory in multimedia learning: An integrated perspective based on process models of working memory", *Educational Psychology Review*, Vol. 26/2, pp. 285-306.
- Sharples, M. et al. (2014), *Innovative Pedagogy 2014: Open University Innovation Report 3*, The Open University, Milton Keynes.
- Sitzmann, T. (2011), "A meta-analytic examination of the instructional effectiveness of computer-based simulation games", *Personnel Psychology*, Vol. 64, pp. 489-528.
- Slavin, R.E. (2010), "Co-operative learning: What makes group-work work?", In H. Dumont, D. Istance and F. Benavides (eds.) (2010), *The Nature of Learning: Using Research to Inspire Practice*. OECD Publishing, Paris. <http://dx.doi.org/10.1787/9789264086487-9-en>
- Small, G.W. et al. (2009), "Your brain on Google: Patterns of cerebral activation during internet searching", *The American Journal of Geriatric Psychiatry*, Vol. 17/2, pp. 116-126.
- Sung, Y.T., K.E. Chang and T.C. Liu (2016), "The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis", *Computers & Education*, Vol. 94, pp. 252-275.
- Takacs, Z.K., E.K. Swart and A.G. Bus (2015), "Benefits and pitfalls of multimedia and interactive features in technology-enhanced storybooks- A meta-analysis", *Review of Educational Research*, Vol. 85/4, pp. 698-739.
- Tamim, R.M. et al. (2011), "What forty years of research says about the impact of technology on learning a second-order: Meta-analysis and validation study", *Review of Educational Research*, Vol. 81/1, pp. 4-28.
- Tapscott, D. (2009), *Grown up digital: How the net generation is changing your world*, McGraw-Hill, New York.
- Thomas, A. (2012), "Children's writing goes 3D: A case study of one primary school's journey into multimodal authoring", *Learning, Media and Technology*, Vol. 37/1, pp. 77-93.
- Thompson, P. (2013), "The digital natives as learners: Technology use patterns and approaches to learning", *Computers & Education*, Vol. 65, pp. 12-33.
- van den Beemt, A., S. Akkerman and R.J. Simons (2011), "Considering young people's motives for interactive media use", *Educational Research Review*, Vol. 6/1, pp. 55-66.
- van den Broek, G. (2012), "Innovative Research-Based Approaches to Learning and Teaching", *OECD Education Working Papers*, No. 79, OECD Publishing, Paris. <http://dx.doi.org/10.1787/5k97f6x1kn0w-en>
- Van der Kleij, F.M., R.C. Feskens and T.J. Eggen (2015), "Effects of feedback in a computer-based learning environment on students' learning outcomes- A meta-analysis", *Review of Educational Research*, Vol. 85/4, pp. 475-511.

- Wang, S.K. et al. (2014), “An investigation of middle school science teachers and students use of technology inside and outside of classrooms: Considering whether digital natives are more technology savvy than their teachers”, *Educational Technology Research and Development*, Vol. 62/6, pp. 637-662.
- Wartella, E., R.A. Richert and M.B. Robb (2010), “Babies, television and videos: How did we get here?”, *Developmental Review*, Vol. 30/2, pp. 116-127.
- Wouters, P., H.K. Tabbers and F. Paas (2007), “Interactivity in video-based models”, *Educational Psychology Review*, Vol. 19/3, pp. 327-342.
- Wouters, P. et al. (2013), “A meta-analysis of the cognitive and motivational effects of serious games”, *Journal of Educational Psychology*, Vol. 105, pp. 249–265.
- Young, M.F. et al. (2012), “Our princess is in another castle: A review of trends in serious gaming for education”, *Review of Educational Research*, Vol. 82/1, pp. 61-89.
- Yuen, T. and M. Liu (2011), “A cognitive model of how interactive multimedia authoring facilitates conceptual understanding of object-oriented programming in novices”, *Journal of Interactive Learning Research*, Vol. 22/3, pp. 329-356.
- Zheng, B. et al. (2016), “Learning in one-to-one laptop environments. A meta-analysis and research synthesis”, *Review of Educational Research*, doi: 10.3102/0034654316628645.