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Interest-Driven Creator Theory: case study of embodiment in an experimental school in Taiwan

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Abstract

Cognisant that the examination-driven culture in most Asian schools will hinder future educational innovation, a group of concerned Asian researchers started collaboration in 2014 to develop a theory to serve as a guide to design interest-driven learning activities. This endeavour then spawned the development of the Interest-Driven Creator (IDC) Theory. The theory postulates that when their learning is driven by interest, students can be engaged in knowledge creation. The continued practice of this creation process in their daily learning routines can lead students to excel in learning performance, develop 21st century competences and eventually form creation habits to be lifelong learners. This paper, therefore, adds on to the current articulation of IDC Theory by highlighting the implementation of an IDC experimental school in Taiwan and by presenting the story of how it embodies the spirit of IDC. The school curriculum prepares students to be lifelong readers and reflective writers with broad knowledge in the fields of Math, English Language, Science, and Interdisciplinary Social Studies. It emphasises not only students' academic growth but also their physical wellness and character building. The endeavour intends to be a comprehensive example of practice-driven research, demonstrating how theory and practice can be bridged, and how a virtuous cycle of research improving practice and practice informing research can be developed. This paper also provides a glimpse of how IDC Theory can inspire the planning and integration of IDC-based education approaches in academic curricula beyond Taiwan. The paper ends with the call for a more concerted effort to create a sustainable alliance to share professional insights into IDC Theory through a non-governmental organisation.

Keywords: Interest-Driven Creator Theory, Innovative school, Experimental school, Curriculum design, Math-Island, Sustained silent reading, Writing curriculum, Math curriculum, Science curriculum, English curriculum, Social study curriculum, Creation, Interest, Habit

Introduction

Since ancient times, the purpose of education has been to bring people to the fullest possible development and realisation of what it means to be a human being while, at the same time, meeting the changing needs of an evolving society. As education progresses into the 21st century, the debate on what our students need for their learning continues to receive attention. For example, Chan (2013), based on the conclusion of a workshop by a group of Taiwanese researchers, summarised the core competences in 21st century as *Learning For Competences* (*L4C)*: *L*ifelong learning, *C*omplex problem solving, *C*ritical thinking and reflection, *C*ommunication and collaboration, and *C*reativity and imagination (also see P21, 2002). Kereluik and colleagues (2013) argued that today's students must not only be able to acquire skills and knowledge on their own but also create new knowledge, resolve complex problems, and think creatively. Harvey (as cited in Sloan, 2012) stressed that 21st century learners must be thinkers. Having a mind to think will inevitably lead students to be successful lifelong learners—where they are able to learn, un-learn, re-learn, co-learn and eventually co-create.

What remains worrying is that the Asian education systems have been slow to respond to the pressing demands of the knowledge-oriented and lifelong learning society. Formal education still remains much the same where students are assessed in terms of their academic achievements or performance. Schleicher (2018) warned that without substantial change to the education systems, the likelihood of the widening gap between what education systems provide and what our societies demand will continue at a worrying rate. He stressed that "there is a risk that education becomes our next steel industry, and schools a relic of the past" (Schleicher, 2018, p. 203). Learners are still being taught the same way as they were in the past through a standardised curriculum that glorified rote learning and individualised testing which resulted in disengaged and unmotivated learners, echoed by Driscoll (2019).

Chan et al. (2018) raised a timely concern by pointing out that formal education in Asia remains examination centric. Given that high stakes examination results shape students' choice of a future career in many parts of Asia, high examination pressure continues. For example, in Asian countries and regions such as Taiwan, Singapore, Hong Kong, Malaysia, Japan, Korea, China and India, students, parents and society at large regard paper qualifications as the epitome of academic success. Moved by the aforesaid scenario, a group of concerned Asian researchers initiated collaboration in 2014 to develop a theory to serve as a guide to design interest-driven learning activities that could engage and motivate learners in classrooms and eventually turning them into habitual learners through the creation of their own knowledge. This endeavour then spawned the development of the Interest-Driven Creator (IDC) Theory through many hours of online and face-to-face discussions amongst the researchers. Intrigued with this theory, several Asian researchers

started applying IDC Theory in the design of learning activities for their students albeit in a piecemeal manner.

Now, within the Asian community, what started as a theory has now led to a more serious endeavour in solidifying the tenets of IDC Theory and, through development and practice, moving it forward for better understanding the future education of Asia (Wong & Wong, 2019). This endeavour has become even more pertinent given that IDC Theory can also play a crucial role amidst the COVID-19 pandemic that has caused unprecedented challenges to the education sector. Approximately half of the world's student population (850 million children and youth) had their education disrupted and were prevented from receiving formal education in 2020 (UNESCO, 2020).

The Asian researchers behind IDC have remained steadfast in their conviction that students can succeed in learning if they develop interest in learning early on. When students develop "self-pursuit interests", they are more likely to develop lifelong learning habits. Thus, with interests and habit formation, and some guidance by their teachers, students will plan, manage, and continue their own learning during the prolonged closure of learning institutions due to the COVID-19 pandemic or even, as preparation, for the post-pandemic era.

This paper seeks to add on to the current articulation of IDC Theory by highlighting the implementation of an IDC experimental school in Taiwan (hereafter we call it the IDC School) and presenting the story of how it embodies the spirit of IDC. In the next section, the concept of an experimental school implemented in different parts of the world is reviewed.

Reviews of some experimental or innovative schools motivated by new ways of learning or pedagogy

In this section, we review some examples of experimental or innovative schools. This review is far from being comprehensive; instead the cases presented are intended to show the disruptive or transformative nature of such schools at the time they were conceived or started in different parts of the world. Indeed, Summerhill School in the east coast of England—considered to be the oldest and most famous democratic school, founded in 1921 by Alexander Neill, embodies what an experimental or innovative school should look like. The founder set out to create a school to fit students rather than forcing students to achieve what parents and teachers expect of them (Summerhill School, n.d.). The school emphasises expressing emotions and learning through feelings where students have the right to play and lessons are optional—a deviation from mainstream schools. As society becomes more concerned with rigid learning environments that focus on knowledge acquisition, memorisation and examination; more alternative schools that are underpinned by the theories of Rudolf Steiner and Maria Montessori began to emerge in recent years.

One of innovative schools is Hellerup School in Denmark. Established in 2000 to 2002, Hellerup School illuminates the present and the future of its space design, where "a modelled landscape with staircases, plateaus, balconies and bridges, and the children can sit, jump about, stand, and move around … The central functions are associated with the staircase or atrium, while teaching takes place in the students' home areas, which are located in the more peaceful corners" (Hellerup School, 2022).

The focus of their students' learning is to develop skills required in the future, such as critical thinking, creative thinking, collaboration, intercultural awareness, and problem solving. Through learning by constructing and learning by play, the school promotes active and engaging learning. Compared with other schools, students are always challenged to be responsible for their own learning to enhance their self-directed learning ability. An innovative timetable is created where the students start studying together for about 10 to 15 minutes, and then they can select to work alone or with their peers based on their needs. Furthermore, a wide range of formative and summative assessment methods is used to assist the students in understanding their progress and future targets, including personal digital portfolios, logbooks, and student plans in the form of assessment. Technology is the key driving force for such innovations. The students not only can access a wide range of devices but also incorporate such technology in a natural and multi-dimensional way, for instance, mobile learning (Kampylis et al., 2013).

In terms of academic achievement, Hellerup School is successful as most of the students are able to enter the higher education institute. Their strengths are especially reflected in project work, independence, time management, collaboration skills, and knowledge of their own learning capabilities and strengths. Even though Hellerup School is a well-known innovation for learning at a small scale, it has a noteworthy impact. As the demand for learning in this innovative school is high, it has contributed to the reform of the industrial zone where it once was located. Besides, it adds value to the local community and warrants stable funding as a public school. With a continued record of innovation, stable funding, and a good multi-stakeholder engagement relationship, it not only meets short-term needs, but also achieves long-term vision, and has formulated a strategic plan to become a future school. Overall, Hellerup School is a promising and sustainable innovation (Kampylis et al., 2013).

Another concept of innovative school is the Chartered Schools in the US. It was a new type of public school that set up since the year of 1991 when the Minnesota governor received a huge education funding bill. Avalon is a living example of the early vision of a chartered school that opened in 2000. This idea was partly conceived by the late Albert Shanker (the president of the American Federation of Teachers) as a way for teachers to develop their own experimental schools. The mission of Avalon School is to prepare students for college and life in a strong, nurturing community that stimulates active

learning, active participation in citizenship and hope for the future. Avalon is built on project-based learning, and students employ the majority of their time alone or in small groups researching projects related to core domains. Unlike traditional school, the teacher runs the school without a principal and superintendent, and makes all decisions on curriculum, timetable, staffing, and budget (Prothero, 2016).

The Innovation Institute of Shanghai American School is a transformative educational method where students can solve real-world problems through a process of innovation and collaboration. The institute provides a two-year program (9th and 10th grade) that puts learners at the centre of the educational experience and nurtures them to think critically and apply their learning to solve contemporary problems with openness and complexity. Students are necessitated to go beyond the traditional learning framework by participating in interdisciplinary projects that need the application of 21st century skills. After studying at this institute, students are able to build up their capabilities in determining and responding to complex issues and problems, adapting to uncertainty, communicating their thoughts about the world in a variety of ways, creating a connection between curriculum and the real world, easy to share ideas and accepting criticism, collaborating effectively, and able to take risks (Shanghai American School, 2020).

The aforesaid schools share common characteristics where they approach education from a new perspective. Positive learning experiences are being designed to be relevant to student interests and personalised to their abilities. An experimental or innovative school is a school that leaves room for un-expectancy and creativity, not just a place that uses the traditional rules (Vanier & Malone, 2017). Clearly, such schools share a common vision of powerful learning which appreciates and promotes deep engagement to empower students to become successful lifelong learners.

Overview of IDC Theory

In this section, we provide a brief review of the IDC Theory. It is a theory constituting three anchored concepts—interest, creation and habit. Each concept consists of a loop comprising three components (Figure 1). This theory postulates that when learning activities in classrooms are designed to spark student interest, this will generate an impetus for students to be engaged in the knowledge creation process which then leads them to be habitual learners through repetition of the creation activities in their daily routines.

The first anchor—Interest Loop promotes learning by *triggering* student interest to learn by arousing their curiosity to acquire new knowledge (Wong et al., 2015; Wong et al., 2020). Once students acquire new knowledge or experience by being inquisitive, they start *immersing* themselves in the learning activity which puts them in the flow state. Students are then completely engrossed in the learning process and start making sense of what they have learnt by *extending* their learning interest to learn even more.

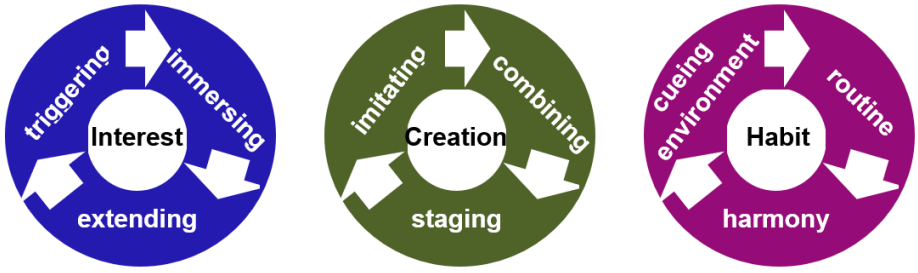

Fig. 1 Three anchored concepts of IDC Theory

The second anchor—Creation Loop focuses on learning processes and outcomes (Chan et al., 2015; Chan et al., 2018; Chan et al., 2019). It extends the meaning of learning as knowledge acquisition (*imitating*) to learning as idea generation and artefacts construction (*combining* for delivering a learning product) and learning as having the learning product being shared and revised by receiving feedback (*staging*). Thus, learning cycles through three stages. At the first stage, students learn by *imitating* the practices of their teachers, mentors or peers. Imitative learning is seen as a natural way of learning and Aristotle once said that man is the most imitative creature in the world and learns at first by imitating others (as cited in Noë, 2016). In the second stage, students then create new ideas or knowledge when *combining* the acquired background knowledge with existing knowledge and artefacts. They then proceed to the final stage, *staging*, where they have the liberty to share or showcase their creation and receive feedback from peers or teachers. It should be noted that activities in each stage must be designed so that, based on the Interest Loop, they can nurture student interest in the pertinent domain to learn, possibly through pedagogical contexts such as self-directed learning, collaborative learning, or game-based learning.

The final anchor—Habit Loop begins with a *cueing environment* (arrangement of place, time, people, or incidents). It acts as a trigger to what is happening in the students' learning environment and their response in the form of learning behaviour (Chen et al., 2015; Chen et al., 2020). According to Lally and Gardner (2013), habits are formed through consistently repeated behaviours over time and is prompted by environmental cues. Such incessant behaviour will eventually progress into a *routine* until they achieve a sense of *harmony*. Students experience a sense of accomplishment coupled with satisfaction and inner serenity—a culmination of students' efforts (Chan et al., 2018; Chen et al., 2020). It should be noted that as a natural outcome of habit formation for learning a particular domain by a student, the pertinent domain to learn becomes the individual interest of the student (Chen et al., 2015).

Background, setup and progress of IDC School in Taiwan

In Taiwan, a new policy was initiated in 2014. It provides three operating experimental education models (Ministry of Education, 2015), which are different from conventional schooling. The first model is *home-schooling*. This is similar to home-schooling as practised in the US and other countries, in which a family can apply to educate their children in their own way at home. The second one involves the setting up of an *experimental education group*. It means that 3 to 30 students can form a group (similar to a class), and educators can design their own curriculum for educating the group in an approved place (e.g., one that satisfies security and safety considerations). The third one is an *experimental education organisation*, which is similar to a small school. The maximum number of students are limited to 250 students (Grade 1-9 together); and they can be extended to include senior high school (Grade 10-12) by applying for an additional enrolment of 125 senior high school students. For all three models, individual students will be interviewed once a year to assess their learning progress. The policy also emphasises that such experimental education is a kind of non-traditional school education model—an implication that school assessment of such experimental education is different from that of public schools.

With the support of digital technology, researchers in Taiwan put their long-term efforts in helping public schools transform their learning and teaching as well as their curriculum. However, such efforts usually result in limited effects due to institutional inertia—schools as institutional entities tend to resist change. After all, most teachers in public schools may have established their own ways of teaching students for a long time towards a status quo. External force may drive them to change, but the effect is often small and unsatisfactory. Another problem is that many innovative models of learning activities are still complex, for example, collaborative inquiry projects. It is not easy to implement and sustain such models thoroughly in public schools unless favourable conditions exist such as teachers working closely together with researchers for a sustained period of time. What is needed perhaps is a compelling example.

The aforesaid Taiwanese policy now enables researchers to establish their own experimental school with which they have more flexibility to implement desired education models, effectively and thoroughly. If such experimental schools are proven to be successful, educational policy makers and practitioners (such as principals and teachers) can be invited to experience first-hand what transpires in the experimental school. To see is to believe; to feel is to ignite fire in the heart; to change is to make a difference for a better world. With this See-Feel-Change strategy (Kotter, 2008), the successful experimental schools may spawn a string of actions towards educational reform.

The IDC School in Taiwan started in the Fall Semester of 2017. At this time of writing, there are four grades, from Grade 1 to Grade 4. Each grade has one class of about 27

students. It is now located in one of the buildings in a junior high school campus in the suburban area of Taoyuan City.

For the last three years, the number of applicants to the school is double of the number of places available for enrolment. The families are interviewed to gauge if they concur with the IDC educational goals. The actual enrolments are about 1/10 to 1/5 (3 to 6 students) short of the full places in the four grades. The school serves mostly middle-class families from the neighbourhood areas. However, there are a few families who live about 40-minute drive away from the IDC School. Unlike public schools, this IDC School is fully self-sustained financially, with all expenses, including teacher salaries, accruing from the tuition fees.

Modus operandi and teacher professional development

The schooling time is different from other public schools. The IDC School runs from 8:00 am to 5:00 pm every day, Monday through Friday. In public schools, elementary school runs from 7:30 or 8:00 am to 3:30 or 4:00 pm; however, for Grade 1 to Grade 4, they only have half-day classes on Wednesdays and Fridays. Thus, there are more class hours for a variety of classes in the IDC School.

In the IDC School, to begin the day, all students do Modelled Sustained Silent Reading (MSSR), a book reading activity to be described further in next section, for 30 minutes in class. This is followed by 30 minutes of exercise time. Afterwards, all grades start the academic curricula. Every class is 40-minutes long. The first 10 minutes of every class will be MSSR time but with books related to the subject matter accordingly. For example, if it is a science class, students read science-related books of their own choice. The rest of the 30 minutes is the class activities for the subject matter. The time after 3:00 pm every day is used for extra-curricular activity time. Before school is dismissed at the end of the day, there will be another 10-minutes MSSR time.

When the first pioneer batch of teachers for the school was selected and appointed, they are assessed if their educational concepts, personality, and attitudes are aligned with the IDC spirit. Pre-service training sessions are conducted to ensure IDC educational concepts are well-understood and thereby embodied into their teaching. There is a once-a-week in-service professional development training with university faculties. In the upcoming years, there are plans to train teachers to be research-oriented and reflective practitioners.

Being professionals to practise educational innovations in the IDC School, teachers may encounter difficulties in adjusting their strategies according to interest-driven curriculum activities for enhancing students' creativity and habits through subject learning. They may also face difficulties in monitoring students' progress and diversity in the development of interest, creativity and habit following IDC-based education approach. Thus, it is important

for the researchers to provide the teachers with professional development in order to prepare them to handle better the related difficulties in classroom context.

The IDC School, with very limited resource, sets a requirement for student admission. Parents must fully support the IDC educational goals while they can expect that their children will persistently learn happily and demonstrate creativity through interest-driven learning activities in school and at home. Hence, the parents of the students are the supporters to extend educational innovations in learning at home.

The students of the school experience educational innovations in their learning life. There is no evaluation of academic performance and IDC readiness for student entrance-selection. In the first semester of their Grade 1, students receive a three-week training to familiarise the basic operation of tablets and digital platforms to be used in subject lessons.

In general, the IDC School intends to become a future school model to inspire how current public schools might be transformed in the future. Therefore, the readiness among teachers, parents, and students is crucial for an effective realisation of this educational innovation.

Curricula design: from readers to writers to creators

To nurture students to become lifelong interest-driven creators, the path towards this goal is to bring learners to be readers to writers to creators. Creation needs bountiful knowledge, and a major way to acquire bountiful knowledge is through reading. Reading is the most prominent feature of the curricula.

With copious inputs of knowledge from reading, students are capable of creating knowledge prolifically through expressing their new thoughts or concepts in a written language. Human thinking involves concept operations: acquiring new existing concepts, revising current concepts, combining different concepts, and creating new concepts. A word represents a concept, and knowledge is composed of concepts, which are then expressed in written language. Writing bridges between reading and creating, forming the foundation of knowledge creation. Thus, a creator must be a writer.

From Grade 1 to 4, the curriculum pays special emphasis on reading and writing, and from Grade 5 to 6 (and even for the three years of junior high in the future when we are ready for it), the emphasis is on creation, not only knowledge creation, but also creations of tangible artefacts or human activities. Nevertheless, they still need written language to describe precisely when they conceptualise these creations. Even though they are young children, if students from Grade 1 to 4 do well in reading and writing, they are “thinkers”. If, from Grade 5 to 6, they can both be thinkers and contrivers of something novel and valuable to their community, they are “creators”.

For English learning, starting from Grade 1, among the four competences of English Language learning—listening, speaking, reading, and writing, the focus is on reading,

especially reading English books. This is because reading is the core competence that strongly influences and complements the other three competences (Krashen, 2004).

For mathematics, self-paced learning is advocated. Each student learns at his/her own pace according his/her ability and effort. Students can learn fast, can learn slowly, but cannot learn without understanding. Along self-paced learning, students undertake learning-by-teaching group activities. Our main concern in mathematics is to maintain and enhance their interest and confidence in mathematics.

Creations often involve projects with outcomes as sort of some products. When one has a novel idea, one will have an urge to work on it to demonstrate what it is and how it works through working on a project. Starting from Grade 5 and above, there are subjects directing to projects, such as science inquiry projects, interdisciplinary social study projects, computational thinking and STEM (Science, Technology, Engineering and Mathematics) projects, and novel composing projects.

In fact, from Grade 1 to 4, every alternative week there is a class called Self-Initiated Challenge, which allows students to discuss possible projects they want to do and then work on them by themselves in groups or individually. At the end of the academic year, all parents are invited to watch their children to demonstrate their projects. From Grade 5 to 6, students extend their self-initiated challenge by choosing a subject that they are interested in—science, social study, computational thinking and STEM, or writing (composing novel)—and then take initiation to discuss with the teacher of the subject about projects they want to undertake and demonstrate at the end of the year.

Academic subjects

Reading

Reading, considered as the major means of acquiring new knowledge, is the strongest focus in the curricula.

Modelled Sustained Silent Reading (MSSR) (Atwell, 2007; Chan, 2016; Chan et al., 2018; Chan et al., 2019; Chen et al., 2020; Chien et al., 2015; Gardiner, 2005; McCracken & McCracken, 1978; Miller, 2009; Pilgreen, 2000; Wong et al., 2020) engages students to read self-selected books every day silently with the teacher, who reads in front of the class, serving as a reading model. MSSR, where M stands for modelling by the teacher; S for a sustainable period of time every day; S for silent; and R for reading for selected books by the student, nurtures reading habit and paves a solid groundwork for self-learning. In fact, reading is the foundation for all learning, and a lifelong learner must be a lifelong reader. With the long-lasting and enjoyable reading experience in school years, we hope that students will become lifelong readers. Furthermore, by reading many books, students acquire rich background knowledge that can facilitate their learning of other subjects. This

is our hypothesis: erudite students may also be curious students, who constantly generate information gaps (Loewenstein, 1994) between what they newly encounter and they have known before (background knowledge). They will then be eager to explore and seek answers to fulfil the gaps. Erudite students are also active learning students. For more detailed information on reading in the IDC School, the reader is referred to the in-depth discussion in the four papers discussing IDC Theory (Chan et al., 2018; Chan et al., 2019; Chen et al., 2020; Wong et al., 2020).

Writing

Writing, the springboard for creation, has been the second strongest focus in the curricula. In fact, the outstanding outcomes in reading and writing, especially writing, in an experiment in 2009 triggered the development of IDC Theory (Chan et al., 2018, pp. 440–441).

If students have assimilated enormous amount of knowledge through reading, we can postulate that they can write often, write about new ideas and knowledge, write well, and write long stories. Indeed, "everyone is talented, original, and has something important to say" (Ueland, 1938). Children feel the urge to write too. They have many ideas, visions, and discoveries to be defined, illustrated, discussed and shared among peers and other people. The writing repertoire in the IDC School is called HCBL (or HaCuBeLo for easy remembering), comprising four forms of writing: write-habitually (by practising daily), write-curiously (by questioning), write-better-and-better (by revising), and write-longer-and-longer (by composing novels). The IDC School teachers sometimes call the approach "I-want-to-write" to emphasise the students' innate drive to write.

The first form of writing, write-habitually, establishes students' writing habits through practising daily. At the beginning of the semester, students are given 10 themes with theme-based articles that are related to their life: events, people and things they are familiar with or they have heard about. In addition to these themes, the teacher encourages each student to find at least two themes they want to write about during the semester.

For each theme, after reading a set of theme-based articles, students then write about the articles by answering a set of questions designed by the teacher. In this part of writing, there are two writing processes here. The first process is objective writing—students write about summaries or main points of the articles in their own words. The second process is subjective writing in which students compose their commentaries, feeling, reflection, predictions, new ideas, questions, and others, which are mostly subjective descriptions based on students' personal views, which, in turn, are associated with their individual background knowledge. The objective writing helps students understand the authors' messages while the subjective writing helps integrate new knowledge from the theme-based articles with students' own background knowledge. In the final process, based on

what they have written so far, students choose a topic to write short articles and post them on the network to show to their peers. Each student is expected to write one short article per week.

The second form of writing is write-curiously. As noted from the aforementioned description, students in the IDC School acquire rich knowledge through MSSR, learn how to write through writing-well, and develop writing habits through write-habitually. Given these foci on developing students' reading and writing habits and abilities, it is natural to seek ways to support their learning of other subjects, such as social studies, science, and others through reading and writing.

Write-curiously differs from write-habitually. After reading theme-based articles and writing down their answers for questions designed by the teacher (this helps understand or learn about the content of the articles), students do not need to develop drafts about the theme. They are instead guided by the teacher to generate their own questions related to the content of the articles, individually and then in groups. This process goes through some brainstorming techniques to generate a set of meaningful questions.

The third form of writing is write-better-and-better. The key to write-better-and-better is revision. This is motivated by novelist Ernest Hemingway's strong conviction: "The only kind of writing is rewriting." This view was also adopted in the classic guide to writing non-fiction "On writing well" by William Zinsser (1976). In one aspect, write-better-and-better, an extension of what we have experimented before (Wang et al., 2016), enables students to learn about the writing processes and skills so that they can write decent and complete articles. First, given a theme for writing, students undergo several rounds of processes: reading articles related to the theme, which we call theme-based articles, drafting or revising drafts, and getting feedback from peers. Reading theme-based articles with different perspectives broadens students' view on the theme. Only through several times of revision, can student raise the quality of their articles. When students work hard on a piece of writing, they tend to develop a strong sense of ownership of their writing—the connection between self and the writing that makes the writing become part of the extended self (Belk, 1988; Dittmar, 1992).

The fourth form of writing is write-longer-and-longer. From Grade 4 to Grade 6, students start to learn how to write novels. They will spend a year to write their individual novels. A novel is a long story that deals with human experience usually through a sequence of events. Obviously, students in Grades 5 and 6 cannot write "long" novels. We intentionally use the word "novel", because it helps students build their confidence in writing as well as their identity as a writer: They can write a "relatively" long novel given their age. This is a challenge to them, but they can accomplish a novel, no matter how long it is, in a year.

IDC Theory postulates that from the point of view of learning as development of interest, student performance will be significantly elevated. Applied to reading and writing together

as in the IDC School, the theory indicates that through reading with interest, students absorb knowledge abundantly, and through writing with interest, they create new ideas, concepts, or knowledge prolifically. Also, reading and writing together are connected to learning of other subjects, naturally forming an integral part of the learning repertoire in the IDC School curriculum. Therefore, we envisage that establishing habits of reading and writing in early schooling will give students, with remarkable erudition, a firm grounding in becoming lifelong knowledge creators.

English Language

English Language is taught by English native speaker teachers and local English teachers. Book Reading Centric (BRC) English, the approach of English Language learning, emphasises reading among the four competences—speaking, listening, reading, and writing—in particular, English book reading called English MSSR.

There are two reasons for a strong focus on English book reading besides Chinese book reading. Firstly, most Taiwanese students, seldom read an English book out of their own interest. If they do not experience the enjoyment of reading English books at schools, it is likely that they will not pursue an interest in reading after leaving schools. In fact, many Taiwanese students admit that their English Language proficiency is at their best during the last year of senior high school level, right before the university entrance examination. The second reason for adopting the BRC English approach is that we postulate reading English books, like the Chinese MSSR, will immensely enhance learning of three other language skills: speaking, listening, and writing. Some prior experiments on learning English as a foreign language through English book reading have been conducted (Huang et al., 2017; Krashen, 2004; Liu et al., 2016). To initiate students into English book reading activities, BRC English starts with learning phonics, building basic vocabulary, and recognising common sentence patterns. Also, the teacher frequently reads aloud English books in front of the class and encourages students themselves to do so too.

Furthermore, to boost their interest in reading English books and connect book reading to speaking and listening, students conduct Reader's Theatre activities regularly. Reader's Theatre also serves as a stepping stone to performing dramas. At the end of every fall semester, all parents are invited to watch English dramas performed by their children.

Also, students, as creators, will develop their own digital English picture books after reading and show them to the class (Liu et al., 2011; Liu et al., 2017). If we regard reading as imitating, as in the Creation Loop of IDC Theory, then making picture books and showing to classmates are regarded as combining and staging, respectively. Finally, in the IDC School, besides the English classes, some subjects such as arts and social studies sometimes are taught in English.

Math

Math is a core subject. The approach is called *Interest-Driven Mathematics Thinking* (IDMT). A critical component of IDMT Math is the adoption of *Math-Island* platform that has been being continuously developed since 2008. At the moment, there are over 30,000 students enrolled in using the Math-Island platform in Taiwan (Yeh et al., 2019).

Math-Island is an online management game with its interface gamified as an *island*. On the island, there are a number of roads called *addition road*, *multiplication road*, *measurement road*, and so forth. The addition road, for example, has a number of buildings to be built by the student. Each of these buildings represents a concept to be learnt, such as "carry over" when adding two numbers. Learning a concept about addition is completed when students complete construction of a building shown on the addition road. Students learn the entire concepts about addition when they complete construction of all the buildings on the addition road. With more than 1,300 concepts to be learnt, Math-Island visualises the whole elementary math curriculum. Such a design of Math-Island can be regarded as a form of open learner model (Bull et al., 2009), enabling students to "see" their work and support self-reflection.

Bloom's taxonomy of educational objectives (Anderson & Krathwohl, 2000; Bloom, 1956)—remember, understand, apply, analyse, evaluate, and create—can be regarded as different levels of thinking in learning mathematics. In particular, we treat the first three levels as the *basic levels* of thinking and the last three as *higher levels* of thinking. The basic levels of thinking correspond to what most teachers intend to teach in Taiwan currently. In fact, they are the foundation that students must master when learning a new concept before moving on to higher levels of thinking.

Learning at the basic levels in IDMT Math, students, with some teacher-led mini-lessons, mainly work at their own pace. Every class has fast and slow learners. For fast learners, the teacher suggests them to proceed to solve more complicated problems when finishing their learning tasks. For slow learners, the teacher finds time to help them individually while paying attention to maintain their confidence and interest. In particular, the teacher encourages them to spend more time on basic material and at the same time induces them to believe that making effort will strengthen their math ability (Dweck, 2007). Such a belief can usually be reinforced when students "see" their own performance being improved on Math-Island. For a few students, if needed, the teacher will ask their parents to accompany them to work more on math at home.

Learning at the higher levels of mathematical thinking in IDMT Math, besides tackling some challenging mathematical problems in groups, for some core or difficult mathematical concepts, students are involved in *Learning-By-Teaching* (LBT). This means that they learn by assuming their role as the teacher: designing content or activity to engage fellow peers to learn. It requires the peer-teacher to re-learn by comprehending,

synthesising, questioning, explaining, analysing and evaluating the pertinent concepts again, helping the peer-student better understand, retain and expand what has been learnt before (Chan, 2010, p. 41; Chou & Chan, 2016).

The earliest proposal for computer supported LBT is by Chan and Baskin (1988, pp. 199–200), putting forward that a student can learn by teaching a computer simulated companion. Since then Chan and his colleagues have been working on a series of LBT research: computer-supported reciprocal peer tutoring (Chan & Chou, 1997; Chou & Chan, 2016), learning by posing math problems (Yu et al., 2003; Yu et al., 2005), reciprocal peer explanation of math problem solution (Yang et al., 2016), and peer video creation for other students to learn (Huang et al., 2020). Supported by the Math-Island, LBT is regarded as a math group project. Currently, students work on video creation a few times a semester. We expect the variety of LBT in the IDC School will increase in the future.

Students are also engaged in math manipulatives activities in groups. Math manipulatives are physical objects intended to represent some abstract math concepts in a concrete way (Furner & Worrell, 2017). Such activities go along with an instruction sheet designed by the teacher. Most students, noticed by the teacher, enjoy manipulatives activities, and some even find them exciting.

Science

In the IDC School, the approach of learning science is called Question-Initiation-Driven Inquiry (QIDI) (Wu, in preparation). The focus of this approach is to arouse students' curiosity about the natural world and undertake both mind-on and hands-on inquiry about the natural world. Postulated by IDC Theory, curiosity (triggering in the Interest Loop) is an enormous driving force behind all learning. A powerful tool for sparking curiosity is, however, questions initiated by students, which will enable students to acquire a strong sense of ownership of the questions and the answers they will be looking for. If the questions they pose are meaningful, then a series of inquiry activities will set off.

Given a science topic, the first step of QIDI is to engage students to observe the surrounding natural world or phenomena about the topic. Guided by the teacher, students recall their prior experiences by associating them with what they are now observing. Such association will lead them to compare what they know before and what they are observing; conflicts, uncertainty, or gaps may emerge. These conflicts, uncertainty or information gaps are the essence of their curiosity (Berlyne, 1966; Lamnina & Chase, 2019; Loewenstein, 1994). Then, at the second step, driven by curiosity, the eager students raise many questions to resolve the conflicts, reduce uncertainty, or fill the gaps. The teacher then selects several student-initiated questions that are both important to the core scientific concepts of the science topic and interesting to most students for further exploration.

Now, for these selected student-initiated questions, in the third step, students are engaged in various inquiry activities and work together to find out possible answers and explanations (combining in the Creation Loop). The fourth step is to have students demonstrate their answers or explanations in the class (staging in the Creation Loop). The fifth step is that the teacher summarises students' explanations and ideas and then introduces the core scientific concepts to the students. At the final step, the teacher stimulates the students to bring up another round of question initiation based on what they have just learnt about the concept. After collecting and selecting the following-up questions, students are encouraged to further their investigation by conducting science projects in groups.

To summarise, the inquiry learning process in QIDI is continuous and progressive, similar to the progressive inquiry proposed by Hakkarainen (2003). However, it highlights the significant role of student question initiation driven by observation and curiosity, igniting students' desire to look for answers and explanations of what they observe. QIDI goes through several steps: student question initiation by triggering curiosity, inquiry questions confirmation, answers and explanations inquiry, core-concept-focused knowledge integration, follow-up questions initiation, and further investigation with science projects. In short, QIDI is triggering and satisfying curiosity repeatedly in a meaningful and authentic context, and this is how students in the IDC School develop their interest in science.

Interdisciplinary Social Studies of "Double E" problems

Interdisciplinary Social Studies start at Grade 4. The approach, called Scenario Issue Resolution (SIR) (Shih, in preparation), is intended to enable students to learn, individually and collaboratively, how to resolve complex and challenging social problems, which sometimes involve science and technology. These problems are related to what are called "Double E" problems: equity and environment problems that characterise most of United Nations' Sustainability Development Goals (SDGs) such as poverty, fairness of education, health, peace, city development, environmental protections, and others. In fact, "Double E" problems occur at all times in our human history across all places (geography) on our planet, namely, the earth.

SIR starts with a historical event. For example, the Great Voyage talks about the expedition of Europeans to other continents (Shih et al., 2017). Another example is the Tayan Passage, which is about the story of Tayan, one of the aboriginal tribes of Taiwan, who defended their homeland village in a mountain near the IDC School. In these two examples, the Great Voyage and the Tayan Passage, the historical events were the trading of goods between countries or tribes or land reclamation. Such stories arouse student interest in history and geography of the Western World and Taiwan.

Based on a historical event, a scenario is constructed with a floor game. The game consists of a large piece of cloth, on which there are landscape, man-made construction, and other environmental information (spatial) at that time in history (temporal) related to the historical event. In addition, various tangible gadgets such as robots and cards as well as computational devices are provided. Such synthetic scenario sparks students' imagination of a time and a place in the past, and, with those "tools", they can "alter" or "do" something about the scenario.

After two sessions of summit meeting games, the students are intrigued to resemble the event by role-playing the stakeholders of the historical event. They then "work" on it through collecting and building of settings, for example. In the process of working on the event, challenging issues and sometimes conflicts between countries/tribes emerge. Confronting these "Double E" problems, students usually intuitively respond with collaboration or competition strategies with each other. Thus, they learn how to resolve their issues by group or inter-group negotiations during and outside of the game sessions. Students in the process discover the complexity and challenge of their problem they are facing when they learn each other's different perspectives. Guided by the teacher, students make strategic decisions and reasonable argumentations. Besides nurturing interest in resolving these global problems of equity and environment in our future world, we hope students can develop social justice in their mind as value in life as well as critical and independent thinking while resolving complex problems (Shih, in preparation).

Other subjects

Other non-academic subjects such as arts, music and physical education (to be discussed in the sub-section below) are also included in the curricula. About once a month, parents or experts in various areas are invited to give talks or conduct workshops to share their work-related topics and experiences.

Physical education and character building

During the sessions for prospective parents, namely, those who are considering to have their children enrolled in the IDC School, parents are informed that reading, physical education, and character building are the three most salient features of the school. This is because daily reading is the foundation for all learning while daily exercise and sports are the basis for good health. We ensure students do exercise every day, performing self-initiated exercises for several periods a day from 20 to 30 minutes each time in the hope that this daily routine will become their lifelong habit. Various kinds of sport programs are also offered in the afternoon almost every day.

In his speech on the purpose of education, Martin Luther King (1948) highlighted that "But education which stops with efficiency may prove the greatest menace to society. The

most dangerous criminal may be the man gifted with reason, but with no morals … We must remember that intelligence is not enough. Intelligence plus character—that is the goal of true education." His assertion underlines that character building forms a pillar of education.

For character building in the IDC School, we put forward the core values of the school as ICE^2, meaning Integrity, Commitment, Equity, Innovation, Communication, and Environment. In the previous subsection we have discussed the Double E problems, Equity and Environment. *Integrity* includes qualities of some moral principles, such as honesty, trustworthiness, consistency in words and actions, never taking advantage of others, trying to see the good in everyone, being humble, and so forth (Cloud, 2009; McFall, 1987). Similarly, *commitment* and *communication* consist of other sets of virtues. Note that integrity, commitment, and communication are linked with socialisation or human relationships, such as how students deal with themselves, with other people in their lives (relatives and friends), and with people they do not know at all—the society. *Innovation* refers to the creation something new and useful or improving something existed already, contributing to the well-being of human life and the globe.

We try to infuse the core values ICE^2 in every part of the curricula and daily routines in the school. To facilitate character building at home, we incorporate it as a part of the program on how to nurture children in Parent Workshop, which requires parents to participate once or twice a semester.

Digital-support for the learning in the IDC School

Vital to transforming learning and teaching into the future, the school-wide digital support is a noticeable feature of the IDC School. Since Grade 1, every student owns a light laptop. Students use their laptop to interact with a digital platform called Planets of Tomorrow as well as with each other. In Planets of Tomorrow, every student owns a *planet* and *manages* the planet. A planet analogically resembles the Earth where human beings are residing, and learning means *managing* the planet. This metaphor suggests that every student should learn how to take care of the Earth. At the moment, the implementation of the platform, however, has not reached the stage that this vision can be realised.

Currently, a planet consists of a number of *islands*, each is designed for supporting learning a subject matter, including reading, writing, and math. *Reading Island* consists of a number of *My-Bookstores*, each representing a genre of books. *Writing Island* comprises a few *My-Publishers*, each representing a genre of written articles or some other forms of digital creation, such as videos or photos. Math-Island requires the student to construct buildings along the *Roads* in the Island such as *Addition Road*, *Fraction Road*, and so on while learning those topics (Yeh et al., 2019). Thus, in a way the platform serves as a part of the subject curriculum.

In the IDC School, classroom and online activities go hand-in-hand. For this, the platform Planets of Tomorrow brings some noticeable advantages. First, through the gamification of the subject matter, we can design learning with enjoyable and engaging experiences in the curricula. Second, it allows recording and accumulating individual student behaviour in the learning process to form student learning portfolios, with which learning analytic technology enables effective assessment of student performance. This is the basis for the system to offer immediate feedback to the student and to inform the teacher how to help the student if needed. Third, the platform allows daily communication to take place among students, teachers and parents. Furthermore, if the school continues to develop and expands in the future, such a platform perhaps can form a basis for building a seamless, and, hopefully, a lifelong learning community around the school (Candy, 1991; Chan et al., 2006; Field, 2006; Looi et al., 2010).

Enactment of IDC practices

Establishing an interest-driven learning and creation culture in the IDC School is crucial to its success, and this requires the joint effort of teachers, students, parents, and researchers. All incoming teachers are required to know about the IDC concepts, endeavour to design activities, and implement them in their classes according to the IDC Theory. Therefore, in the regular professional development sessions, the teachers are reinforced to revisit IDC concepts and reflect on their practices.

Teachers of a particular subject are expected to consider the first priority of their teaching goals is to develop student interest of that subject while the learning performance is put as the second priority. In particular, teachers are reminded to pay more attention to the learning progress of individual students instead of comparing their relative performances. Similarly for students, they are encouraged to evaluate their own progress instead of comparing performance with their peers, even though comparison is inevitable in school and in life. Parents and students are constantly reminded that efforts are positively related to learning performance. They should be aware that if their children spend enough time in the subject, then learning performance will improve, provided that they safeguard and maintain their children's confidence and interest in the subject. In fact, most learning activities in the IDC School, such as MSSR, are inherently interest-driven. It is still an on-going task for us to design good questionnaires and assessment tools for observing student interest development.

In IDC Theory, creation, whether it is knowledge creation or artefact creation, refers to a sequence of activities: imitating (input), combining (output), and staging (being seen and refinement). Every subject, whether it is reading, writing, math, English, science, or interdisciplinary social study projects, follows a similar sequence of learning activities. For example, in MSSR, after extensive book reading (imitating for input), students are

encouraged to write recommendation for the books they like to share using the online platform (combining for output). After that, in the book-talk activities, they are invited to give an oral introduction of the books they recommend in front of the class based on their written pieces (staging for being seen and refinement).

Other subjects such as writing and math all require undertaking similar sequences of activities. It should be noted that for the staging process, students not only receive social recognition but also receive feedback and assessment from peers, leading them to go through another round of the Creation Loop for refinement. Since creativity usually refers to the novelty and usefulness of the student creation, and since absolute novelty (absolute originality compared to related creations of the whole world) and real-world usefulness are rare if not unrealistic to achieve by students, we are more concerned how to engage students to improve their products' creativity—novelty and usefulness—through the Creation Loop iteratively.

Changes observed and impact created

Students in the Grade 1 classes in the past few years showed deep interest with amazing progression in reading. By the end of the first year, approximately two-thirds of the students read text-based books that mainly consist of words with very few pictures. Several of them even sought to read more challenging and exciting books. It was encouraging that all students in the class formed a habit of reading. Students not only read books in schools but continued the habit outside of schools such as at home, shopping centres and restaurants. We hope that such habitual reading behaviour can be sustainable and students would eventually continue reading into adulthood. For students in the Grade 4 classes, most of them could read books which are at the junior high school level.

For writing, as expected by our previous experiment (Chan et al., 2018, pp. 440–441; Wang et al., 2016), students significantly outperformed students in the public schools given their reading habit. In Grade 3, they can, on average, write compositions that matches the writing proficiency of Grade 6 level students in public schools.

For math, the observation of 24 students in one class starting from their Grade 1, revealed that besides three students completing the public school Grade 2 curriculum, others went beyond Grade 2 level with 6 of them even completing the Grade 4 curriculum. Along the way, most of them became increasingly self-motivated and self-regulated. For those low-achieving students, they also found learning math to be interesting and encouraging (Yeh et al., 2019).

In the past four years, administered by the Education Bureau of Taoyuan City, senior education reviewers have been visiting the school to conduct one-to-one interviews with the IDC students. They found that students enjoyed their learning and loved to come in school every day. Parents showed satisfaction and are eager to promote the school to their

friends and neighbours. Also, students are found to be not only outstanding in reading and writing, but also articulate and eloquent while interacting with adults. When they asked the students which subject they liked most, most of them referred to math, an unexpected answer but a pleasant surprise. Teachers regarded this as a miracle because most elementary students in Taiwan go through boring and painful drill-and-practice activities in order to obtain high scores in math tests.

Officers from the Ministry of Education (MOE) also visited the school because of the ongoing project for disseminating the "Reading for Tomorrow" (MSSR) model for all schools in Taiwan. Their purpose was to monitor the best practices of MSSR being enacted in the IDC School. They also intended to gain new ideas or insights from the practice in other subjects for disseminate to public schools. Officers from the Education Bureau of an adjacent city, New Taipei City, also visited the school and sought the possibility of seeing some mature models of IDC for further dissemination purposes. We hope that these initial outcomes will show possibilities for informing how present schools may evolve in the future.

The school is gaining reputation nationally. More efforts are required to move the journey forward. Nevertheless, we plan to form partnership with the central and municipal governments for disseminating IDC Education in Taiwan by spreading out the theoretical concepts, transferring best knowledge of practices, releasing digital learning platforms, conducting teacher professional development programs, and assembling resources for sustainable development. It is our goal that our experimental results can inform educational policy formation and scale up to wider educational communities including public schools, private schools and after schools.

Challenges and issues

Challenges are many; only a few are mentioned here. Despite the support by a group of researchers, a small experimental school is still a school, demanding almost everything that an ordinary school should have. To meet the demand, we have to seek various resources, whether they are administration or curriculum related matters, to support the school. For example, we have been developing the Math-Island to support public schools for years, but for setting up the math curriculum for the IDC School, we have to purchase paper-based material in order to incorporate the Math-Island.

Teacher professional development is obviously a challenge. All teachers are hardworking, and they have a strong will to learn. When we recruit teachers, we understand that a teacher who has been working in a public school for many years may not be appropriate for the IDC School at this beginning stage. We target those who have at most 6 years of teaching experience. When we conduct professional development sessions, as expected, we notice that they all have learnt about the concept of student-centred learning for years. However,

from time to time, they tend to revert to the teacher-centred learning approach in the class, without realising it. One possible reason is that those teachers who have been teaching in other schools for a few years still find it difficult to change their habit of teaching. Another possible reason is that the longstanding practice of teacher-centred learning is still prevalent in most schools. Therefore, they seldom see examples of truly student-centred learning in the real world. This, however, raises an interesting issue: All teachers perform well in MSSR, which is a typical student-centred practice, but they are unable to transfer their experience in MSSR to other subjects. Another interesting issue is that many teachers are unaware that they do not understand the new concepts they have learnt from the IDC Theory, but they thought they understood. We believe that building convincing examples of new practices for each subject, regular class observations, and continuous discussions between teachers and researchers are crucial to the success of the IDC School. Nevertheless, the research team are grateful to the teachers, because exchanges between teachers and researchers are precious opportunities for researchers to learn from the teachers—why something works, why something does not, and how to revise them—accelerating the research process.

The use of computer by students at such a young age causes another challenge. Parents are requested to purchase computers for their children to use at school and at home when they come to the school in the first year. Many parents worry about the overuse of computers will be harmful to their children, both to their eyesight or possible addiction to video games, social media, and so on. It turns out that this is the reverse situation: The school insists that the sole purpose of using computer by students is for learning, not for any other uses. A computer, just like a pencil or a book, is a learning tool.

Accordingly, parents are requested to work with the school for the enactment of the following policy: First, the computer used by a student must be a mini-laptop computer, heavy enough that the student will not be able to hold it for a long time. Second, parents are advised firmly but fairly that it is their responsibility to help their children develop good habit of computer use at home. For example, they should set up family usage agreements. Also, they should not give their children smart phone or tablet to use.

In some special situation, they may lend a phone or tablet for their kids for a short while, but the device must be returned to them. Third, parents are required to attend the Parent Workshop organised by the school to learn about the danger of misusing computers and how to deal with their children when inappropriate computer use happens. Since digital learning researchers are more knowledgeable than parents not only about the advantages of using computers for learning but also the disadvantages and danger of misusing or overusing the computer by young children, it is the research team and the teachers' responsibility to work together with parents to protect the students.

Parents' expectation of extending the current IDC elementary school to inclusion of junior high school brings another challenge. At the beginning of establishing the school, parents were told that a decision on the extension of the elementary school to junior high will be considered after a few years of experience running the school. Given that the school has limited resources at the moment, and is still in the process of soliciting funds for building a much larger school, the decision is not to extend to the junior high, but to stay on the elementary school levels for a few more years with a focus on improving the quality of the school. Note that from Grade 1 to Grade 4, the curricula are mostly based on ideas from the research team. When parents were told the decision early this year, many parents were concerned about whether their children can adapt to another school's curricula in their junior high. Now, for this reason, curricula for Grade 5 and Grade 6 must include those contents in the standard curricula in the public school. Fortunately, the students are substantially more advanced than students in the public school, and, with some adjustment, this will not be a problem. In the future, if IDC is extended to a high school, both junior and senior high are included so that such problem will not happen again when students finish their junior high.

At least there is still one challenge that the IDC School has not been faced yet: Will students perform well in a national examination by the end of their junior high school in the future? IDC Theory postulates that students excel in learning performance and will be prepared for high-stakes examinations. Although IDC School students currently demonstrate their potential in achieving high learning performance, it does not mean that they can do well or excel in high-stakes examinations. However, learning and assessment are a coin with two faces. Based on IDC Theory, if learning activities can be designed so that students develop interest in learning, then assessment activities can also be designed so that they like tests, enjoy tests, and treat tests as their own goals they want to pursuit. This is another item of future work for the IDC School.

Discussion

Moving forward

When looking forward to the future, there are several aspects that are worth considering. For research, there is a need to conduct various studies to verify and refine the IDC Theory. In particular, it is hoped that there will be longitudinal studies for 20 years or more to see how well students perform in their academic performance and career achievement. These would provide data for further research to know whether these students can sustain their learning and creation habit lifelong, contribute to the global well-beings incessantly, and enjoy a life of satisfaction and harmony.

For practice, we need to develop more complete curricula of different subjects to align with IDC Theory. Also, the curricula can interconnect different subjects so that learning of a topic in a subject can support learning of a related topic in another subject. Next, since it is the teachers who implement the IDC Theory in the classroom, not the researchers, teacher professional development must be more methodical and well-planned. In fact, teacher professional development shapes teachers' teaching belief and ensures their instructional practices conformed to IDC Theory.

Parent education, an essential component in the IDC School, should be more systematic in the future. It is obvious that linking school education and home education closely does not only increase parents' understanding of IDC-based learning, but also enable parents to collaborate with teachers and participate deeply in students' learning process. Moreover, since digital technologies provide both new opportunities for learning and dangers such as internet addiction, technology literacy and internet security issues will be included in teachers', parents', and students' learning repertoire in order to develop proper perception, attitude, and habit of the use of digital technology. Thus, as can be seen, stakeholders all together would form the culture of the IDC School.

For technology support, as digital and AI technologies continue to surge, together with the longstanding research on intelligent tutors, computer-supported collaborative learning, game-based learning, virtual learning companions and educational robots, AR/VR supported learning tools and environments, learning analytics, and many others becoming more pervasive in the educational arena, it is envisaged various forms of intelligent resilient and seamless learning community will emerge, which can adapt to post-pandemic era.

Virtuous cycle of research improving practice and practice informing research

Thus far, this paper has shared how IDC Theory steers the development of the IDC School. With limited experiences at this initial stage of embodying the theory in the school, more research is needed to develop detailed principles to guide future designs. With IDC Theory at hand, the bearings in design can proceed with confidence. This means that the theory tells us *why* to do it this way, provides assurances that *what* to do is appropriate, and hence directs efforts towards *how* to do it. For example, nurturing interest is the intended outcome, but how to nurture interest is the design work. Knowing why and what thing to do is right can lead to a focus on how to do it rightly. A theory is a tremendous benefit in designing learning if it can optimise the likelihood that it will succeed.

Has the school implementation been cycled back to improve the IDC Theory? The answer is definitely. First of all, there is *increased confidence* in the theory due to the accumulation of positive evidence. IDC Theory poses a pivotal hypothesis: with careful design, the learning of any subject can be turned into individual interest of that subject. We are now more certain about this hypothesis when in the context of the IDC School in Taiwan we

notice how students build and sustain their reading habits. Also, about one-sixth of students develop their writing habit. However, such successes require the teacher to be patient enough in nurturing student interests. So, that is one improvement.

Another essential hypothesis of IDC Theory is that if learning has become a student's interest, then the student will excel in learning performance. Although rigorous proof for the hypothesis is still needed by collecting more evidence and analysing data, learning outcomes in reading, writing, and math seem to be in favour of the hypothesis. That is another improvement.

These two improvements assure us more that both reading and writing habits can be successfully nurtured. Since reading is fundamental for knowledge acquisition while writing is the basis of knowledge creation, these two habits need to and can best be fostered in early elementary school. In addition, given that improving student English proficiency is an emerging government policy in Taiwan, nurturing habits of English book reading is another task we shall address in the future design. Thus, as can be seen, this is an example that the improvements of the theory based on accumulated evidences virtuously cycle back to practice, that is, contribution to the advancement of the practice.

No doubt the design of the IDC School reveals room for improvement in the theory. For example, assessment tools on various concepts and sub-concepts in the theory are by and large lacking, for example, assessment tools for interest and habit. They need to be developed, or their absence will hinder the future advancement of the theory. Perhaps the most needed improvement is that the theory should elucidate more about the different roles of the three anchored concepts—interest, creation, and habit—in the design process. It is clear that it is different from designing some short-term experiment that lasts only for a month or so for testing hypothesis underlying a concept, in designing a complete curriculum for a subject, all concepts must be included. Will there be clear and general guidelines, procedures, or principles to help IDC curriculum designers?

Given there are only a few IDC experiments around the world so far, it is perhaps too premature for producing such guidelines yet, but they may emerge if collective endeavour among researchers from different regions continues to work in this direction. With internationally collaborative efforts, it is hoped that the theory and practice of IDC Theory, will profoundly change our future education, particularly in Asia.

Implementation of IDC beyond Taiwan

In Hong Kong, IDC loops are tried out in a curriculum development initiative that pioneers coding education in 32 local primary schools, benefiting 16,500 students and 112 teachers (Kong, 2016). A three-year curriculum is designed and implemented for incubating students at senior primary grades (Primary 4 to Primary 6) to be interest-driven creators in the digital era, who demonstrate the concepts, practices, and perspectives necessary for

coding skilfully and meaningfully to solve daily problems in the digitalised society. The three-year coding curriculum exposes students to the incremental experience of coding in Scratch at Primary 4, using tablets or desktop computers; and then coding in App Inventor at Primary 5 to Primary 6, using mobile computing devices. This curriculum development initiative incorporates IDC Theory into the design of a series of computational tasks and the arrangement of final project per year, in order to guide students in fostering their interests in learning and applying coding, capabilities of creation through coding, and habits of developing coding competence and creating coding products.

This initiative takes the IDC Theory as the theoretical ground for guiding the curriculum design to immerse students in the interest-driven learning process, and so to foster their development to be lifelong creators in the digitalised society. The three concepts anchored in the IDC loops—namely interests, creation, and habit—are incorporated into the design of coding curriculum activities for the 10 sessions of coding tasks and the two sessions of final project per year. The focal point of the curriculum design is to trigger student interest at the initial stage (i.e., level one in the curriculum), and then to maintain and extend student interest throughout the other two levels in the curriculum.

The application of IDC Theory in this initiative has five steps for a pedagogical connection with the delivery of coding education to help nurture creators in this curriculum. First, it triggers students' initial interest in programming with interesting and meaningful learning activities. Second, students maintain their interest through more complex computational tasks and final projects. Third, students imitate examples of the coding curriculum (apps development) and combine them with their own ideas. Fourth, students create new mobile apps and stage their creations. Fifth, students receive feedback that furthers the refinement and gives a sense of satisfaction. These five steps form the IDC loops to provide students with a series of opportunities to learn the knowledge, skills and perspectives of coding; imagine the opportunities to use coding for solving daily problems; think about the coding solutions possible for solving daily problems; and then create the coding products for solving daily problems.

This initiative adopts two strategies to link up the Interest, Creation and Habit Loops in the IDC Theory in the delivery of coding curriculum. First, this initiative uses interest-driven activity design as a strategy to incubate interest-driven creator. This initiative designs interesting and meaningful learning activities to nurture creators. The learning activities are designed to be up-to-date and relevant to students' daily lives. Curriculum designers conduct survey to understand what the students regard as interesting and meaningful, and in turn to inform the design of curriculum activities. A relaxing learning environment is created for both students and teachers with no pressure in curriculum delivery or learning assessment. These efforts contribute to an interest-driven learning

process in which students can activate, maintain, and extend their interest, for nurturing their creativity.

Second, this initiative uses the assessment criteria and staging of the final projects as the guidelines to motivate students' creativity. It covers four components of Creativity (Association of American Colleges and Universities, 2010) to look into students' sensitivity, flexibility, innovative thinking, and ability to connect, synthesise and transform ideas—for evaluating students' competence in developing timely and novel coding products that solve problems in connection with their daily lives and community. This initiative recognises the importance of staging in the final projects to help nurture students' creativity. Students are found to treasure most the feedback from other people, which encourages them to refine their creations. The process of continuous refinement of their works helps students to develop more innovative solutions, thus enhancing creativity. This initiative progressively develops students' habit of coding, as the three levels of curriculum content engage students in sustained interest-driven learning activities to learn coding as a routine in the three-year curriculum. The weekly lessons in this initiative serves as an effective cue to trigger students to learn and apply coding regularly.

Inspiring IDC practices beyond Taiwan

In Hong Kong, as mentioned, a cross-year curriculum development initiative on coding education adopts the IDC-based education approach to nurture students at senior primary grades to develop interests in coding, to be creative through coding, and to develop habitual practices to learn and apply coding. The pedagogy "To Play, To Think, To Code" is designed to foster students to build interest in coding through "playing" the target apps, to recognise the target problem through "thinking" about the target knowledge, and to create computational solutions for the target problem through "coding". This initiative has been extended to its second phase for four years more to expand the promotion of coding education in 200 local primary schools.

The strong emphasis of creation (both knowledge creation and artefact creation) in every IDC curriculum component in the IDC School in Taiwan inspires our partners in Hong Kong to refine the pedagogical design in the coding curriculum initiative for deepening students' engagement in the Creation Loop. The design of the pedagogy has been refined to add two more components, as reflected in "To Play, To Think, To Code, To Reflect, To Create". The two new components focus students' attention to their creation of coding products, in which students need to check their computational solution through "reflecting" on the target knowledge; and to extend their computational solution through further "creating" coding products for the target problem. Such a pedagogical refinement is intended to deepen students' engagement in the process of combining different concepts to form new concepts, i.e., an ability essential in the Creation Loop.

In Malaysia, the encouraging learning outcomes as reflected by the positive learning experiences gained from the curriculum of the IDC School has inspired several instructors at one public university to design learning activities for undergraduate students modelled after IDC Theory. The emphasis of the learning activities is on developing students' interest in educational technology given their non-technology background. The learning activities are currently being refined over a span of one and a half years based on the tenets of the Interest Loop of IDC Theory, the Creation Loop, and eventually the Habit Loop. This refinement is crucial especially for a course in which students have no prior knowledge or typically find the course uninteresting. Unlike Hong Kong, the adoption of IDC-based education in Malaysia did not happen at the school level, neither was it conducted on a large scale basis. However, the development could be seen as an indication that IDC Theory can play an important role in cultivating interest in learning among older learners.

In Singapore, designing learning environments that foster learner interest has also caught policy makers' attention in education. In doing so, in alignment with the IDC Theory, one has to understand existing learner interests or plan situations that elicit learner interest. For example, the Ministry of Education launches the STEM Applied Learning Programme (ALP) that seeks to support an innovative 21st century learning environment in Singapore schools and encourage the application of academic knowledge learnt in class to real-world contexts. The STEM ALP was introduced in selected schools in 2014, with the intention to shift learning from a didactic, teacher-centred traditional learning environment to a more student-centred one.

The program, anchored on new pedagogical forms, aimed to help students appreciate the relevance of what they learn in their lessons and consequently, develop a stronger interest in acquiring additional knowledge and skills independently. Students were allocated a few hours a week to work on given tasks with some freedom to explore through creative experimentation and ideation. This attempt in school reform signalled a shift from a schooling system critiqued for its over-emphasis on examination results to one where students' abilities to mastering skills needed for a lifelong learning was the desired educational outcome (Lim, 2014).

Conclusion

This paper presents a case study of the establishment and implementation of an experimental school in Taiwan, which embodies the IDC Theory. It is about a transformation of the elementary school curriculum to prepare 21st century learners who are able to take advantage of digital technologies to learn, un-learn, re-learn, co-learn and eventually co-create in their daily lives. The IDC School is established with the objectives of cultivating students to be highly motivated, readily creative, and eventually habitual to

learn and apply knowledge for problem solving in the digitalised society. The IDC School implements a curriculum with seven foci to prepare students to become lifelong readers and reflective writers who have broad knowledge in the fields of Math, English Language, Science, and Interdisciplinary Social Studies. It emphasises not only students' academic growth but also their physical wellness and character building in the digital era.

With the successful experience in nurturing teachers' pedagogical practices and the encouraging results in students' academic growth under the IDC curriculum, the case study of the IDC School in Taiwan can inspire the planning and integration of IDC-based education approach in academic curricula across different parts of the world. Other instances of smaller IDC or IDC-like implementations in Hong Kong, Singapore, Malaysia, and other places, have also been articulated.

Considering the aforementioned inspirations to share the knowledge of the IDC School in Taiwan to other places, there is a need for collaborative efforts to scale up the IDC-based education approach across different parts in the world. In this international collaboration, a group of Asian scholars endeavours to create an Asian alliance to share professional insights into IDC Theory and the design and practices of the experimental elementary school in Taiwan. They seek to initiate their own research to establish their own IDC experimental sites in their own regions. Plans are underway to gather more researchers and further develop and deepen IDC Theory through research and practice. An initiative of creating a global Non-Governmental Organisation (NGO) is being mooted and planned.

Hong Kong, in a slightly different direction from that in Taiwan, attempts to make collaborative dissemination efforts in the direction of promoting the IDC-based education approach through integration with the existing curriculum initiatives. There are two examples of the collaborative dissemination efforts. The first example rides on a city-wide curriculum pilot of coding education—in which 200 primary schools implemented a three-year pilot curriculum for Grade 4 to Grade 6 students to develop computational thinking through coding in Scratch and App Inventor. The second example rides on a university-specific curriculum pilot of artificial intelligence (AI) literacy education—in which more than 100 local university students join a 32-hour non-credit-bearing course with three levels to understand AI and its applications, and then develop AI applications.

In these two pilots, the IDC Theory serves as the theoretical background for curriculum development and implementation. The learning activities are designed to engage students through experiencing the fun use of target artefacts for building their interests in learning the intended coding knowledge, and then creating their own artefacts in the form of coding programming artefacts in the first example and developing AI applications in the second example. The IDC-based education approach therefore reaches a large number of students through these existing curriculum initiatives. The implementation in Hong Kong includes

further attempts to scale up the aforementioned efforts for a wider dissemination of IDC Theory through curriculum integration.

Malaysia takes the stand of promoting IDC-based education through teacher education programs offered at universities given that pre-service training can shape future teachers' instructional practices to be resonant with IDC Theory. The relevancy of their experiences with IDC inspired learning activities during teacher training may lead them to incorporate the IDC tenets in their future instructional practices. Malaysia is eager to be part of the NGO as international collaborators to gain more valuable insights of the design and best practices in relation to the Taiwanese experimental school.

This paper shares the trajectory of the development of the IDC Theory, culminating in an IDC School in Taiwan that seeks to put into practice what is espoused in the theory. It is hoped that more partners or collaborators can join in this journey of designing and conducting various IDC experiments in different countries and regions, and through this concerted collaborative effort, can respond to the current and future challenges of education in Asia and the world.

Abbreviations

AI: Artificial Intelligence; ALP: Applied Learning Programme; BRC: Book Reading Centric; IDC: Interest-Driven Creator; IDMT: Interest-Driven Mathematics Thinking; L4C: Learning For Competences; LBQ: Learning-By-Questioning; LBT: Learning-By-Teaching; MOE: Ministry of Education; MSSR: Modelled Sustained Silent Reading; NGO: Non-Governmental Organisation; QIDI: Question-Initiation-Driven Inquiry; SDG: Sustainability Development Goal; SIR: Scenario Issue Resolution; STEM: Science, Technology, Engineering and Mathematics.

Endnotes

[1] The development of the theory in fact started in 2009 when Chan and his colleagues noticed that the striking outcomes of a year-long experiment on habitual reading and writing in a school in Taiwan needed a theory for explaining the remarkable outcomes. They then spent several years to discuss the nature of the theory and identified that it must involve three critical concepts: interest, creation, and habit. All these concepts seem lacking in some Asian education systems because of their considerably examination-driven nature. In 2014, a meeting was held in Japan during the International Conference on Computers in Education among a group of Asian researchers to embark on an initiative to build the IDC Theory.

[2] We do not describe computational thinking and STEM projects in the IDC School here. They are the context of the application of IDC Theory in Hong Kong, and will be discussed later in this paper.

[3] The IDC School teachers usually call write-curiously Learning-By-Questioning (LBQ) to address the importance of asking questions by students in their learning (Ruggeri & Lombrozo, 2014). This is because most teachers and parents in Taiwan admit that students seldom ask questions in class.

[4] "The only kind of writing is rewriting" is Ernest Hemingway's famous quotation from the book The Movable Feast.

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Authors' contributions

Chee-Kit Looi proposed the writing of this paper, designed the key framework of the paper, discussed some IDC-based work in Singapore, and wrote the initial version of the draft. He also involved in tightening up the final version of this paper.

Su Luan Wong wrote the introduction of the paper, the overview of IDC Theory, literature review and innovative schools in other countries as well as applying IDC Theory in teacher professional development program in Malaysia. She also involved in tightening up the final version of this paper.

Siu-Cheung Kong wrote the IDC-based work on computational thinking curriculum in details in Hong Kong.

Tak-Wai Chan was the main author of the paper who wrote the various parts in the paper.

Ju-Ling Shih wrote the second initial draft with Tak-Wai Chan after Chee-Kit Looi finished the first version. She also wrote about her work on Interdisciplinary Social Studies in the curricula design section.

Ying-Tien Wu wrote the science curriculum in the curricula design section.

Ben Chang, Charles Yeh and Chih-Yueh Chou wrote the math curriculum in the curricular design section with Tak-Wai Chan. Both Ben Chang and Chih-Yueh Chou helped format the draft.

Chen-Chung Liu wrote the English curriculum in the curricula design section together with Tak-Wai Chan.

Tzu-Chao Chien and Hui-Chun Hung wrote the reading curriculum in the curricula design section together with Tak-Wai Chan.

Zhi-Hong Chen, Hercy Cheng, and Calvin Liao wrote the writing curriculum in the curricula design section together with Tak-Wai Chan.

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Availability of data and materials

This is more or less a position paper, describing how a new theory is being embodied in an experimental school. No empirical data was used for analysis and reporting in developing the paper.

Declarations

Competing interests

There are no competing interests that we know of.

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