International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

IB research paper

Approaches to learning: Literature review

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Executive summary

Introduction

The International Baccalaureate's (IB) major objectives are "to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect" and "to encourage students to become active, compassionate and lifelong learners" (IB 2008). To align with these goals, it is essential to implement student-centred and constructivist learning approaches supporting "whole-person" development.

Over the last decade, there has been a rapid growth in the number of schools offering the IB's four programmes throughout the world (Hallinger, Lee and Walker 2011). The four IB programmes—the Primary Years Programme (PYP, 3–12 years), the Middle Years Programme (MYP, 11–16 years) and the Diploma Programme (DP) and Career-related Certificate (IBCC) (16–19 years)—were established at different times without much inter-programme linkage. The DP was first established in the 1960s, the PYP and the MYP were established in the 1990s, and the IBCC was introduced in 2011. It should be noted that because the IB has only just introduced the IBCC, it is not discussed in this paper. The three traditional programmes (PYP, MYP and DP) have different structures and are self-contained, which makes it difficult to make a smooth transition across programmes (Bunnell 2011). For a "continuum of international education", the question of how to design aligned curriculum, pedagogy and assessment across different developmental stages needs to be answered. Cross-cultural differences are another important issue to be addressed in implementing various student-centred learning approaches, as well as in the programme transition.

Based on these important issues for the development of the IB, four research questions are delineated and discussed in this literature review. This literature review includes four major parts, and each addresses one research question (RQ).

RQ1: How are "approaches to learning" related theories and practices perceived and outlined in the curriculum of various national and international educational systems? What are their commonalities in terms of goals, objectives, components and other considerations?

RQ2: How are these perspectives unpacked and implemented in practice, for example, integration with the school-based curriculum, pedagogical strategies and inclusion in teacher training?

RQ3: How is the issue of age-appropriateness addressed, that is, how are connections between metacognitive, cognitive, affective and sociocultural development of children and young adults and these learning approaches and skills specified?

RQ4: What are the implications for the development of the IB's programmes to ensure the transition between and across different stages of learning?

Method

This is a literature review project focusing on "approaches to learning" related theories and their implementation at the school and classroom levels. To answer the four research questions, an extensive search and review of the existing relevant literature was conducted.

The sources reviewed in this paper come from four major sources: (1) academic books from the library of Teachers College, Columbia University; (2) peer-reviewed journal articles from digital databases including PsycInfo, Web of Science, Eric, and Google scholar; (3) government curriculum guidelines and documents online; (4) other online electronic resources.

Some of the sources were obtained through the snowballing method by checking the references lists of the existing sources.

Overview of this literature review

In section 1, common educational objectives across national and international educational systems are reviewed. A balanced emphasis on knowledge and higher-order thinking skills can be found in the curriculum guidelines of various educational systems. Critical-thinking, creative-thinking, metacognitive and self-regulation, social and affective skills are briefly discussed in section 1.1. Constructivist and student-centred approaches are very important to achieving these educational objectives; thus section 1.2 briefly discusses some basic concepts of constructivism and student-centred learning approaches, and how technology has introduced new opportunities for implementing constructivist and student-centred approaches.

A variety of constructivist and student-centred learning approaches can be implemented at the classroom level and school level. Inquiry-based learning is an important constructivist approach, allowing knowledge construction via asking questions. Inquiry-based learning needs to be well structured and scaffolded, and inquiry cycles can be effectively applied in various educational settings. Problem-based learning refers to students working in small groups to solve authentic problems, in which inquiry strategies are usually involved. Constructivist approaches assume that learning is situated in context; the situated and embodied cognition model is discussed in section 2.1.3 as an important constructivist learning approach. These learning approaches are not mutually exclusive; classroom level practices may involve a variety of learning approaches for specific learning goals. Developing students' metacognitive ability and learning skills is an important learning objective, and section 2.1.4 discusses how to practise self-regulated learning skills at the classroom level. Although these constructivist and student-centred learning approaches are emphasized in the IB's programmes, many issues such as "how to provide the proper level of scaffolding in inquiry-based learning" and "how to integrate content and skills learning well" still require further exploration. The cognitive apprenticeship model provides practical strategies regarding instructional scaffolding (see section 2.1.5). Collaborative learning (see section 2.1.6) could facilitate knowledge construction in many contexts, but its effective implementation depends on many factors such as students' prior knowledge and age-related characteristics such as social cognitive ability. In designing collaborative learning, these factors need to be addressed. Section 2.1.7 discusses the distinctions between an integrative approach and an interdisciplinary approach in curriculum design, which aligns with the distinction between the transdisciplinary approach in the PYP and the interdisciplinary approach in the MYP. Affective and sociocultual perspectives are also important aspects in the constructivist learning models (see section 2.2). Topics such as students' motivation and teacher–student relationship are covered. Section 2.3 focuses on "assessment". The notion of "assessment for learning" suggests that assessment, in addition to its traditional function of measurement and selection, should also direct future learning and teaching. Under this notion, it is essential to delineate clear assessment criteria and implement differentiated assessment strategies. Some practical forms of assessment are described in section 2.3.2. Many challenges and issues lie in the implementation of various constructivist and student-centred learning approaches; sections 2.4 and 2.5 discuss some of the challenges and possible solutions.

As discussed in section 2, many factors interact to determine the effectiveness of a specific curriculum, instructional or assessment approach, such as age-related constraints and sociocultual characteristics. These factors need to be addressed in developing curriculum, instruction and assessment. Developmental theories such as Piaget's and Vygotsky's provide us with a framework to describe age-related characteristics such as students' cognitive, metacognitive, social-cognitive and affective development. These theories have shaped primary and secondary education in a significant way. Section 3.1 is a review of these developmental theories and 3.2 their implications for designing developmentally appropriate curriculum, instruction and assessment. Many examples of developmentally appropriate curriculum, instruction and assessment are described. For example, a recommended curriculum can be readjusted and redeveloped to adapt to a specific age group; abstract concepts need to be grounded in concrete contexts especially at the elementary level; students at the middle school level need to be guided to correctly and realistically evaluate their own work; coherent and consistent assessment criteria need to be aligned across grade levels, and so on. Additionally, some important issues such as "the role of content knowledge at lower grade levels" and "the importance of facilitating identity formation in new contexts" are addressed in section 3.2, which might provide implications for the IB's programmes. Cross-cultural differences are also addressed throughout section 3.

Although the IB programmes are coherent and consistent in their educational philosophy and major educational objectives, many challenges exist in the smooth transition across the programmes. Section 4.1 summarizes some major challenges in the programme transition: first, the different structures and curricular approaches in the programmes; second, some misconceptions on the relationship between content knowledge and skills; and third, cross-cultural differences in transitional challenges. Section 4.2 draws upon the implications from the review in sections 2 and 3, and discusses how to improve the curriculum component of the three IB programme frameworks and facilitate programme transition. This sub-section focuses on four aspects: curriculum, pedagogy, assessment alignment and special transitional programmes.

The limitations of this literature review and some future research questions are discussed in section 5.

1. "Approaches to learning" related theories

The trend of moving away from a knowledge-based, examination-driven system to a student-centred, performance-driven system is widely emphasized across cultures, although it may be at different stages in different contexts due to historical and cultural reasons. For example, the United States (US) has a hybrid of examination-driven and performance-driven culture, Canada generally has a performance-driven culture, and Asia predominantly has an examination-driven culture in their educational systems (Hudson 2009). It has been recognized that knowledge, skills and understanding are three essential elements of learning, and the ties among them set guidelines for curriculum designers (Skelton 2002). Important learning abilities and skills (for example, critical thinking, creative thinking, metacognitive ability) have emerged as important educational goals indicated in the curriculum objectives across different educational systems. Constructivist approaches and student-centred approaches are supported by contemporary learning theories. A brief comparison of the educational objectives in the US common core, European framework and Hong Kong curriculum council shows many commonalities and overlap in the educational objectives across the three educational systems (see "Appendix A"). Those educational objectives and standards are demonstrated in the curriculum enactment and pedagogical strategies across different disciplines and also show how those curriculum guidelines are enacted in teaching mathematics, language and science.

1.1. Emerging educational objectives

1.1.1. Multiple intelligence theories

Compared to earlier intelligence theories, contemporary theories of intelligence, such as Gardner's multiple intelligences (MI) theory (1983) and Sternberg's theory (1999), put more emphasis on delineating different intelligence components. Although different theories have different taxonomies, they usually describe human intelligence on cognitive, metacogntive, affective and sociocultual dimensions. Gardner's multiple intelligences theory (Gardner 1983) has had an impact on education around the world. The eight major intelligences (logical-mathematical, linguistic, visual-spatial, bodily-kinesthetic, musical, interpersonal, intrapersonal, naturalist) have been shaping the curriculum, pedagogy and assessment in many ways over the last two decades (Armstrong 2009).

Students are smart in different ways and have different learning approaches; thus, the student-centred approach becomes a necessity to account for different learning styles in the classroom (Hudson 2009). Regarding learners' minds as complex systems with heterogeneous natures helps us better understand the constructivist perspectives of learning, implement a student-centred model of instruction and appreciate differentiated curriculum, instruction and assessment paradigms (Klein 2003). A review of the curriculum guidelines and objectives of a variety of education systems shows the increasing popularity of the multiple intelligences theory. Accounting for individual differences has been integrated into the curriculum, pedagogy and assessment principles of some educational systems (for example, British Columbia's Ministry of Education 2002; Curriculum Development Council 2002; Ministry of Education, Singapore n.d. b.). Compared to the past, abilities and skills aligned with those intelligences, including both traditionally important ones and emerging ones, have been more clearly delineated in the curriculum, pedagogy and assessment. For example, critical-thinking skills, creative-thinking skills, communication skills and metacognitive ability have been emphasized in different content areas at different learning stages in both Western and Asian educational systems (for example, Li 2010).

1.1.2. Critical thinking

Critical thinking is a complex mental process involving paying attention to details, selecting relevant information, analysing carefully and skeptically, making judgments, and metacognitive thinking such as reflection and higher-order planning (Cottrell 2005). It is an essential skill for both academic achievement and for dealing with various real-life problems. Critical thinking, as a generic thinking skill, is emphasized in a variety of content areas of curriculum planning documents across cultures, for example, the US (National Commission of Excellence in Education 1983), Hong Kong (Curriculum Development Council 2007), Singapore (Sale, Leong and Lim 2001), Taiwan and Japan (Li 2010). Critical-thinking curriculums are relatively more difficult to implement in Asian classrooms because the teachers and students are more accustomed to the passive, transmissive, and knowledge-based model of learning; thus, more clear practice guidelines and more

transitional time are needed for Asian learners to practise and acquire this essential skill (Vandermensbrugghe 2004).

1.1.3. Creative-thinking skills

Creative thinking refers to the ability to look at problems and situations in new ways, be able to generate new ideas and provide original, elaborative, and appropriate solutions (Sternberg 1999). Creative-thinking skills, as an essential ability for success, have been emphasized in the curriculum across cultures (for example, Curriculum Development Council 2007; British Columbia's Ministry of Education 2010); likewise, it is more difficult to implement in examination-driven and teacher-centred educational cultures. Instructional and learning models following the constructivist and student-centred approaches are more likely to help learners acquire and practise creative thinking. For example, in an e-learning setting in Malaysian schools (Sultan, Woods and Koo 2011), constructivist environments were found to reinforce creative thinking in addition to the knowledge acquisition.

1.1.4. Metacognitive and self-regulation skills

Metacognition can be considered as the knowledge, awareness and control of one's own thinking and learning processes (Flavell 1977; 1981; Schraw and Moshman 1995). Metacognition contains two components: knowledge of cognition and regulation of cognition (Schraw 1998). The abilities of self-regulation and metacognition are emphasized in the curriculum guidelines in both Western and Asian educational systems (for example, Curriculum Development Council 2007; British Columbia's Ministry of Education 2010).

1.1.5. Affective, social skills

Aligning with the interpersonal, intrapersonal and naturalist intelligences in Gardner's theory (1983), various affective and social skills have become an important educational objective around the world. For example, being "a confident person", "a self-directed learner", "an active contributor" and "a concerned citizen" are listed as the desirable outcomes in the Singapore educational system (Ministry of Education, Singapore n.d. a). Similar curriculum guidelines can also be found across national and international educational systems (for example, Curriculum Development Council 2007; British Columbia's Ministry of Education 2010).

1.2. Major perspectives of learning and instruction

1.2.1. Constructivist perspectives of learning

Constructivism as a learning theory, simply speaking, is to make learning meaningful. The core constructivist perspectives are as follows: (a) learning is a self-directed process—knowledge is constructed rather than directly received; (b) instructor as facilitator; (c) learning as a sociocultual process (Tobin and Tippins 1993). It has long been argued that a constructivist approach is essential for the development of skills and abilities, as discussed in section 1.1. Constructivism is a big concept and a variety of its implementations will be further discussed in section 2.

1.2.2. Student-centred learning and instruction

Some core concepts of student-centred learning and instruction are: (a) creating multiple experiences for knowledge construction; (b) creating authentic and complex sociocultual learning environments to mediate learning (Land and Hannafin 2000). Contemporary learning theories have influenced the design of student-centred learning environments. Practical strategies such as inquiry-based learning, situated learning, project-based learning, self-regulated learning and collaborative learning have been implemented in various settings and continuously tested, which will be further discussed in section 2.

1.2.3. Technology enhanced learning and instruction

Various educational technologies have created tremendous opportunities to create effective student-centred learning environments (Jonnassen 1999). For example, rich perceptual experience can be easily created in a computer-based learning environment for students to construct meanings; the internet brings in rich information that's socially and culturally familiar to the students. An emphasis on designing technology-enhanced learning environments can be seen in the curriculum design guidelines across cultures (for example, Curriculum

Development Council 2007; Ministry of Education, Singapore n.d. b). Jonassen, Carr and Yueh (1998) argue that computers need to be applied to the educational settings as mind tools rather than simple knowledge deliverers. Computers act as the mentor that leads learners into the desirable learning tracks, and improve their learning performance. However, ways to create effective technology-enhanced constructivist learning environments are usually not very well described in curriculum guidelines.

1.3. Summary

Section 1 addressed the first research question: How are "approaches to learning" related theories and practices perceived and outlined in the curriculums of various national and international educational systems? What are their commonalities in terms of goals, objectives, components and other considerations?

In this section, common educational objectives across different educational systems were reviewed. Learning objectives of various national and international education systems usually show a balanced emphasis on various intelligences (section 1.1.1). Meanwhile, there has been a great emphasis on developing students' higher-order thinking skills including critical thinking (section 1.1.2), creative thinking (section 1.1.3), metacognitive and self-regulation skills (section 1.1.4), affective and social skills (section 1.1.5). Constructivist and student-centred approaches are essential in meeting these educational objectives (sections 1.2.1 and 1.2.2), and the emergence of technology has brought tremendous opportunities to create constructivist and student centred instruction (section 1.2.3). Various implementation examples will be further discussed in the next section.

2. Implementation of constructivist and student-centred learning approaches

Various learning models based on the constructivist views and student-centred approaches can be implemented in curriculum design, instruction, formative and summative assessment. In section 2.1, some practical learning models are discussed with a focus on cognitive and metacognitive aspects of development. In section 2.2, the discussion focuses on concerns regarding affective and sociocultual aspects. The notion of "assessment for learning" has been gaining much attention in various national and international educational systems. How to delineate clear assessment criteria and implement differentiated assessment are discussed in section 2.3. Challenges in adopting constructivist and student-centred learning approaches are summarized and discussed in sections 2.4 and 2.5.

2.1. Curriculum, pedagogy and assessment: From cognitive and metacognitive perspectives

2.1.1. Inquiry-based learning

Inquiry-based curriculum assumes students learn to solve real problems by asking questions, analysing problems, conducting investigations, gathering and analysing data, making interpretations, creating explanations and drawing conclusions (Marx et al 2004). Inquiry processes address many thinking and learning skills such as critical thinking, creative thinking, self-regulated learning skills, metacognitive ability and communication skills (Hmelo-Silver, Duncan and Chinn 2007).

A project aligned with the Science Education Reform in the US implemented four inquiry-based science curriculum units among 8,000 middle school students in Chicago over three years (Marx et al 2004). This project is a good example of demonstrating how researchers, curriculum designers, teachers and administrators should collaborate to design and enact inquiry-based curriculums. In that project, the inquiry-based curriculum included driving questions, structuring activities and benchmark lessons to help students practise inquiry skills such as conducting investigation, creating and demonstrating artifacts for students to understand abstract concepts and serving as the basis for discussion, feedback and revision. Technology was infused in the curriculum as a tool to mediate the learning process, for example, using computer visualizations as learning artifacts. Teacher training in that project was a collaborative and constructive process. Teachers were trained in summer institutes over months, going through the cycles: enactment with the new practice→reflection on classroom experience→discussion, collaboration.

Well-structured inquiry-based learning can produce desirable learning outcomes. In a field quasi-experiment with a sample of 76 Korean sixth graders (Kim 2005), the inquiry-based learning strategy was operationalized into five steps in teaching mathematics: (1) inviting ideas; (2) exploring; (3) proposing; (4) explaining and solving; (5) taking action or application. Compared to the traditional introduction–development–review approach, the well-structured inquiry approach produced higher learning achievement and higher motivation.

Edelson, Gordin and Pea (1999) summarize five general challenges in designing inquiry-based learning: (a) motivating students to engage in inquiry-based learning; (b) students mastering inquiry strategies (for example, interpret problems, data collection and analysis); (c) covering enough content knowledge of the topic for inquiry-based learning; (d) students managing and coordinating complex activities and resources in open-ended inquiry-based learning; (e) practical constraints of the learning context (lack of technology, large class size, and so on).

To address these challenges, sufficient guidance and scaffolding is necessary when inquiry-based curriculum is implemented in the classroom. For example, during instruction, the teachers can try to make the inquiry strategies and learning sequences structured and explicit (Hmelo-Silver, Duncan and Chinn 2007). The cognitive apprenticeship (Collins, 2006) model can be an effective way to scaffold inquiry-based learning. Since enough content knowledge is important for effective inquiry, some benchmark lessons which teach content knowledge are needed in an inquiry-based curriculum. Age-related constraints need to be addressed in an inquiry-based curriculum; for example, more teacher-initiated questions and scaffolding are needed for younger students.

The difficulty of implementing inquiry in the classroom might differ across cultures. For example, a qualitative study conducted in Hong Kong demonstrates that many inquiry strategies may only be applied superficially in Asian classrooms due to the robust teacher-centred, transmissive model of instruction (Yeung, 2009). In that study, 10 lessons were video recorded and in-depth interviews were conducted. The data show that although teachers tried to implement an inquiry-based approach in social science classes, the instruction was still very much teacher-directed. Systematic teacher training is very important for effective implementation of inquiry-based learning. An inquiry cycle with classroom-level implementation examples can be seen in “Appendix B”.

Differentiated formative assessment can be used to provide feedback to both students and teachers for better teaching and learning (Hudson 2009). Inquiry-based curriculums pose great challenges for both students and teachers and various formative assessment strategies are needed to guide the curriculum planning and curriculum enactment. Inquiry is such a complex process that assessment rubrics on content knowledge and various skill sets need to be designed for formative assessment. Teachers need to be trained on how to observe and identify students’ ability in using inquiry strategies (for example, whether students are able to form a valid hypothesis after analysing a problem).

Inquiry-based learning is an important learning approach in the IB programmes and inquiry cycles are well adopted in the programmes. For example, the personal project at the end of the MYP and the extended essay at the end of the DP require students to practise research and inquiry skills. How to design a more adaptive, inquiry-based curriculum addressing various age-related and cultural characteristics is a question worth further exploration. More in-depth case studies and action research may be needed to better answer this question.

2.1.2. Problem-based learning

Problem-based learning (PBL) takes a student-centred approach, usually conducted within small groups. The teacher acts as a facilitator in problem-based learning. The required knowledge and skills are achieved in the process of solving authentic problems (Barrows 1996). Problem-based learning and inquiry-based learning are not mutually exclusive; rather, problem-based learning involves inquiry strategies. Some objectives of PBL are: (1) helping students develop cognitive flexibility; (2) practising problem-solving skills as generic skills; (3) self-directed learning which requires high metacognitive ability; (4) practising collaborative skills and communication skills; (5) increasing intrinsic motivation (Hmelo-Silver 2004).

Kolodner et al (2003) list a sequence of PBL classroom practices: (1) analysing a problem scenario and facts in groups; (2) hypothesizing and explaining how to solve the problem; (3) dividing up the learning issues within the group, learning new knowledge which is needed to solve the problem; (4) returning to the problem;

evaluating the hypotheses and learning issues; (5) repeating the learning cycle until the problem is successfully solved; (6) reflection and abstraction.

A meta-analysis study done by Dochy et al (2003) generates some interesting results showing the general effects of PBL on knowledge and skills, and factors moderating the effect of PBL.

1. The effect of PBL on skills could be positive across students' expertise levels; however, the effects of PBL on content knowledge might differ significantly based on students' expertise levels and knowledge base. Age-related characteristics such as students' metacognitive skills, social-cognitive and affective ability need to be addressed. For example, students with a low level of prior knowledge may be overwhelmed when asked to apply the newly encountered knowledge.

2. Although students might learn slightly fewer facts and less content knowledge in a PBL environment, the knowledge they acquire is much more elaborate; thus, students in PBL might perform better in retention and transfer of the knowledge in larger contexts.

3. Different forms of assessment might yield different results due to the complex structure of achievement; thus, a range of diversified assessment strategies are needed to gain a clear picture of students' knowledge and skills achievement in PBL.

The implementation of PBL is difficult especially in educational systems where transmissive instructional models are pervasive. For example, the teacher's role change, training model transitions, the constriction set by the classroom resources (for example, technology, students' experience in using technology) are major challenges in applying the PBL learning model in China (Tang and Shen 2005).

Some practical examples of implementation for two different age groups[1] are given here.

1st and 2nd graders: Mathematics and language arts materials are embedded in a virtual environment with animated characters and interesting stories. Students are assigned roles in playing the game in which the mathematics and language questions are embedded. The scenario can be a practical problem which is age-appropriate. For example, a problem scenario could be: the password to a door is the total number of apples on two trees; a piggy needs to open the door in order to save his friend. To help them analyse the problem, the teacher can ask questions such as "If you want to get the password, what should you do?" Teacher–student reciprocal interaction with hints and support can help students reflect on their own learning state, set further goals and think reflectively after solving the problem. The progression of problems can gradually get more difficult.

In a curriculum teaching the respiratory system to middle school students, problem scenarios could be "diagnose various respiratory diseases" or "design an artificial respiratory system". Students can be divided into groups and each group assigned a problem such as "how is asthma caused?", "what happens to the respiration if the chest muscles are injured?" Each group is assigned a worksheet, which provides basic problem-solving sequences and guidelines. The students will be learning the mechanism of the respiratory system from the textbook, online resources, computer simulations, and will discuss how the knowledge can be used to solve the problems. The groups then present their work to the whole class. The whole class can work together to design an artificial respiratory system.

2.1.3. Situated and embodied cognition model

According to the constructivist perspective, people interact with the environment to acquire knowledge, and knowledge needs to be grounded in socially and culturally acceptable mediums (Barab et al 2007). Embodied cognition is a new topic in the field of cognitive science; the basic argument is about the importance of bodily experience in sense-making and learning (Nunez et al 1999). Perceptual experiences from multimodal representations (visual, auditory and haptic channels) are important for people to understand abstract concepts (Glenberg and Kaschak 2002). The implications for curriculum design and pedagogy can be drawn from situated and embodied cognition theories. For example, mathematics concepts can be embedded in authentic contexts so students are able to visualize and understand the problem (Bransford et al 1990); visual artifacts

1 Various problem-based curriculum cases: http://pbln.imsa.edu/

(for example, computer simulations, visual manipulatives involving hand movement) can be created to ground abstract mathematical and science concepts (for example, Black 2010); using gestures and acting out stories help young children perform better in reading comprehension (for example, Glenberg and Kaschak 2002). Various technology-enhanced interactive learning environments can be used to embed abstract academic content, and this has been argued effectively in enacting K-12 curriculum (Ryan 2001).

Barab et al (2007) listed some strategies in designing embodied curriculum: (a) a rich perceptual and/or narrative grounding needs to be constructed for the academic content; (b) the relationship between the underlying abstract concepts and the context needs to be well explained and illuminated; (c) experience, analysis and reflection need to be scaffolded to ensure students notice and appreciate the underlying deeper level of knowledge; (d) further scaffolding for knowledge application and transfer are needed in the curriculum plan, for example, asking students to apply the knowledge in multiple similar contexts.

Formative assessment and feedback in a situated and embodied curriculum is very important for students to benefit from the learning environment. The teachers can observe and reflect on when and how the underlying concepts are extracted and applied by the students; provide scaffolding for the students to reflect upon the experiences in the learning activities, and to abstract their understanding (Barab, et al 2007). The assignments, as a type of formative assessment, need to help learners see the connection between the context and the underlying concepts, rather than merely measuring the academic content disconnected from the experience during learning. In other words, assignments may also be situated and embodied in various forms, measuring both knowledge and skills at different levels. For example, comprehending the underlying concepts is a relatively lower level achievement, and applying the new knowledge in new contexts is a relatively higher level achievement (Hichey et al 2003).

Some examples of implementation are given below.

Various tools fostering sufficient multimodal perceptual experiences can be used to ground abstract concepts; for example, young children can manipulate a digital number line to learn counting; use gestures and physically act out stories to understand narrative texts; use computer-based agents and a voice-over to provide hints and support in problem-solving, and so on. Sometimes a minimal level of embodiment can be helpful; for example, when reading narrative texts, asking students to imagine the story like they are mentally playing a movie can benefit information retention and deep understanding. An embodied cognition approach of curriculum design often involves technology[2].

2.1.4. Self-regulated learning

Self-regulated learning (SRL) ability is important for performance in and beyond school. It is a complex learning phenomenon involving metacognition, motivation and thinking strategies (Schunk and Ertmer 2000). A clear framework of the SRL construct is important for teaching and assessing SRL. Boekaerts (1999) listed some key components of SRL: (a) the ability to effectively choose and coordinate various cognitive strategies; (b) the ability to set learning goals and direct one's own learning; (c) the ability to commit to and engage in reaching the self-set goals.

Self-regulation skills need to be taught in an explicit way. Directly modelling self-assessment and task selection with examples could improve students' SRL ability (Kostons, van Gog and Paas 2012); for example, using self-assessment rubrics and mental effort distribution rubrics in the classroom to help students practise SRL skills. Prompting questions at key points is a good technique to promote reflective thinking (Lin 2001).Teachers can often ask questions like "why do you think this is important?" and "how does that help you achieve the goal?" Scaffolding for SRL should be individualized since students differ in their individual needs, SRL ability and SRL styles (Boekaerts 1999). The teachers need to attend to students' differentiated sociocultual background, learning goals and learning styles.

Reciprocal teacher–student conversation and peer collaboration can influence SRL in a significant way. Feedback from the teachers is very important for students to develop SRL skills, and the teacher–student discussion can also act as formative assessment to measure students' SRL skills (Nicol and Macfarlane-

2 The following link includes some embodied cognition projects developed by the Institute for Learning Technologies, Teachers College Columbia University: http://www.ilt.columbia.edu/projects/projects_current.html

Dick 2006). The teachers need to be trained to give timely and high-quality feedback in student–teacher discussion. Various collaborative activities can be designed for students to improve SRL skills; for example, sharing ideas on those reflective questions and peer assessment with rubrics.

Some implementation examples are given here.

Students can be asked explicitly to set learning goals at different learning stages. For example, students can be asked to discuss in groups questions such as "what resources are needed in order to understand the acid rain phenomenon?", "where can you get relevant information?", "what's your plan for completing this research project?" At different learning stages, the teacher can always ask these questions regarding goal-setting. Goal-setting sheets can be used throughout the semester, with regular check-ins and self-evaluations (SRL presentation @ CUNY.ppt n.d.).

Reflection tasks and feedback are needed for students to be aware of and monitor their learning processes. Self-assessment rubrics can be effective learning tools. Self-assessment and peer assessment will be further discussed in section 2.3.2.2.

"Learning how to learn" is an important objective of IB programmes. For example, "approaches to learning" is a required theme in designing interdisciplinary curriculum in the MYP, and the reflective theory of knowledge course in the DP is expected to develop students' metacognitive skills (Stobie 2005). How to practise self-regulated learning skills in everyday classrooms and integrate knowledge and skills training could be an interesting and important question for the IB to explore.

2.1.5. Cognitive apprenticeship model

A traditional definition of "apprenticeship" is that an expert transmits knowledge or skills to the learner by showing the process of the work. The expert shows a learner how to perform a task, and the learner may take a small portion of the work and gradually practise to take over all the steps. In a cognitive apprenticeship model, the cognitive and learning processes are explicitly demonstrated by the teacher for the students to practise various cognitive, metacognitive and sociocultual skills (Collins 2006). In a cognitive apprenticeship model, students can be well scaffolded to tackle complex problems.

Collins, Brown and Holum (1991) list some general guidelines for applying the cognitive apprenticeship model in the classroom: (1) identify the processes of a task and explicitly demonstrate how the task can be accomplished; (2) ensure the abstract tasks are situated in authentic contexts; (3) diversify the contexts and articulate common underlying concepts to scaffold transfer.

Some practical methods for applying the cognitive apprenticeship model (Collins 2006) are: (1) the modelling method means the teacher explicitly showing how a task can be performed, for example, a science teacher can demonstrate and explain the steps for constructing an electric circuit in a science lab; (2) coaching refers to the teacher observing students perform a task and facilitating by providing hints, challenges and feedback, for example, the teacher can observe how the students edit a video and provide feedback and hints at key points; (3) articulation refers to the teacher encouraging students to verbalize their thinking process, which facilitates students' reflective thinking; (4) scaffolding refers to the teacher providing specific support for students' task accomplishment; (5) reflection refers to the teacher guiding students to compare their problem-solving steps to that of an expert's or their peers' to foster reflective thinking; (6) exploration refers to the teacher encouraging students to ask questions and solve their own problems. For example, the teacher can set general goals for a task and invite students to come up with sub-goals and questions regarding particular issues in the task. Based on the specific requirements of a discipline and students' age-related characteristics such as prior knowledge, metacognitive ability and communicating skills, the teacher may choose different methods.

2.1.6. Effective collaborative learning

Collaborative learning can be defined as a learning environment in which students make contributions to solve problems together (Teasley and Roschelle 1993). Following social constructivism concepts, learners construct knowledge through interacting with others (Atwater 1996). Collaborative learning is usually embedded in other student-centred learning models such as inquiry-based learning and problem-based learning. Contemporary literature on collaborative learning shows the extensive involvement of technology (Resta and Laferriere 2007).

Collaborative learning has potential benefits for cognitive and metacognitive achievement, while its effectiveness depends on factors such as group members' prior knowledge, the composition of the group and the quality of explanations (Janssen et al 2010). Without enough prior knowledge, learners may fail to provide high-quality explanations or construct a deep understanding of the perspectives provided by other group members. A group composition without above-average students may generate insufficient joint attention to the group task and a low quality of collaboration (Webb et al 1998). High-quality and elaborative explanations (for example, explaining to "why" questions) in group discussion predicts high group performance (Barron 2003). Metacognitive activities for example, planning and monitoring the task progress and evaluating group plans, can also improve group performance, (Janssen et al 2007). Collaborative learning among different age groups and cultural groups may require different levels of scaffolding and different ways of operation, which will be discussed in section 3.

In assessing group collaboration, in addition to measuring individual academic performance, the teacher needs to observe how group members respond to each other and whether joint attention to the task can be maintained (Barron 2003).

2.1.7. Integrative approach of curriculum design

Integrative curriculum is usually designed and organized around real-life problems without many academic content boundaries (Dowden 2007). It follows a constructivist and student-centred approach. Curriculum objectives and assessment standards are essential in designing integrative curriculums. Vars and Beane (2000) discuss how an integrative curriculum can be implemented in a standards-based educational system. Generic learning and thinking skills that can be core standards for assessment include metacognitive thinking skills, self-regulated learning skills, thinking and reasoning skills, communication skills, and affective and social skills. Assessment rubrics, including these abilities and skills, can inform the design and implementation of an integrative curriculum. Integrated standards in today's occupational fields can be delineated as more comprehensive integrative curriculum standards (Vars and Beane 2000).

One misconception curriculum designers and teachers are likely to hold is to conflate integrative curriculums with subject-centred multidisciplinary approaches due to the ambiguity of the literature and guidelines (Dowden 2007). An integrative curriculum starts from real-life problems, then brings in the content knowledge from different disciplines that is needed for solving those problems; while an interdisciplinary model of curriculum design is focused around the discipline content and brings in relevant content knowledge from other disciplines. The PYP's transdisciplinary curriculum takes the integrative approach described here. In the PYP, the curriculum is designed around six themes including "who we are", "where we are in place and time", "how we express ourselves", "how the world works", "how we organize ourselves" and "sharing the planet". The MYP takes an interdisciplinary approach in curriculum design, as teachers usually start from a specific discipline and try to find its connections to other subject content.

2.1.8. Summary

In section 2.1, a variety of constructivist approaches were discussed and implementation examples were described. Inquiry-based learning usually involves inquiry cycles with probing questions that model and scaffold knowledge construction (see section 2.1.1). Problem-based learning usually involves authentic problem scenarios. Students collaborate in small groups. Inquiry strategies and inquiry cycles are usually employed in problem-based learning and various higher-order thinking skills are practised (see section 2.1.2). Situated and embodied learning models emphasize the importance of grounding abstract knowledge in sociocultually acceptable mediums (see section 2.1.3). Self-regulated learning skills are very important to students' school performance and future success. They should be taught explicitly at the classroom level for the students to internalize those self-regulation strategies (see section 2.1.4). Sections 2.1.5 and 2.1.6 look at the students' roles and teachers' roles in teaching and learning. The cognitive apprenticeship model (section 2.1.5) induces various methods that teachers can apply to scaffold and facilitate the learning process. Different levels of scaffolding may be applied based on students' cognitive and learning ability. Collaborative learning (section 2.1.6), as an important constructivist approach, needs to be well designed to be effective. Within each sub-section, the basic implementation strategies and concrete examples of each model were discussed. One important notion is that different constructivist approaches are not mutually exclusive; rather, they could be well integrated and applied addressing different instructional purposes and constraints. The commonalities across these approaches are characteristics of constructivism such as the teacher's role as a facilitator, learning being meaningful to the students, and students constructing knowledge in well-scaffolded learning cycles. Factors

such as age-related constraints (which will be discussed in section 3) and students' cultural background influence the effectiveness of those constructivist and student-centred approaches, and should be addressed in the instructional design. Section 2.1.7 focused on the implementation of constructivist curriculum design. A very important notion in designing integrative curriculum is to start from authentic real-life problems and then bring in content knowledge from different disciplines, while interdisciplinary curriculum is designed around content knowledge of one discipline with relevant content knowledge from other disciplines aligned and mapped. Based on the educational objectives and specific constraints set by a certain grade level, either an integrative or an interdisciplinary model can be implemented.

Implementation of constructivist and student-centred approaches may encounter more difficulties in cultures where teacher-centred approaches and transmissive instructional models are pervasive. More effort might be needed to help teachers to change their mindset. For more on "teacher training" see sections 2.5.2 and 2.5.4.

2.2. Curriculum design and pedagogy: From affective, sociocultual perspectives

Section 2.1 discussed some learning and instructional models from cognitive and metacognitive perspectives; this section will focus on practical strategies addressing students' motivation, and other affective, sociocultual issues.

2.2.1. Addressing students' motivation in the classroom

2.2.1.1. Student identity and the learning environment

A student's identity in the classroom can be defined as a representation of the cognitive, affective, sociocultual aspect of self. Identity formation depends on self-context interaction (Rennigner 2009). A learning context can be regarded as a holistic construct in which various factors are interrelated, and students with their own backgrounds engage in the context to find their own identity (Volet 2001). The interaction between students' sociocultual beliefs and the learning context affects the affordance of the context (that is, the features of a context that allow individuals to take ceratin actions), which then affects students' motivational states and cognitive and affective engagement. This integrative approach to understanding motivation can be simply defined as whether one is satisfied with one's own identity in an environment. By holding this idea, it might be much easier to bring forth suggestions on how and when to provide scaffolds and intervention (Volet 2001).

In a classroom with a diversity of sociocultual traits, the teachers need to be able to understand students' initial perceived identities, help students to understand their own traits, explicitly explain the expectations of a learning environment and scaffold identity formation (Rennigner 2009). Continuous interaction helps students gradually form new identities and the development goes through a step-wise trajectory (Rennigner 2009). Frequent assessment of students' affective and motivational states through teacher–student conversation and reflective questionnaires can be practical strategies.

Helping students understand their own traits generates positive affective consequences; for example, Multiple Intelligences Surveys used in a foreign and second language classroom produced great affective outcomes among the students because of increased metacognitive awareness (Harley 2001).

Teachers need to learn how to analyse the conflicts between students' perceived identity and the learning environment; this could help them provide adaptive interventions. For example, the belief of "being a good student" differs across cultures; students in collective cultures are more accustomed to listening quietly and taking notes, and are not used to collaborative problem-based learning. In Confucian-heritage cultures, for example, two key concepts guided human relationships: hierarchy and obedience (Hu and Fell-Eisenkraft 2003). Students might be more comfortable with listening and following directions, and they may feel great conflict between their initial perceived identity and their expectations set by a collaborative and dynamic environment (Chen et al 2006).

Chen et al (2006) summarize how beliefs in two different cultures are manifested in peer relationships.

Individualism (European American societies)	Collectivism (many Asian and Latino group-oriented societies)
"Assertive, self-directive and autonomous ways in social interaction" "Encouraged to follow their own interests and goals" "Encouraged to maintain personal autonomy and freedom during peer interaction" "Sociability is regarded as important competency"	"Appreciate more affilliative and cooperative activities, show greater self-control" "Encouraged to learn skills and behaviours that are conducive to interpersonal cooperation and group functioning" "Display lower autonomy and competitiveness" "Higher mutual sensitivity and compliance in social interactions"

Table 1. Beliefs and values in two cultures manifested in peer relationship

2.2.1.2 Students' beliefs about intelligence and learning

Carol Dweck's motivation theory focuses on how students' self-conceptions about intelligence influence their learning goals and how the environment can contribute to the formation of beliefs about intelligence (Dweck 2006). A fixed mindset refers to students believing intelligence as a fixed entity thus not being motivated to make an effort; and growth mindset refers to the beliefs that intelligence can grow and effort is important. Teachers can assess students' self-conceptions of intelligence and learning, and provide adaptive intervention. For example, for students who believe intelligence is fixed, teachers need to transfer the idea of how the mind works and how hard work can improve one's intelligence. Understanding the importance of current learning to future goals also increases intrinsic motivation (Vansteenkiste, Lens and Deci 2006).

2.2.2. Establishing self-relevance in the curriculum

Sociocultually familiar contents can be brought into the classroom to increase motivation and engagement. This can also improve students' affective and sociocultual development (Bransford et al 1990), for example, teaching the ecological stability concepts by using a neighbourhood pond as an example, conducting a site visiting event; after learning the content knowledge, the students can be asked to work collaboratively coming up with suggestions to improve the water quality of the pond in their neighbourhood. The technology makes it easier to create self-relevance in situated and embodied contexts (Barab et al 2007); see also section 2.1.3.

2.2.3. Establishing positive teacher–student relationships

An affective teacher–student relationship is very important to students' engagement and school performance (Roorda et al 2011). Rovai (2002) defines four essential components of classroom community: spirit, trust, interaction and learning. Spirit, simply speaking, is a feeling of involvement and belonging in the class; trust is "the feeling that community can be trusted and feedback will be timely and constructive". A sense of belonging and positive feelings can influence learning in significant ways.

2.2.4. Summary

Many affective and sociocultual aspects need to be addressed in the curriculum design and pedagogy. Students' perception of their own identities and their beliefs about intelligence and learning contribute to their motivation. Teachers need to attend to the identities and beliefs students bring into the classroom, and provide adaptive intervention to accommodate their individual needs. New identity formation requires continuous teacher–student interaction. Bringing sociocultually familiar topics into the curriculum may also increase students' motivation. Creating a secure environment with a positive teacher–student relationship is very important to students' engagement and school performance.

Sociocultual and affective development and the implications will be further discussed in section 3.1.4.

2.3. Contemporary views of assessment: Assessment for learning

Following the student-centred and performance-driven approaches, a new trend of assessment called "assessment for learning" has been gaining much attention, especially at primary and middle school level (Black and Wiliam 2009).

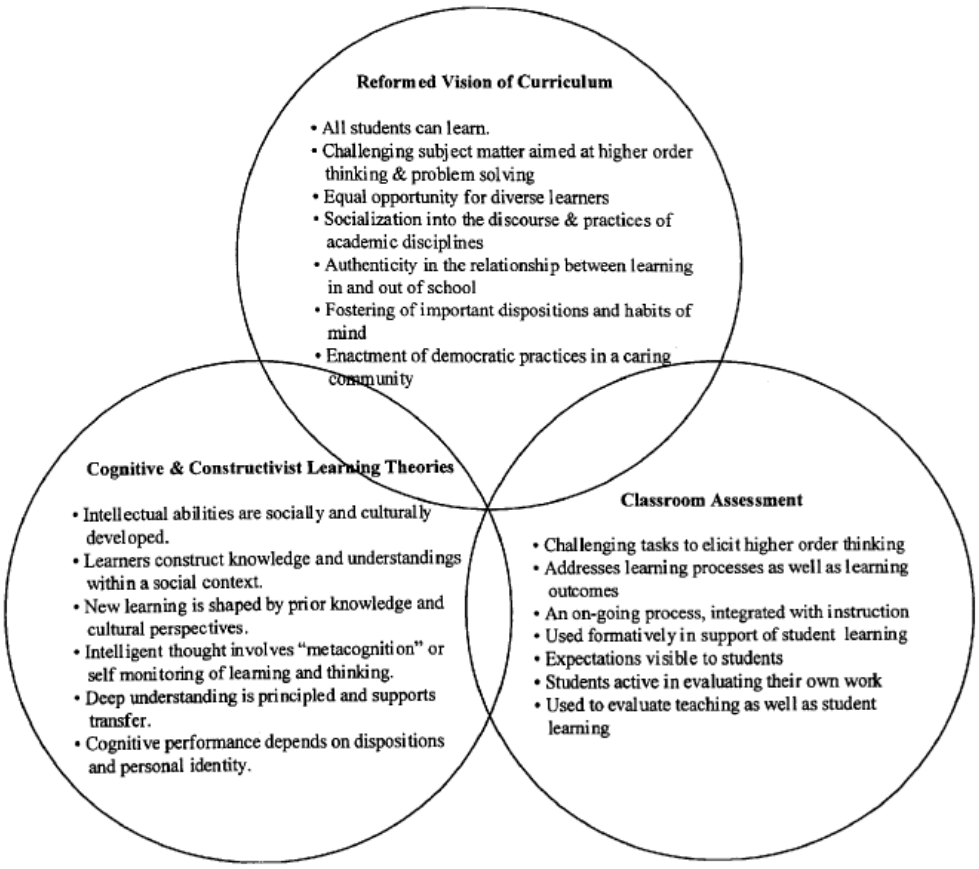

Figure 1. Shared principles of curriculum theories, psychological theories and assessment theory characterizing an emergent, constructivist paradigm. (Shepard 2000, figure 4, p 17)

2.3.1. Delineating achievement criteria and writing clear learning outcome statements

"What is assessed" and "how performance is interpreted" are two important questions that need to be answered in an assessment framework ("The Common European Framework" n.d.). A balanced coverage of content knowledge and skills needs to be ensured in the assessment (Skelton 2002), and higher-order thinking needs be addressed in the assessment criteria (Shepard 2000). In order to effectively assess achievement, the educators need to understand what "deep understanding of a topic" looks like in the learning context ("Common Core State Standards for Mathematics" n.d.). For assessment purposes, criteria specifications of each learning objective need to describe clearly not only what the students know but also what they are able to do at different levels of a criterion. Writing clear statements of expected learning outcomes requires (a) delineating different aspects and hierarchical levels of a skill construct; and (b) contextualizing each aspect of a skill (what the student is able to do if he or she has acquired this level of ability). In an articulation document, clear learning outcome statements can illustrate how each aspect of a thinking skill is contextualized in a specific discipline, and what the students are able to do at a certain level. This can make articulation more understandable.

A vague outcome statement: "Students will be able to recite the Bill of Rights."

Improved outcome statement: “Students will work in cooperative groups to plan and perform skits comparing how life in the United States would differ with and without the constitutional amendments known as the Bill of Rights.” (Eby, Herrell and Jordan 2006: 91)

Rubric-referenced assessment promotes effective teaching and learning (Reynolds-Keefer 2010). Clear criteria can be used for formative assessment to show the learning processes, to be shared with students as self-regulation tools, and to guide classroom questioning (Black and Wiliam 2009). Assessment rubrics[3] can be designed as criteria references in many forms of assessment, and can make it easier when assessing a variety of performances simultaneously in complex tasks[4] (“Informal Classroom Assessment” n. d.).

2.3.2. Differentiated assessment

Measuring students’ knowledge and level of understanding is the major function of both formative and summative assessment; another important objective of formative assessment is to measure students’ learning strategies and learning progress. Classroom assessment such as informal observation and asking questions are important at all grade levels (Brookhart 2009). The teacher needs to continuously measure students’ interests, goal orientations and level of understanding, based on which the teacher may plan future lessons and provide differentiated adaptive intervention. It can be a part of the formative process to help students learn. Simply speaking, there are two major purposes of formative assessment: to inform the teacher how to plan lessons based on students’ needs, and to inform the students of the learning targets and how to achieve the expected learning goals. Diversified assessment methods may also account for cultural diversity and individual characteristics. Students from a particular culture may be more used to certain types of assessment, and diversified assessment may help them appreciate other types of assessment and understand their performance better (Hudson 2009).

2.3.2.1. Continuous informal assessment

Informal assessment through teacher observation and teacher–student interaction, and intermittent assessments (assignments, quizzes) help teachers to determine and clarify the learning targets, and guide students to meet expectations. A constructivist and student-centred approach of instruction requires continuous informal assessment to adjust curriculum plans and activities (Shepard 2000).

2.3.2.2. Self-assessment and peer assessment

Self-assessment and peer assessment can provide learners with a framework of learning targets and foster reflective thinking. It is also very essential for practising self-regulated learning skills (Andrade and Boulay 2003). Assessment rubrics can be designed and customized for self-assessment and peer assessment.

2.3.2.3. Authentic assessment

Contextualizing generic skills such as critical thinking, creative thinking and self-regulated learning skills into specific content areas allows criteria to be specified. One example: the task requires students to develop an original work called “Wall Street Decision”. The assessment is rubric-guided and includes six areas. In the task, the students are measured on the extent to which they apply mathematical concepts such as fraction conversion, decimals and percentages in decision–making, and how students critically analyse the information and provide explanations (“Development of Differentiated Performance Assessment Tasks for Middle School Classrooms” n.d.). Assessment rubrics with clear learning outcomes statements can be particularly essential to the reliability and validity of authentic assessment. One concrete example of authentic assessment is demonstrated in section 3.2.5.1.

Aligned authentic assessment and curriculum refers to an assessment approach that is criterion-referenced but conducted in a natural context (Cook 2004). According to Cook, the criteria for the assessment can be derived from developmental areas such as the development of social-emotional, cognitive and communicating abilities. She illustrated how authentic assessment can be designed based on these standards. Although her focus is

[3] Assessment rubrics examples see http://edtech.kennesaw.edu/intech/rubrics.htm

[4] As an example, British Columbia’s Ministry of Education provided grade 1–grade 9 curriculum packages with clear performance indicators and measurable learning outcomes, which can be retrieved from http://www.bced.gov.bc.ca/irp/gc.php?lang=en.

more on early childhood assessment, the basic procedure for designing criterion-referenced authentic assessments can be applied to higher grade levels. The process for designing authentic assessment is:

a. Group the assessment criteria items into categories. Under each category, the more specific items are listed in an ordinal manner (from simple to complex).

b. Try to incorporate the assessment items into routine activities or deliberately create authentic activities and contexts in which to embed these assessment items. This can be conducted regularly, and the teacher can have a systematic approach of observation.

c. Create a rubric or assessment form for systematic observation and recording.

d. Collect data with the assessment form.

2.3.2.4. Construct student portfolios

Assessment needs to show how knowledge and skills develop over time. For example, the "European Language Portfolio" (ELP) records and presents individuals' performance on multi-dimensional aspects ("The Common European Framework" n.d.). A student portfolio[5] can be organized into content and skill sets categories, recording the performance level with students' work as data. For example, the ELP takes a modular approach covering different aspects of language knowledge and skills.

2.3.4. Summary

Aligned with the constructivist view of learning, "assessment for learning" has become increasingly popular. Clear and measurable achievement criteria are essential for designing valid and reliable assessments. In section 2.3.1, the question "how to delineate achievement criteria" was discussed and examples of writing clear learning outcome statements were demonstrated. In section 2.3.2, some practical formative assessment methods and classroom-level applications were described. Section 2.5.3 discusses how formative and summative assessment could be constructive and benefit future teaching and learning. Section 3.2.5 discusses how to design and conduct developmentally appropriate assessment.

2.4. Summary of the major challenges in implementing student-centred learning approaches

A review of the learning and instructional models shows some common challenges in implementation.

1. Traditional teaching and learning models can be robust, and it is difficult for the students and teachers to change their roles. The constructivist and student-centred learning models are even more difficult to implement in cultures where transmissive instructional models are pervasive.

2. Although a variety of educational objectives are emphasized in the curriculum guidelines across cultures, the lack of guidance and ambiguity of the implementation strategies, and the inexperience of school staff and teachers might lead to superficial implementation.

3. Many factors such as age-related constraints need to be addressed in implementing these learning approaches, and these need to be included in the articulation documents.

4. Although emerging technologies provide opportunities for implementing various constructivist and student-centred learning models, they may not be effectively and appropriately used in the classroom due to the inexperience of curriculum designers and teachers.

5 A good website demonstrating the usage and design of student portfolios for different age groups: http://www.teachervision.fen.com/assessment/teaching-methods/20153.html.

2.5. Some suggestions addressing the challenges

2.5.1. Construct a clear framework of goals and case-based descriptions of the learning models

A comprehensive framework of goals is essential for curriculum design, pedagogy and assessment (Vars and Beane 2000). Instructional goals are always the first questions curriculum designers and teachers have to answer. For example, "what content are we trying to teach", "how much background knowledge do the students have?", "what affective or motivational goals do we have?" To account for cultural diversity, more questions such as "what sociocultual issues and values need to be embraced in the curriculum?" should be considered (Au and Apple 2009). To construct a clear framework of goals, curriculum designers and teachers need to deeply analyse the discipline and topic, assess the background of the students, and delineate the learning goals and desirable learning sequences clearly. The issues from cognitive, metacognitive and sociocultual perspectives need to be addressed in the goal framework. Based on the goal framework, very specified and contextualized learning outcome statements need to be written (also see section 2.3.1). To help teachers better understand articulation documents, case-based descriptions of various learning models need to be included, addressing the following aspects: how various constructivist and student-centred models address the instructional goals, how the learning outcomes are contextualized in a specific discipline, how they can be observed in students' performance, and what assessment tools (for example, criterion-referenced rubrics) can be used (Zech et al 2000).

2.5.2. Account for individual differences and cultural diversity

Cultural integration in the curriculum, and inclusive curriculum and pedagogy may help accommodate cultural diversity in the classroom (Au and Apple 2009). Diversified cultural themes can be covered in the curriculum, for example, stories introducing the festivals of different countries can be learned in a literature class; in a science class, students can be asked to compare the geography of different countries and collaboratively work together to construct a world geography chart.

To meet students' individual needs and account for cultural diversity in the class, "how to implement inclusive pedagogies" has become an important topic in teacher training (Sleeter 2009). Sleeter (2009) discusses some practical strategies for teachers to implement inclusive curriculums and pedagogies.

a. The teachers need a repertoire of cultural knowledge of the communities. Teachers can learn to work with the neighbourhood communities and include community knowledge in the curriculum and instruction.

b. The teachers can benefit from dialogues with students from different cultures. Teaching profiles based on students' narratives can be constructed for the teachers to reflect upon and as references for pedagogical design and classroom management.

c. The teachers need to spend time and make an effort to learn more about multicultural topics as well as working with community representatives from cultures different from their own.

d. The teachers need to be aware of the political and economic dynamics beyond the community.

2.5.3. Align assessment with the constructive, student-centred learning models

The major role of formative assessment is to guide the teachers to plan future instruction and guide the learners to understand their learning states and see improvement with clear goals (Hudson 2009). More diversified and innovative assessment practices need to be used at the classroom level such as self-assessment and peer assessment with checklists (see section 2.3.2.2). Formative assessments should bridge teacher–student communication in learning and instruction, timely and understandable feedback is needed to guide students in future learning. Formative assessments should cover both content knowledge and skills, especially higher-order thinking skills (for example, creative thinking) (Carless 2005).

For summative assessment, both content knowledge and various skills need to be measured in multiple ways for teachers to gain a better picture of students' achievement. A hierarchical assessment structure with clear outcome statements may ensure the reliability and validity of the assessment. For example, in the study by

Marx et al (2004), the content knowledge and science process skill are measured at three cognitive levels: lower level (recall and comprehension), middle level (drawing and understanding relationships, transfer knowledge), higher level (various inquiry strategies such as describing and analysing data, phrase hypotheses, and so on).

Clear learning outcome statements are essential for both formative and summative assessment (please also see section 2.3.1). Bloom's taxonomy can be used to write out curriculum objectives and design assessment tools for different grade levels and in different disciplines (Anderson et al 2001).

Developmentally appropriate assessment and examples are further discussed in section 3.2.5.

2.5.4. Collaborative inquiry models for professional development

New concepts related to teaching and learning need to be infused in teacher training. It is difficult for teachers to fully understand constructivist and student-centred instructional approaches and assessment practices without direct instruction. Fostering collaboration and inquiry helps teachers reflect upon the teaching experience and learn to talk about students' thinking and deepen understanding of the curriculum and pedagogy (Zech et al 2000). Teachers' learning also needs to be constructive and situated in examples and content. Inquiry cycles like "Questions→Hypotheses→Data, Evidence→Collaboration→Reflection" could be effective. Zech et al (2000) also illustrates how teacher training can be conducted in the classroom, at school level and across schools. In the classroom, clear questions guide teachers to observe students' learning and collect relevant data to answer the questions; at school level, teachers share experience and ideas on those questions; professional workshops can be held across schools. Below are some examples illustrating how inquiry cycles can be carried out at the classroom level and school level (Bakkenes, Vermunt and Wubbels 2010).

At the classroom level: in an art history class, a teacher may notice that students often regard the lessons as separate entities and fail to make connections. He may question his own teaching method, and generate hypotheses about how some new strategies could be effective. For example, it could be effective to help students visualize continuous chronological course movements with a visual timeline, and ask students to explain how one movement is based on earlier ones in a review session. He may experiment with these new instructional strategies and observe the learning outcomes with classroom-based formative assessment (for example, questioning, quizzes). Based on the data, he may reflect on the results and share his experience with other teachers.

At the school level: initiatives for innovative instructional methods (for example, to increase students' self-regulated learning skills) may be operated in a top-down manner. With the guidelines, teachers may work together to come up with some useful techniques and experiment at the classroom level. With a clear framework to structure their reflection, the teachers may share their experiences in staff meetings or online spaces (for example, writing digital learning logs).

2.6. Summary

Section 2 addresses the second research question: How are these perspectives unpacked and implemented in practice, for example, integration with the school-based curriculum, pedagogical strategies and inclusion in teacher training?

In this section, various implementations of constructivist and student-centred approaches were discussed. From cognitive and metacognitive perspectives, various learning models such as inquiry-based learning, problem-based learning, situated learning, self-regulated learning and collaborative learning can be effectively applied at the classroom level (see section 2.1). These learning approaches can be used together or separately for different instructional goals and based on specific constraints. Students' cognitive and metacognitive ability, prior knowledge and cultural background are all potential moderators in the effectiveness of these constructivist approaches and need to be carefully addressed in designing the curriculum and pedagogy. Section 2.2 discussed how affective and sociocultual characteristics of students can be addressed in designing a constructivist curriculum and pedagogy. The notion of "assessment for learning" has been gaining much attention these days. Assessment for learning requires clear achievement criteria and differentiated assessment methods, which were discussed extensively in section 2.3. Formative assessment has become

increasingly important as it could direct both teaching and learning. Sections 2.4 and 2.5 summarized the challenges in implementing these constructivist and student-centred approaches, and discussed how these challenges can be met.

Section 3 will focus on how age-related characteristics can be addressed in designing student-centred curriculums, pedagogy and assessment.

3. Age-appropriateness addressed in the implementation of student-centred learning approaches

As has been pointed out in section 2, age-related characteristics need to be addressed in implementing constructive and student-centred learning models. In this section, theories on cognitive, social-cognitive and affective development are reviewed (section 3.1), and developmentally appropriate curriculums, instruction and assessment are discussed (section 3.2).

3.1. Cognitive, social-cognitive, affective development

The discussion on developmental appropriateness in educational practices are usually based on stage theories such as Piaget's stages of cognitive development, and sociocultual theories of development such as Vygotsky's zones of proximal development.

3.1.1. Piaget's cognitive development theory and its implications

Piaget's developmental theory provides a basic framework for discussing age-related constraints on learning and for discussing children's thinking. It informs teachers how to design age-appropriate curriculums and instruction, especially at the pre-school level and elementary level. To design age-appropriate instruction, age-related characteristics need to be taken into consideration. For example, at the elementary level, it is difficult for students to think abstractly and systematically, thus the concepts need to be more grounded in perceptual experiences; most inquiry steps might need to be teacher-initiated; more instruments, artifacts and tools are needed to maintain joint attention in collaboration. At the middle school and high school levels, more sophisticated scientific reasoning skills such as control of variable concepts can be emphasized in the science curriculum (Kuhn 2000); self-regulated learning skills need to be addressed more in the curriculum. However, Piaget's theory receives criticism for its over-simplification of the developmental stages, and for overlooking the cross-cultural differences (Hinde and Perry 2007). It has been argued that content inclusion and exclusion in curriculums should not be based purely on the stage framework, as what children can do with proper instruction may be underestimated (Siegler and Alibali 2005). One misconception many primary school teachers hold is "to wait until the kids are developmentally ready before something can be taught". When planning a curriculum, we should ask questions such as "what level of understanding can students reach in learning this type of content?", rather than making claims such as "this content is not age-appropriate because the kids are not developmentally ready to learn this" (Hinde and Perry 2007: 76). In fact, appropriate challenges may lead to higher motivation, engagement and creativity. Hinde and Perry (2007) unpack the debate over social sciences standards in primary grades in Arizona, based on which, they argue that both Piaget's theories and developmental appropriate practices are helpful in teaching social science in primary grade levels. More challenging content can be customized with age-appropriate instruction to fit the elementary and middle school level curriculum. These are some illustrations of curriculum adaptation to students' age and cultural characteristics (Johnson, Janisch and Morgan-Fleming 2001): One teacher who wanted to introduce "Middle Ages" to the 4th grade students asked students to create a concept map about castles, which she believed the students would probably have some prior knowledge of. The 5th/6th grade students were even able to handle challenging topics such as "Shakespeare" through play writing.

Although it is always believed that top-down imposition of a highly specified curriculum may be detrimental to children's development at the elementary and lower secondary levels, a specified core curriculum adapted according to students' age-related and cultural characteristics can actually lead to highly student-centred instruction (Hinde and Perry 2007). In other words, a "recommended curriculum" needs to go through much

adaptation and modification to become the "learned curriculum" which is developmentally and culturally appropriate (Johnson, Janisch and Morgan-Fleming 2001). The teacher needs to address students' age-related and cultural characteristics in tailoring the recommended curriculum to meet students' needs. For example, in implementing Hirsch's core curriculum of literacy (1988), elementary teachers questioned Hirsch's scope and sequence of the curriculum and critically chose specific areas and theme units based on students' interest, and sociocultual background. One teacher focused on Aztec civilization since most of her students were Hispanic.

3.1.2. Vygotsky's sociocultual theory of development and its implications

The basic notion of Vygotsky's sociocultual theory of development is that learning and development happens in social interaction. It emphasizes the mediating role of social interaction on the construction of knowledge. It shapes the early childhood education curriculum and pedagogy in a significant way (Hedge and Cullen 2011). Vygotsky (1986) believed that formal and conceptual knowledge emerges from a repertoire of daily experience and interaction with adults and peers. Children may work with tools or artifacts together with an adult, via language, signs and symbols; knowledge, cultural norms and rules are gradually internalized to be a part of the children's thinking. At different grade levels, the teacher needs to measure what the students cannot do by themselves but are able to do with help from the teacher or more skillful peers, which is defined as the zone of proximal development (ZDP). Think-aloud is an effective instructional strategy at the upper elementary and middle school level (Blake and Pope 2008). The teacher can explicitly explain the steps in tackling a task, and also ask students to explain their steps, which makes thinking visible to the students.

As has been discussed in the cognitive apprenticeship model (see section 2.1.5), scaffolding and modelling can take place at different levels based on students' competencies. At elementary level, more structured modelling and scaffolding are needed. For example, students can be asked to replicate steps in completing a task after direct instruction and demonstration; the small group and large group collaboration needs to be sufficiently guided and visual organizers and very structured guiding questions are needed in discovery learning (Blake and Pope 2008). At secondary level, there could be more space for student-initiated questions and activities.

The individualistic-collectivist cultural distinction framework, though it has received criticism over its over-simplicity in categorizing sociocultual characteristics and their manifestations, helps us understand children's participatory and interactive behaviours (Medina and Martinez 2012). Sociocultual values may affect children's sociability in peer interaction and collaboration (Chen, French and Schneider 2006). For example, the engagement level in peer interaction could be lower among Chinese students compared to students in North American cultures (Chen, French and Schneider 2006), but they may engage more in non-social activities. According to Vygosky's ZDP notion, more teacher involvement and coordination might be needed in collaborative learning in collectivist cultures compared to individualistic cultures.

Cross-cultural studies show some interesting differences in teachers' classroom practices. In one study comparing the behaviour, engagement and attention in 1st grade mathematics classes in China and the US (Lan et al 2009), compared to the US teachers, Chinese teachers tended to provide more proactive instruction (before a task) to clarify the requirements, the steps and expectations, which is a way to socialize self-regulation strategies.

3.1.3. The development of metacognition

Metacognition, in a narrower sense, includes metacognitive awareness of one's beliefs and knowledge (metaknowledge) and metastrategic control in selecting and applying strategies in processing information. Developing metacognitive skills is an important educational objective, and it is essential for higher-order thinking such as scientific reasoning and problem-solving, and self-regulated learning (Kuhn 2000, see also section 1.1.5 and self-regulated learning in section 2.1.4). It emerges early in life and develops, becoming increasingly explicit and powerful. During early childhood, the ability to understand one's knowledge state and executive control develops rapidly (Zelazo and Frye 1998), which constructs a foundation for further development. One approach to increase children's metacogntive awareness and metastrategic control is through exercising at an external social level (Kuhn 2000; Vygosky 1986).

For example, children at pre-school level and lower elementary level usually apply a variety of strategies in learning addition, and the development lies in using more advanced strategies such as count-on (Siegler 1994). The teacher needs to help children reflect on the value of more advanced strategies through conversation, and guide the children to discuss their problem-solving strategy for comparison and reflective thinking. This requires

the teacher to be able to categorize and evaluate children's strategies during on-time tasks and provide immediate feedback.

One important educational objective regarding metacognition ability is to accurately estimate the task scope and demand, which then directs attention, effort and use of strategies. Garcia-Mila and Andersen (2007) compared 4th grade students and community college students in their note-taking behaviours in a 10-week inquiry-based science lab course. The 4th grade students were less likely to take notes because they underestimated the demands of the task and didn't perceive the value of it in their learning; they were less likely to take notes effectively because they had a relatively low ability to evaluate what they already knew and what they needed to know. One implication of fostering metacognitive development is to help children properly estimate their knowledge state, and provide guidance in utilizing and appreciating learning strategies. For example, at elementary level, the teachers can use very structured note-taking worksheets with reflective questions, explicitly teach students how to take notes effectively, explain why they need to take notes, and guide them to review previous notes.

As can be seen, sociocultual interaction and explicit instruction is very important in the development of metacognitive ability. Vygotsky's ZPD notion (see section 3.1.2) provides implications for everyday classroom practice.

Metacognitive development may show different patterns in different cultures, for example, recent cross-cultural research on human development shows both similarities and differences in metacognitive development patterns in Western and Asian cultures. Although actual metacognitive skills develop with age, self-efficacy and value of learning are two important metacognitive competencies that decline with age. This has been found both in Western and Eastern cultures (Pajares and Valiante 2002; Mok, Fan and Pang 2007). The large scale study on cognitive-metacognitive competencies carried out in Hong Kong (Mok, Fan and Pang 2007) shows that from primary 4 (age 9) to secondary 5 (age 17), students' perception of the metacognitive competencies shows a sharp decline in the primary–secondary transition. Some explanations Mok, Fan and Pang (2007) provided are that: (a) adolescents are more likely to compare themselves to their peers in assessing their own competencies (Renninger 2009); (b) the task and assessment demands increase faster than the development of students' cognitive and metacognitive competencies; this might lead to the discrepancy between actual and perceived competencies; (c) more use of surface learning approaches rather than deep learning approaches as students transit to the secondary level of education. Despite the similarity of the declining trend of self-efficacy in the primary-secondary transition across cultures, Asian students usually show relatively lower self-ratings on self-efficacy and self-regulated learning ability compared to their Western counterparts (Klassen 2004); however, Asian students score higher on mathematics and science (Shen 2002). It has been argued that Asian students tend to more modestly and realistically measure their competencies to direct their effort and strategies, and a merely optimistic sense of self-efficacy may not fit in a highly competitive context (Mok, Fan and Pang 2007).

Among the implications for school curriculums in upper primary level, middle school level and high school level is the need to emphasize more the development of metacognitive skills: students need to be encouraged to hold realistic perceptions of their own abilities and goals, as well as holding positive self-concepts. The studies reviewed in this literature review were conducted in Western or the Asia-Pacific regions; that is to say, no systematic worldwide cross-cultural comparison is discussed, which could be seen as one of the limitations of this literature review.

3.1.4. The development of social cognitive skills and affective skills

Social cognition development refers to the developing conceptions of the self, social reality, and relationships between people such as friendship, love, power, influence, and other related phenomena (Selman and Byrne 1974). Selman's five stages perspective taking[6] can demonstrate some age-related constraints of social cognitive skills. Knowledge about feelings and emotions, and the ability to make inferences about another person's emotional state develops with age (Branden-Muller et al 1992). Age-related identity development may influence the effectiveness of certain instructional methods (Renninger 2009). The development of social cognitive skills and affective skills needs to be emphasized in all levels of education. Brain research evidence suggests that during childhood, children gradually become more self-conscious, attend to other peoples'

[6] For more information, please see: http://everything2.com/title/Selman%2527s+Five+Stages+of+Perspective+Taking

feelings, thoughts and perspectives, and the adolescent years (middle school and high school years) are an especially sensitive and critical period of social cognitive and affective development (for example, Steinberg 2005; Choudhury, Blakemore and Charman 2006). For example, compared to adults, adolescents are more susceptible to peer influence, and compared to younger kids, adolescents are more likely to compare their own skills and competencies with their peers to form their identity. Competition and feedback from peers may affect their self-efficacy for the ones who haven't developed an individual interest in the learning content (Renninger 2009). To provide adaptive intervention, it is critical for middle school and high school teachers to understand how social relations direct students' motivation and academic goals, and affect academic outcomes. Increased self-awareness and schools' emphasis on competition and social comparison is one of the major difficulties young adolescents face in the PYP–MYP transition.Interventions such as academic tracking to adapt to individual needs, and educational support initiatives to ensure the social emotional well-being of students may facilitate programme transition (Cowie de Arroyo 2011).

Group work for middle school students and elementary school students may need to be organized differently. At the lower elementary level, without sufficient guidance from the teachers it is difficult for children to conduct effective collaborative discussion since they may fail to consider others' perspectives. Middle school students are more likely to compare their own skills and competencies with their peers to form a self-representation; thus, group work that singles anyone out for peer assessment may have negative consequences, as students may be too engaged in comparing themselves to others (Renninger et al 2007).

The interaction between students' perceived identities and the sociocultual environment contributes to students' motivation and affects school performance (also see section 2.2). At different developmental stages, individuals may have different social identities, which are defined as one's knowledge of how he or she belongs to the social group. The process of social identity construction takes place by interacting with the members in that social group (Duveen 2007). According to Winther-Lindqvist (2012), the objectives, central activities and leading motives of a social environment establish students' perception of their membership in that group. School transition and a change of sociocultual environment usually involve major changes of objectives, cultures and values, and may involve the construction of new social identities. For example, when pre-school children transit to the elementary school, a sudden change of leading school activities and objectives (learning becomes the major objective) may cause a social identity crisis. Elementary students may form social identities in play-based participatory environments, and internalize the values and motives; in transition to the middle school, they may face many changes and may need to form new social identities (for example, additional school responsibilities, more self-regulated activities). The sudden change of learning cultures when students enter high school may also cause negative emotional consequences. This social identity concept can also help us understand why students might have identity crises when coming to a new culture. For example, for Asian students, solitary work and effort, good self-control and good academic performance are believed to be appreciated by the teacher and peers. When they are in a culture where collaborative interaction and inquiry are the central activities, they may not be accepted by their peers and they may then have a negative social identity (Chen, French and Schneider 2006), which could negatively affect their learning performance.

Adult guidance and negotiation on the central motives and activities are very important to help students construct new social identities (Winther-Lindqvist 2012). To create a sense of belonging requires the teacher to understand students' perception of self and social values through teacher–student conversation. The teacher needs to explicitly clarify the expectations and negotiate with the students about the desirable behaviours and actions to help them form positive social identities (Osterman 2000). Teachers need to understand students' social identities and corresponding learning behaviours. During staff meetings, teachers can share their experience to get a better image of students' potential identity crises in the context, especially when they newly transit to a higher grade level. Transitional support to clarify the expectations, objectives and central learning activities of a new programme may help the students form new identifies much faster.

3.2. Implications of developmental theories on curriculum, pedagogy and assessment

3.2.1. Developmentally appropriate curriculum

Clear curriculum standards with specifications of the expected learning outcomes are essential for curriculum design for all grade levels (Eby, Herrell and Jordan 2006). Based on the curriculum standards, teachers can transform the content into meaningful learning through conducting various developmentally appropriate practices. Modifying the recommended curriculum to address age-related constraints is very important for elementary level education. Some questions teachers can ask themselves in planning the curriculum based on the standards are listed below.

"What is the most meaningful for children at this age? What is most meaningful for these particular children? What might a beginner need to know regarding this curriculum standard? What do the children already know? How can I integrate this standard into day-to-day learning?" (Kostelnik, Soderman,and Whiren 2007)

For example, teachers can collaborate to design integrative projects that are connected to children's daily life and sociocultual background. In Datnow, Borman and Stringfield's (2000) study on the implementation of core knowledge curriculums, a Texas school has a large Latino population, so the first-grade teacher designed a curriculum based on the core knowledge curriculum while placing special emphasis on the unit on Aztecs, Incas, and Mayas, and on Mexico.

3.2.2. Developmentally appropriate pedagogy and instruction

Based on Vygotsky's zone of proximal development (ZPD) framework, the level of scaffolding from the teacher needs to accommodate the constraints set by a certain developmental stage. Guided participation in culturally valued activities can be applied effectively at lower grade levels (Rogoff et al 1995). Two major concepts are incorporated in guided participation: children's behaviour is guided by skilled members, and the children participate in activities that are culturally valued. Continuous informal assessment and diagnosis of individuals' ZPD are needed to provide adaptive instruction.

An illustration about adaptive instruction to improve self-regulated skills is given below.

Self-regulation skills development is one of the essential expected learning outcomes (see section 2.1.4). Following the ZPD notion, a metaphor of self-regulation skills acquisition is "transition of other-regulation voices to self-regulation voices" in the reciprocal social interaction (Karasavvidis, Pieters and Plomp 2000). For example, at the beginning, the teacher may help students set goals for a task, provide strategies for the students to use, and prompt questions at every step triggering reflection. Gradually, the teacher leaves more space for the students to practise setting goals by asking questions like "How would you approach this problem?", which are also an informal assessment of students' self-regulated behaviour. Instead of directly giving students the options of strategies, the teachers may ask the students to discuss and figure out strategies to use. The scaffolding from the teacher is gradually phased out as the students become more familiar with the task format. The teacher needs to have some standards in mind, and continuously measure students' ability in self-regulation skills, for example, with checklists. This helps the teacher measure the ZPD for providing adaptive instruction (Allal and Ducrey 2000). This also provides implications for the alignment of pedagogy across grade levels. The interaction among different grade-level teachers may involve discussion about their experiences in providing scaffolding, students' ability in certain types of tasks, and so on. In this way, teachers may have a better idea of how these self-regulated skills develop and how to provide the appropriate amount of scaffolding. For example, the teacher may stop more often to ask the students to think reflectively and set goals for younger students.

Due to the different level of development on cognitive, social-cognitive and affective aspects, different age groups may differ in their self-regulation skills (Zimmerman 2002), which may be manifested in various contexts. In pre-school, children are able to learn to control their actions and pay attention; at elementary school level, they may be required to control behaviours in various environments, learn to achieve goals, seek help, keep track of their work, and so on. After they get to the secondary level, more self-initiation and goal-oriented planning and monitoring are expected. A smooth transition across levels requires the teachers to have a clear idea of the ZDP at each level. Some questions the teachers can ask include: "what is the level of the

students' self-regulated ability?" "How much can they improve with proper intervention?" "Will the students feel overwhelmed about the expectations?"

Across age groups, problem-solving and inquiry skills may differ on several dimensions (Dochy et al 2003), for example, the scope of problems that students can handle (based on prior knowledge), the ability of systematic question asking and strategic planning, the ability to think abstractly, and so on. The level of scaffolding and use of instructional tools need to be customized for different age groups. The abstraction level, the number of steps of a problem-solving strategy and the amount of support from the teacher (for example, teacher-initiated questions versus student-initiated questions, explicit guidance on information searching, explicit reflective questions) are all aspects that need to be addressed in designing learning tasks.

Abstract concepts are not expected to be taught easily to students who are developmentally in the concrete operational stage (<11–12 years old), but it is not impossible. Curriculums and instruction for students at elementary level may require a higher level of embodiment and situatedness due to their limited ability to deal with abstraction. For example, when teaching historical content such as civilization, role-playing and acting out stories in guided play-based curriculum may work effectively in elementary level; various activities to reinforce critical thinking and creative thinking such as collaboratively creating a graphic historic timeline can work well.

The ability to collaborate effectively with peers develops relatively late, and it is difficult for young children to conduct high-quality interaction among peers for a common goal (Siegler and Alibali 2005). Lack of prior knowledge and self-regulation skills in younger children may also lead to unsuccessful joint attention on a common group goal (Webb et al 1998). For students at a younger age, more guidance, intervention and coordination from the teacher are needed to clarify a group goal, set out more clear steps for the children to solve a problem, and create a caring and motivating environment.

3.2.3. Guided participatory curriculum at elementary level: A balance between student-initiated activities and teacher intervention

The learning goals for early childhood usually focus on whole-child learning (NAEYC 2009). "Play", as a developmentally appropriate approach, may act as a primary medium for learning since it creates authentic learning experiences and an ample amount of social interaction (Walsh et al 2010). An effective play-based curriculum requires sufficient guidance and intervention from teachers (Broadhead 2006). The role of adults in providing scaffolding (associated with Vygotsky) has been emphasized in play and activity-based curriculums for early childhood students. "Play", from the perspective of education, should not be interpreted superficially (Bronstrom 2007). To ensure the effectiveness of a play-based curriculum, a clear objective framework and an activities structure are needed from the teachers' side, and "play" needs to happen within a confined space targeting various learning goals (Wood 2007).

Due to a lack of knowledge and skills repertoire, confined and guided participatory curriculums are needed for young children. Hong and Diamond (2012) compared two instructional approaches for teaching pre-school students (4–5 year olds, in a mid-size American mid-western community): responsive teaching (RT) versus a combination of responsive teaching and explicit instruction (RT+ET). The children in the RT+ET group learned more science concepts, vocabulary and content-specific problem-solving skills.

3.2.4. The role of content knowledge in student-centred curriculum and pedagogy

Contradictory views over the role of content knowledge exist in the field of childhood education. Some argue that subject-based approaches may lead to inappropriate pedagogies and non-student-centred instruction (Corrie 1999). On the other hand, some argue that content knowledge is essential for designing high-quality inquiry-based and problem-based learning at the elementary and middle school levels. Sociocultual perspectives of learning, which emphasize the co-construction of knowledge between the children and adult members, may resolve the contradiction (Hedge and Cullen 2005). Even at a very young age, children may ask questions related to formal academic content, driven by their interests and curiosity. For example, a child may discuss how a ship made of iron can float; how a car can run; or why people need to eat. Those are the great teachable moments that could broaden and deepen children's interests. The teacher can have a spontaneous discussion, within which guided inquiries and explorative approaches are taken to help the children construct knowledge. Hedge and Cullen (2005) argue that teachers need a large content knowledge repertoire to mediate this process effectively. One implication for the transition across grade levels is that teachers may

need to have a better understanding of the curriculum continuity across levels and increase their content knowledge repertoire. This allows them to better prepare students for future learning.

3.2.5. Age-appropriate assessment

3.2.5.1. Developmentally appropriate assessment

Various difficulties exist in designing effective assessment practices to document young children's learning outcomes and progress, while the accountability of learning outcomes has been increasingly emphasized (*No Child Left Behind Act of* 2001). Grisham-Brown, Hallam and Brookshire (2006) discussed some important practices of effective assessment for younger children: "authentic assessment practices", "linkage between assessment and curriculum development" and "alignment of assessment with standards". Authentic assessment (also see section 2.3.2.3) can be very effectively implemented at pre-school and elementary levels. Authentic assessment needs to be criterion-referenced and infused in the curriculum. The "Work Sample System" is a good example of authentic performance-oriented assessment suitable for K-5 classrooms (Meisels 1997). Based on national and local standards, and classroom level objectives, contextualized criteria statements can be written. The teachers continuously document and evaluate children's academic, affective and social development progress over the school year with checklists, portfolios and summary reports. The teacher needs to be able to observe, document and translate students' performance based on the criteria statements. Technology may make the documentation process more systematic, the assessment much easier, and the data much more explicit[7].

Observation and informal assessment are especially important at elementary level, and elementary teachers can usually implement a variety of assessment methods (Brookhart 2009), for example, guiding the students to demonstrate their competency, questioning such as oral testing and delving, paper and pencil quizzes, homework as formative assessment, rubric-referenced performance assessment with a scoring scheme, self- and peer assessment. Documentation is important when the teacher is implementing formative assessment for better instruction and the improvement of students' learning (Meisels 1997). Grades may come from combining various assessment data.

Formative assessment is also essential for both learning and instruction at secondary level (Brookhart 2009). The adolescence stage is a critical and sensitive period for affective and social-cognitive development, and the importance of establishing a safe assessment culture needs to be emphasized. Some key elements for teachers to successfully implement formative assessment in secondary schools (OECD 2005) are: (a) create a secure classroom environment for students to make mistakes, and provide tools for self-assessment; (b) establish clear learning goals and track students' learning processes, communicate with students on their learning goals; (c) a mixed approach to assess students' knowledge and understanding in the classroom; (d) providing timely verbal and written feedback on students' work, addressing specific assessment criteria.

Although high-stake selection-oriented summative assessment still remains in a central position in many Asian countries, more diversified assessment and formative assessment have been increasingly emphasized (Ross, Cen and Zhou 2011; Berry 2011). For example, educational reform in Hong Kong has put formative assessment in a very important position under the notion of "assessment for learning" (Carless 2005; Black and Wiliam 2009). Since 2001, school-based assessment has been introduced from primary 1 to secondary 3, and a balanced use of formative and summative assessment in the local schools has been included in the curriculum guidelines at primary 1–secondary 6 (Berry 2011). Education reform in mainland China shows obvious intentions of moving beyond the examination-oriented learning cultures to a more quality-oriented and student-centred culture, although there is much tension between the national policy and practices at school level (Liu and Dunne 2009).

7 Examples of online work sampling system can be found at https://www.worksamplingonline.com/ and training basics can be found at http://www.pakeys.org/docs/WS%20Admin%201.pdf.

3.2.5.2. Coherence and consistency of assessment criteria across grade levels

Based on the cognitive models describing the skill constructs, specific expected learning outcomes at different levels can be aligned based on the skill development progression. Bloom's taxonomy framework categorizes cognitive demand into six categories (Davis and Buckendahl 2011: 306).

a. Knowledge: Information retrieval

b. Comprehension: Understanding the meaning of information

c. Application: Using information to solve problems that have a best answer

d. Analysis: Understanding parts of a whole and the organization of the parts to make inferences or draw conclusions

e. Synthesis: Applying knowledge and skills to produce new ideas or representations of material

f. Evaluation: Using information and knowledge to make judgments

This could be used as a common framework across different grade levels in designing assessment criteria, and cognitive demand can be operationalized differently based on students' competencies. In other words, as the grade level gets higher, there will be more emphasis on higher-order thinking items in the framework. For information on how to write clear learning outcome statements, please refer to section 2.3.1.

At a lower grade level, the curriculum and assessment standards can be loaded more with lower-level processing such as knowledge and comprehension, gradually helping the learners move to the higher-order skills such as "analysis" and "synthesis". A common assessment criteria framework can make the articulation process easier across grade levels.

Research in the cognitive field and learning sciences to date has clarified the hierarchical levels of various higher-order thinking skills (Schraw et al 2011), which can help with writing clear and aligned expected learning outcome statements across grade levels.

3.3 Summary

Section 3 focused on research question 3: How is the issue of age-appropriateness addressed, that is, how are connections between metacognitive, cognitive, affective and sociocultual development of children and young adults and these learning approaches and skills specified?

In section 3.1, theories on cognitive, metacognitive, sociocultual and affective development were reviewed and their implications were discussed. Although Piaget's cognitive development theory has been criticized for its oversimplification in describing development stages, it gives us a basic framework to understand age-related constraints on learning. For example, it is difficult for elementary students to think abstractly and systematically; thus, more visual tools and sociocultually familiar problems are needed to ground the abstract concepts. Vygotsky's theory emphasizes the importance of the sociocultual environment and social interaction on development. Comparative studies show that teachers' classroom scaffolding methods may differ cross-culturally (see section 3.1.2). The central notion of Vygotsky's theory is the zone of proximal development (ZPD), which provides implications for classroom practices. For example, teachers can ask the students to explicitly explain the learning process, measure students' ZPD through interaction, and provide adaptive scaffolding and guidance. The ZPD notion is especially important to develop students' metacognitive ability (section 3.1.3). Students' social cognitive and affective development also goes through stages, and adolescence is a critical period for social and affective development.

In designing developmentally appropriate curriculum, instruction and assessment, students' cognitive, metacognitive, social-cognitive and affective abilities, and their sociocultual background need to be fully addressed. Recommended curriculums can be modified based on students' prior knowledge and other age-related characteristics (section 3.2.1). How age-related factors can be addressed in implementing constructivist approaches such as inquiry-based and problem-based learning was discussed in section 3.2.2. Some

illustrations of adaptive pedagogy and instruction for different age groups can be found in sections 3.2.3 and 3.2.4. Delineating assessment criteria and differentiated assessment have been discussed in section 2.3. Regarding developmentally appropriate assessment, various formative assessments such as authentic assessment may be easier to implement at elementary level and middle school level, and it has been argued that more differentiated assessment methods are needed at higher grade levels. Aligned assessment criteria across grade levels may increase the coherence and consistency of assessment at school level (section 3.2.5).

4. Concluding remarks: Implications for the IB's three programmes and programme transition

4.1. Problems in the transition across the three IB programmes

Historically, the IB's three programmes appeared at different times[8]. The DP was initially introduced in the 1960s emphasizing "international-mindedness in students". As a pre-university programme with external examinations, it is successful in its academic rigour and wide university recognition (Stobie 2005). The PYP and MYP were adopted 20 to 30 years later for a K-12 continuum of international education, based on the same philosophy as the DP: global, intellectual, personal, physical, creative and social development of students (Bunnell 2011). The curriculum in the MYP is expected to prepare students well to enter the DP. Different from the DP, there is no external examination at the end of the MYP, which allows the MYP to be more flexible and holistic. The educational philosophy of the IB programmes is coherent and consistent, as indicated in the IB curriculum documents (Stobie 2005). However, smooth transition across the programmes in partial and full continuum IB schools faces many difficulties and challenges.

First, the three programmes of the IB are self-contained and have different structures and curricular approaches (Bunnell 2011). The challenges in the transition from the PYP to the MYP, and from the MYP to the DP can be analysed from academic, procedural and social perspectives (Cauley and Jovanovich 2006). The PYP emphasizes knowledge construction through personal experience and inquiry, and takes an integrative approach in designing the curriculum. The MYP takes an interdisciplinary approach in curriculum design, and there could be much more academic and social demand on the students compared to the PYP. Additionally, the social-cognitive and affective characteristics of young adolescents may add another level of difficulty in the smooth transition from the PYP to the MYP. The DP has a much more test-oriented culture than the PYP and the MYP. Teaching practices in the MYP are inquiry-oriented while the detailed prescribed content in the DP may inhibit the implementation of an inquiry approach. However, a lack of in-depth content knowledge may result from such an inquiry-based curriculum framework, thus inhibiting high quality learning of discipline specific knowledge. It has been argued that more standardized assessment for accountability in the PYP and MYP is needed. Unclear assessment standards are sometimes cited as one of the major limitations of the PYP and the MYP (Stobie 2005). Inconsistent curriculum objectives, teaching practices and assessment tools across programmes are big obstacles for smooth transition. Cross-curricular thematic approaches of curriculum development may sometimes be operated in a superficial and "forced" manner (Bunnell 2011). While in the DP, a detailed content and rigorous test preparation curriculum might have restrained the implementation of student-centred and constructive approaches. More integrative and interdisciplinary curriculums, reduction of detailed content, a "holistic" development approach, and more diversified assessment methods need to be implemented (Hallinger, Walker and Lee 2011). Based on a global survey commissioned by the IB in 2008, Hallinger, Walker and Lee (2011) analysed the major challenges in the IB programme transition. In total, 177 IB World Schools (around half of them were full continuum IB schools offering all three programmes, and half were partial continuum IB schools offering two programmes) and 235 IB coordinators participated in the survey study (please see Table 2 and Table 3 for some descriptive statistics from the survey).

[8] As mentioned earlier, the IBCC is not included in this discussion.

Issue	Percentage of IB coordinators who viewed the issues as transition challenges
Dealing with detailed and prescribed content in DP	69%
Change in student attitude to learning	52%
Transition problems embedded in programme design (MYP)	46%
Decreased emphasis on skill development in the DP	42%
Difficulty in identifying through-lines	40%
Discontinuing holistic development of students	38%

Table 2. Challenges in MYP–DP transition indicated as relevant by IB coordinators (Hallinger, Walker and Lee 2011: 129)

Area	Percentage of IB coordinators who indicated an area needed to be changed
1. Publication of MYP vertical and horizontal articulation documents	87%
2. Publication of IB cross programme articulation documents	81%
3. Provision of more teacher support and guidance for the MYP	78%
4. Greater MYP recognition with governments and universities	76%
5. Development of standardized internal MYP assessment tasks	67%
6. Access to a wider range of assessment tools in the DP	65%
7. Increased emphasis on interdisciplinary learning in the DP	61%
8. More teacher support and guidance for the DP	54%

Table 3. Eight areas where there is a need for change regardless of school types (Hallinger, Walker and Lee 2011: 130)

Second, misconceptions about the content and skills development may have hindered the curriculum and pedagogical alignment. Learning skills cannot be easily acquired without interacting with meaningful content knowledge. Although inquiry-based learning is emphasized in the MYP, an effective inquiry-based approach fostering deep learning is difficult, since the curriculum touches upon a broad scope of topics without much depth of content; it has been recommended that some prescribed curriculum for the MYP might be effective (Hallinger, Walker and Lee 2011). Suggested curriculums can be provided in the MYP leaving the designers and teachers enough flexibility to readjust and redevelop the curriculum units. In this way, the MYP curriculum can be more structured but still leave enough space for flexibility and creativity (Visser 2010). In the DP, the learning skills are expected to be developed in the “reflective theory of knowledge” course, which might not be sufficient. Skills development needs to take place in various disciplines.

Third, the adoption of the IB's three programmes and the transitional difficulties across programmes may differ across cultures, which makes the articulation and practices more difficult. In the Hong Kong Institute of Education's project on "successful practices in the IB programme continuum" (Hallinger, Walker and Lee 2010), mixed methods were used with quantitative analysis of a global survey on programme transition and case studies of five IB schools in the Asia-Pacific region (two in Thailand, one in Vietnam, one in Hong Kong, one in mainland China). Differences and similarities of Asia-Pacific IB schools and other IB schools were synthesized. For example, IB schools in the Asia-Pacific region in general have a more test-oriented learning culture even in the MYP, thus external MYP examinations may not be viewed as important, while the implementation of an effective inquiry-based approach may encounter more difficulties. One limitation of this literature review is that cultural factors are not addressed in enough depth; studies from other cultures such as African and Latin American, and systematic cross-cultural comparison are not covered in this literature review.

In articulating the transition problems in a specific culture, the academic-procedural-social structure (Cauley and Jovanovich 2006) could be a useful framework for delineating the transition difficulties in different cultures. When the MYP is adopted in a specific culture, readjusting and redeveloping the curriculum based on the cultural characteristics and specific constraints could be a very useful strategy. For example, when the MYP was adopted in Dutch public schools, the MYP as an international model encouraged the teachers to think beyond textbooks and readjust the curriculum and instruction to fit both the local and the IB's requirements (Visser 2010). How the IB's programmes can fit into a specific cultural context is an essential question for the IB to explore. To make the question more researchable, two sub-questions are delineated: "how to readjust and redevelop the curriculum, instruction and assessment in a specific cultural context?" and "how to articulate the cultural characteristics for readjustment and redevelopment?"

4.2. Potential strategies for facilitating the PYP–MYP–DP transition: More action research needed

In this section, implications drawn from the review on "approaches to learning" will be discussed in three sub-sections: Coherence and consistency of the curriculum and pedagogy across the PYP–MYP–DP; aligned assessment approaches in the PYP–MYP–DP; and transitional programmes and teacher training.

4.2.1. Coherence and consistency of curriculum objectives and standards across the PYP–MYP–DP

To ensure the continuum of the PYP–MYP–DP, different dimensions of curriculum objectives including content and skill sets standards need to be aligned.

4.2.1.1. Curriculum content

Staff members in a school can work together to map the curriculum for continuity across programmes (Hayes-Jacobs 1997). Teachers need to become familiar with the curriculum content in different programmes, which can serve as references for them when choosing thematic topics in their own classroom.

As supported by some successful applications of prescribed curriculums (for example Johnson et al 2001), bringing challenging content knowledge into the PYP and MYP, but with age-appropriate instruction could be useful practice. Content knowledge may make deep and elaborate inquiry possible (Hedge and Cullen 2005). Some prescribed curriculum topics in the PYP and MYP with age-appropriate instruction may create some level of continuity across the programmes. Both school-wide and within-programme curriculum content maps can be designed and shared among teachers. An example of a within programme curriculum content map is given in Table 4. Additionally, as a topic for teacher training, teachers in the three programmes need to enlarge their knowledge repertoire of the school-wide curriculum content. Some techniques can be used to increase the level of continuity of curriculum and pedagogy across programme levels, for example, tackling different levels of a topic across grade levels could potentially increase the continuity of the school-wide curriculum.

Even prescribed curriculums can be modified to adapt to students' sociocultual backgrounds. Questions need to be addressed when teachers are working on a specific curriculum unit, for example, "what is most meaningful for this group of students" and "what problems can give this group of students a sense of self-relevance?"

Topics	Kindergarten	1st grade	2nd Grade	3rd Grade	4th Grade
Environment	Seasons	Weather	Seashore	Ecology	WatercCycle
Physical world	Sink and float	Magnets	Attributes	States of matter	Electricity
Human body	Five senses	Safety	Nutrition	Health	Circulatory system
Living things	Animal families	Seeds and plants	Habitats	Life cycles	Adaptation

Table 4. A K-4 science curriculum content map (Eby, Herrell and Jordan 2006: 85)

4.2.1.2. Alignment of curriculum standards

Downward planning of curriculum standards is believed to increase the continuity of curriculum standards and facilitate cross-programme articulation (Hallinger, Walker and Lee 2010).

As has been discussed in 2.3.1, at the macro level, specified and contextualized learning outcome statements need to be written within each programme and shared across programmes; and at the classroom level, clear learning outcome statements can be used to direct curriculum planning, pedagogical design and assessment.

Other learning objectives from the social and affective perspectives can be contextualized in a similar way as cognitive goals, with school-wide downward planning. Clear outcome statements indicating what exactly students are able to do in a context (rather than vague statements) are essential for classroom implementation. This is an example of a classroom-based affective outcome statement:

"Students will become aware of the amount of time they and their classmates spend watching television and will make value judgments about whether they want to continue spending their time in this way." (Eby, Herrell and Jordan 2006: 124).

4.2.2. Alignment of pedagogy

4.2.2.1. Student-centred approaches

Inquiry cycles have been implemented in all three IB programmes. An inquiry cycle (for an example, see "Appendix B") can be tailored to adapt to different age groups and can differ in the dimensions such as problem complexity, the number of student-initiated activities, the requirements for systematic question-asking, the level of teacher support, and so on. In cultures where transmissive instructional models are pervasive, more training might be needed for teachers' roles to change. The teachers in all three programmes need to be trained to attend to students' ability in conducting inquiry and provide effective scaffolding in the ZPD. For example, compared to the DP, in the PYP and MYP, teachers might need to provide more benchmark lessons to equip students with sufficient prior knowledge and more explicit inquiry strategies, such as worksheets listing the inquiry steps. When implementing an inquiry-based approach in the DP, more self-regulation and reflection may be expected. Inquiry-based learning needs to be strategic and explicit to increase students' metacognitive awareness. Criterion-referenced self-assessment and peer assessment (for example, with inquiry skills checklists or rubrics; see 2.3.2.2) can clarify what the students should do to meet the learning requirements, and thus increase metacogntive awareness and self-regulated learning behaviours.

There are some different concerns in implementing various constructivist and student-centred learning models in the three programmes. For example, in the PYP and MYP, although inquiry-based and problem-based approaches are emphasized, age-related constraints might need to be addressed to provide developmentally appropriate instruction. It has been argued that more inquiry-based and problem-based approaches need to be implemented in the DP (Hallinger, Walker and Lee 2010). Teachers need to be trained to develop integrative inquiry-based curriculums to avoid only superficial implementation. To start from a discipline and try to deliberately bring in content knowledge from other disciplines may not give students a sense of "authentic real-life problems". Teachers need to work together around real-life problems to develop integrative curriculums. Various real-life problems from today's occupational fields (for example, business, engineering, journalism) can be used to design integrative topics (Vars and Beane 2000).

Thinking and learning skills as common objectives in the three programmes might also better align the pedagogy across the programmes. For example, the learning objectives can be loaded more on the lower levels of a skill construct in the PYP and MYP, and more on the higher levels of a skill construct in the DP. In the DP, more skills-oriented interdisciplinary curriculum and instruction can be designed. Targeted development of skills could be implemented in which various student-centred approaches can be embedded including project-based learning approaches, inquiry approaches and collaborative learning.

Cross-cultural differences need to be accounted for in implementing various instructional approaches. For example, it could be more difficult implementing student-centred approaches in IB schools in the Asia-Pacific region since it might be difficult for teachers to shift the focus of their roles in the classroom. Compared to more individualistic cultures (European and American societies), students in more collectivist cultures (many Asian and Latino group-oriented societies) are not accustomed to student-initiated questions in inquiry-based learning, and effective collaborative learning could be difficult. More teacher training might be needed in these contexts to facilitate the implementation of student-centred learning approaches. A higher level of teacher involvement in collaborative learning and more intervention might be needed for students to understand the expectations, and the guidance needs to be more explicit.

4.2.2.2. Learning how to learn

Self-regulated learning (SRL) is emphasized in all three IB programmes. SRL is a relatively domain-general skill (please see section 2.1.4). Key components of SRL include the ability to:

a. effectively choose and coordinate various cognitive strategies

b. set learning goals and direct one's own learning

c. commit to and engage in reaching the self-set goals (Boekaerts 1999).

As has been discussed in 3.2.2, at different developmental stages, students have different self-regulated learning skills. Teachers need to measure students' self-regulation abilities effectively in various contexts and provide adaptive intervention. Criterion-referenced informal assessment is very important to measure SRL skills since it is a complex construct with many dimensions and manifestations. The learning objectives, contextualized outcomes (SRL behaviours in specific contexts) and teachers' experience in providing intervention in the ZDP in each programme can be written in the articulation documents and shared with other programmes. Although the exhibition project in PYP, personal project in the MYP and extended essay and reflective theory of knowledge course in the DP are argued to practise students' research skills, metacognitive ability and learning skills, self-regulated learning needs to be emphasized beyond the small project level and needs to be developed consistently and continuously at the classroom and school levels. This could be an important issue for the IB worth further exploration.

4.2.3. Aligned assessment approaches in the PYP–MYP–DP

Both formative and summative assessment need to be based on the curriculum standards and learning outcome statements for the alignment (how to write clear outcome statements and design criterion-referenced assessment is dealt with in 2.3.1); in this way, formative assessment can provide explanations for the summative assessment results. For the PYP and MYP, formative assessment needs to be more criterion-based, and aligned with the summative assessment. Age-appropriate formative assessment such as authentic assessment with clear criteria (see 3.2.5) can be implemented. While in the DP, a variety of criterion-referenced formative assessment as discussed in section 2.3.2 can be implemented.

Across the programmes, reliable and valid summative assessment is essential for accountability. To address age-appropriateness and cross-programme continuity, it could be effective to apply common school-wide assessment frameworks with differentiated weightings loaded on different hierarchical objective items. Bloom's taxonomy assessment tools adaptated to fit different levels are good examples.

4.2.4. Special transitional support and teacher training

A sudden change of learning cultures might lead to an identity crisis, which could lead to negative consequences in school performance. Special transitional support clarifying the central objectives and learning cultures in a new programme are very important for new identity formation (Winther-Lindqvist 2012). Cowie de Arroyo (2011) studied how special support for academic, procedure and social transition could improve academic performance. This action research project was conducted in a K-12 IB school in Bogotá, Colombia. The transition support led to much improved academic performance in that school. One of the strategies from the academic perspective: a group of teachers were trained, teaching two subject areas each and collaboratively creating interdisciplinary curricular units to help students move from a transdisciplinary to an interdisciplinary unit. One of the strategies from the procedure perspective: since middle school teachers didn't know their students as well as the elementary teachers, in the first year of the MYP both the number of teachers each student had to interact with and the number of students a teacher needed to supervise was reduced, which helped the teachers better understand and attend to students' individual needs. One of the strategies from the social perspective: because young adolescents are more sensitive to social competition and peer pressure and need to feel secure and successful, more suitable assessment tasks and education supports were provided.

Sufficient guidance and collaboration among teachers has been recognized as an essential aspect in the IB's three programmes and in programme transition. Sections 2.5.2 and 2.5.4 briefly touched on teachers' professional development models, which are important topics for future research.

5. Summary: Limitations and suggestions for future research

Various learning models and their implementation are discussed in this literature review. Articulation is believed to be "a key vehicle for program transitions" in the IB (Hallinger, Walker and Lee 2010: p 79). How to ensure effective articulation and alignment of programme objectives, curriculum, pedagogy and assessment still remains obscure. The learning approaches and concerns about age-appropriateness reviewed in this paper provide frameworks for future research and discourse. Scaffolding and careful planning are essential in implementing constructivist learning models such as inquiry-based and problem-based learning. Teachers need sufficient guidance and training in enacting constructivist learning models in the IB programmes, addressing age- and cultural appropriateness. Age-related and cultural-related factors need to be fully addressed in curriculum planning and enactment. Aspects including cognitive, metacognitive, social-cognitive and affective development set a framework for describing age-related constraints in the IB's programmes. Not enough action research and case studies are reviewed in here, which is one of the paper's limitations. In-depth case study results and case-based description need to be included in the articulation documents.

Regarding some limitations of the three programmes, it is important for the IB programmes to search for a balance of content knowledge and skills in the curriculum standards. For example, it is difficult to conduct deep inquiries in the PYP and MYP because of the lack of in-depth content knowledge resulting from the inquiry based approach. It might be helpful to bring in some content knowledge from a higher grade level while readjusting it to be meaningful to a lower grade level. Some limitations in the DP include the difficulty in implementing an interdisciplinary curriculum and the lack of development of skills. Authentic problems from the occupational fields can be brought into the curriculum in the DP, allowing for more integrative curriculum units. A deep look into the constructivist approaches show that content knowledge and skills cannot go without each other. Skills development should go beyond any single course and special project; rather, it should be emphasized in all disciplines and in everyday classrooms. For example, students can be taught to evaluate their own learning with rubrics in different classes, and teachers can encourage think alouds and explicitly teach self-regulated learning skills in the classroom. More school-based action research and case studies are needed to verify these approaches.

From sociocultual and affective perspectives, creating secure environments are very important to students' academic achievement and programme transition. For example, strategies such as reducing the competition and peer pressure by adjusting the assessment format and providing academic support may facilitate programme transition from the PYP to the MYP (Cowie de Arroyo 2011). Sociocultual and affective supports could be provided at the school level for better programme transition; cultural characteristics of a specific

school also need to be addressed in the implementation. This is an important research question for the IB to further explore.

One major limitation of this literature review is that the cultural factor in implementing the constructivist approaches is not discussed enough. Most of the studies reviewed in this thesis are conducted in western and Asia-Pacific regions, so are not inclusive enough. In the future, more systematic worldwide cross-cultural comparison including North American, European, Asia-Pacific, Latin-American and African cultures are needed.

About the Author

Na Li is a PhD candidate in Cognitive Studies in Education at Teachers College, Columbia University. Her work focuses on learning sciences and understanding the complex cognitive mechanism behind learning and designing adaptive learning environments and instruction. Research interests include complex learning, systems thinking, science inquiry, instructional scaffolding and technology-enhanced learning environments, and her dissertation is entitled "*Designing Better Scaffolding in Simulation-based Learning Environments Teaching Complex Science Systems*". In her own words, "once regarded as a slow kid at school, I simply dreamed of becoming a good student, then a good educator. Now that the dream is no longer beyond my reach, I feel a strong a responsibility to devote a lifetime to education. Life is really amazing!" Na Li received her BA from Zhejiang University in China.

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Appendix A: General guidelines and implementation examples

	US Common Core Standards	European Education Framework on Language Learning	Hong Kong Curriculum Development Council
Some key aspects demonstrated in the curriculum standards	Teaching problem-solving and inquiry Balancing knowledge and skills Emphasizing deep and higher-order thinking Teaching team work Self-regulation Teachers role as a facilitator (ASCD "Whole Child Bloggers", 2012) Retrieved from: http://whatworks.wholechildeducation.org/blog/project-based-learning-and-common-core-standards/	A performance-driven approach Acquire competencies including knowledge, skills and characteristic that allow a person to perform actions A balance of knowledge and skills Sociocultual aspect of development Account for the differentiated characteristics and needs	A balance of various aspects of development (intellectual, sociocultual, moral, atheistic) Study skills such as self-regulated learning Thinking skills such as problem-solving, analytical, critical and creative thinking Sociocultual, moral aspect of development Communication skills
Some implementation examples	**Common core standards: Mathematics** Students are expected to make sense of mathematical problems and persevere in solving them: younger children may interact with realistic visual objects to understand the mathematical problem; students guided to construct a coherent representation of a mathematical problem rather than just computing them Critical thinking is emphasized in constructing mathematical augmentations and in communicating with others Students can be asked to creatively use various tools in discussing mathematical concepts (eg, construct tables, diagrams and flowcharts) In practising inquiry, students can be guided to use various resources such as digital visualization to help them conduct a variety of inquiry strategies	**Second language learning** Diversified goals in the curriculum planning and instruction for a pluricultural and plurilingual class Authentic use of language (eg using authentic written texts such as newspapers, magazines; participating in computer conferences) Collaboration (eg conversation with a competent partner on an authentic issue) Guided self-regulated learning (eg the teacher and students negotiate and pursue self-directed objectives with the help of available instructional media) Differentiated instruction for diversified instructional goals and individual needs (eg diversified learning activities, a combination of presentations, explanation, group work) A balance of content knowledge and skills (eg drill exercises and practice in authentic contexts)	**Science education** Emphasize self-regulated learning (eg, students need to learn to actively search for information from multiple resources including libraries, various digital resources; students need to actively engage in designing and conducting scientific experiments) Emphasize scientific thinking (eg students are asked to propose hypotheses for an intriguing phenomenon; introduce how scientists conduct an experiment; various hands-on collaborative activities) Help students understand the relationship between science, technology and society—develop the attitude of responsible citizenship

Appendix B: Inquiry-based learning approach examples—An inquiry cycle

(Schwarzer and Luke 2001)

Activate prior knowledge

In learning a history topic, students are asked to watch video clips and read interesting historical stories, the teachers may scaffold the discussion and invite questions. In learning a science topic such as water quality, the students can first experience the real life cases on “water and environment” with internet resources. In learning mathematical concepts such as “fractions”, the students can first be asked to discuss some real life examples related to fraction concepts, and bring in prior knowledge.

Find questions based on observation, experience and explorations

With some major directions and example questions, the teacher can invite questions after the students read the historical stories. Through classroom and group discussions, the teacher can help students elaborate their questions; the questions can be recorded and categorized into types for students to reflect upon.

Learn multiple perspectives: inquiry groups, research, experiment, studio time

The teachers can introduce experts’ perspectives on a historical event with multiple resources, and record and compare different ideas on a poster board. Knowledge about the ecological system, and relevant science knowledge about water and pollution are brought in, and the students are encouraged to test their hypotheses with computer simulations on the relationships between human activities and water quality. With multiple fraction examples and with various instructional tools (for example, digital visual manipulatives), the teacher guides the students to recognize the fraction concepts in those concrete problems.

Compare, contrast and critique multiple perspetives

Students are encouraged to compare their own initial concepts to experts’, The teacher can design some rubrics listing various aspects the students can compare and critique on.

Share learning experience

The groups can be asked to present their inquiry circle including “questions they initially have”, “what were their hypotheses”, “what and how they learn to test and hypotheses”, “what conclusions they can draw”, and so on. As one group is presenting, other groups can be asked to critique their peers’ work and use peer assessment rubrics.

Reflect upon learning experience and plan new inquiries

The groups get feedback from the teacher and their peers after presenting their work, and then can be guided to learn new knowledge to fill some gaps. The assignment can be to write reflection essays (with guiding questions) summarizing how they could improve the work. The teacher can also give a benchmark lesson commenting on students’ work and introduce more sophisticated inquiry strategies.

Take thoughtful action and apply new knowledge

After the inquiry cycle of work, the students can be encouraged to use what they learn to design a plan for solving a practical problem (for example, how to improve the water quality in a neighbourhood). Students can be guided to undertake assignments fostering higher-order thinking, for example, synthesizing the concepts

about an historical event generated by the whole class. Students can also be asked to start another inquiry cycle by probing deeper into a problem.