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FOREWORD

A Paradigm Shift in Science Learning and Teaching

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Contents

There is a great demand for paradigm shift in education to meet the challenges of rapid globalization, tremendous advances in information technology, and strong pursuit of economic and social developments in the new century. A new paradigm of school education has been proposed by Cheng (2000)*. It is built on the concepts of contextualized multiple intelligences**, globalization, localization, and individualization in schooling,

teaching, and learning. Its assumptions about the future of the world, the human nature, the developments of individuals and the society, the aims of education, the students and learning, the teachers and teaching, and the school and schooling are contrastingly different from the traditional paradigm. The new paradigm is named as "***New Triplication Paradigm***" and the traditional one as "***Traditional Site-Bounded Paradigm.***" Triplication refers to the process including globalization, localization and individualization. The adaptation of this new paradigm to science learning and teaching can be illustrated as follows:

New Aim of Science Education

In the new paradigm, the aim of science education is to support students particularly through science learning to become contextualized multiple intelligence (CMI) citizens who will be engaged in life-long learning and will creatively contribute to the building up of a multiple intelligence society and a multiple intelligence global village. But in contrast, the traditional aim of science education is to equip students with the necessary science skills and knowledge to survive in a local community or to support the development of a society particularly in the economic and industrial aspects.

New Paradigm of Science Learning

In the new paradigm, science learning should be triplized: individualized, localized, and globalized. (Table 1)

Individualized Science Learning:

It assumes that student is the centre of science education. "Individualized Science Learning" means that students and their science learning should be facilitated in a way such that all types of transfer, adaptation, and development of related values, knowledge, technology, and norms during science learning process can meet their needs and personal characteristics, and that their potentials particularly CMI can develop in an optimal way. Different students can learn in different style. Individualized and tailor-made science programs (including targets, content, methods, and schedules) for different students is necessary and feasible. Students can be self-motivated and self-learning with appropriate guidance and facilitation, and science learning is a self-actualizing, discovering, experiencing, and reflecting process. Since the information and knowledge are accumulated in a unbelievable speed but outdated very quickly, it is nearly impossible to

make any sense if science education is mainly to deliver skills and knowledge of science, particularly when students can find the knowledge and information easily with the help of information technology and Internet. Therefore, the new century paradigm emphasizes that the focus of science learning is on how to learn, think, and create in science related domains. In order to sustain science learning is life long, science learning should be facilitated as enjoyable and self-rewarding.

Localized and Globalized Science Learning:

Students and their science learning should be facilitated in such a way such that all types of science learning activities and processes can bring in local and global resources, support, and networks to maximize the opportunities for their developments during science learning process. Through localization and globalization, there are multiple sources of science learning. Students can learn from multiple sources of science materials and experiences, inside and outside their schools, locally and globally, not limited to a small number of science teachers in their schools. Participation in local and international learning programs can help them achieve the related community and global outlook and experiences in science beyond schools. Also their science learning is a type of networked learning. They will be grouped and networked locally and internationally. Science learning groups and networks will become a major driving force to sustain the learning climate and multiply the learning effects through mutual sharing and inspiring. We can expect that each student can have a group of life long partner students in different corners of the world to share their science learning experiences.

It is expected that science learning happens everywhere and is life-long. School education is just the start or preparation for life-long science learning. Learning opportunities are unlimited. Students can maximize the opportunities for their science learning from local and global exposures through Internet, web-based learning, video-conferencing, cross-cultural sharing, and different types of interactive and multi-media materials. Students can learn from world-class teachers, experts, scientists, peers, and learning materials from different parts of the world. In other words, their science learning can be a world-class learning.

But in the traditional thinking, students and their science learning are part of the reproduction and perpetuation process of the existing science

knowledge and manpower structure to sustain developments of the society, particularly in the economic and industrial aspects. In science education, students are the followers of their science teacher. They go through standard programs of science education, in which students are taught in the same way and same pace even though their ability may be different. The science learning process is characterized by absorbing science knowledge: students are "Students" of their teachers, and they absorb knowledge from their teachers. Science learning is a disciplinary, receiving, and socializing process such that close supervision and control on the learning process is necessary. The focus of science learning is on how to gain some knowledge and skills of science. Science learning is often perceived as hard working to achieve external rewards and avoid punishment. All science learning activities are school-bounded and teacher-based. Students learn from a limited numbers of school teachers and their prepared materials. Therefore, science teachers are the major source of knowledge and learning. Students learn the standard curriculum from their science textbooks and related materials assigned by their science teachers. Students are often arranged to learn in a separated way and are kept responsible for their individual learning outcomes. They have few opportunities to mutually support and learn. Science learning happens only in school within a given school time frame. Graduation tends to be the end of students' science learning.

Table 1: New Paradigm of Science Learning

New Triplization Paradigm of Science Learning	Traditional Site-Bounded Paradigm of Science Learning
Individualized Science Learning: • Student is the centre of science education • Individualized science programs: • Self-Learning in Science • Science learning is a self-actualizing and exploring process • The focus of science learning is on how to learn, think, and create • Science learning is enjoyable and self rewarding	**Reproduced Science Learning:** • Student is the follower of science teacher • Standard science programs: • Absorbing science knowledge from science teachers • Science learning is a process of receiving science knowledge • The focus of science learning is on how to gain some knowledge and skills of science • Science learning is hard working to achieve external rewards and avoid punishment
Localized and Globalized Science Learning: • Multiple sources of science learning, inside and outside their schools, locally, and globally • Grouped and networked science learning • Science learning happens everywhere and is life-long • Unlimited opportunities for science learning • World-class science learning • Local and international outlook in science:	**School-Bounded Science Learning:** • Teacher-based science learning: Teachers are the major source of knowledge and learning • Separated science learning. • Science learning happens only in school within a given time frame • Limited opportunities for science learning • School-bounded science learning • Mainly school science experiences

New Paradigm of Science Teaching

In the new paradigm, science teaching should be triplized: individualized, localized, and globalized. (Table 2)

Individualized Science Teaching:

Teachers and their science teaching are facilitated in a way such that all science teaching activities can maximize their potentials to facilitate students' science learning in an optimal way. Science teaching is considered a process to initiate, facilitate, and sustain students' self-learning and self-actualization; therefore, teachers should play a role as a facilitator or mentor who support students' learning. The focus of science teaching is to arouse students' curiosity and motivation to think, act, investigate, explore, and learn. Also, science teaching is to share with students the joy of process and outcomes of science learning. To teachers themselves, science teaching is a life long learning process involving continuous discovery, experimenting, self-actualization, reflection, and professional development particularly in the area of science. Science teachers should be a multiple intelligence teacher who can set a model for students in developing their multiple intelligences during the process of science learning. Each teacher has his/her own potential and characteristics, and different teachers can teach in different styles to maximize their own contributions to science education.

Localized and Globalized Science Teaching:

The new paradigm emphasizes that teachers and their teaching should be facilitated in such a way such that all science teaching activities can bring in local and global resources, supports and networks to maximize the opportunities for their developments in science teaching and their contributions to students' science learning. Through localization and globalization, there are multiple sources of science teaching, for example, self learning programs and packages, web-based learning, outside experts, and experiential programs, inside and outside their schools, locally and globally. Teachers can maximize the opportunities to enhance effectiveness of their science teaching from local and global networking and exposure through Internet, web-based teaching, video-conferencing, cross-cultural sharing, and different types of interactive and multi-media materials. With their help, students can learn from the world-class teaching materials, scientists, peers, and teachers in different parts of the world such that their science teaching can become world-class teaching. Through participation in local and international development programs, teachers can achieve global and regional outlook and experiences in science, beyond schools. Furthermore, their science teaching is a type of networked teaching. Teachers are grouped and networked locally and globally to

develop and sustain a new professional culture and multiply their teaching effects through mutual sharing and inspiring. They become a world class and networked science teacher through localization and globalization. It is not a surprise that each science teacher can have a group of life long partner teachers in other parts of the world to continuously share and discuss their experiences and ideas of professional practice in science education.

But in the traditional paradigm, teachers and their science teaching are often perceived as part of the reproduction and perpetuation process of the existing science knowledge and manpower structure to sustain developments of the society. As compared in Table 2, the characteristics of teacher and teaching are contrastingly different from those in the new paradigm.

Table 2: New Paradigm of Science Teaching

New Triplications Paradigm of Science Learning	Traditional Site-Bounded Paradigm of Science Learning
Individualized Science Teaching • Science teacher is the facilitator or mentor to support students' science learning • Different teaching styles to maximize potential for students' science learning • The focus of science teaching is to arouse students' curiosity and motivation to think, act, investigate, explore and learn • Science teaching is a process to initiate, facilitate, and sustain students' self-learning and self-actualization • Science teaching is to share the joy of process and outcomes of science learning with students • Science teaching is a life long learning process involving continuous discovery, experimenting, self actualization, reflection, and professional development	**Reproduced Science Teaching** • Science teacher is the centre of science education • Standard teaching styles and patterns to ensure standard science knowledge delivery • The major task is to transfer some knowledge and skills of science to students • Science teaching is a disciplinary, delivery, training, and socializing process • Science teaching is hard working to achieve some external standards in science examinations • Science teaching is a practice, application, or transfer of the previous science knowledge the teacher has already owned
Localized and Globalized Science Teaching: • There are multiple sources of science teaching inside and outside their schools, locally and globally • Locally and globally networked science teaching • World-class science Teaching • Unlimited opportunities for science teaching • Participation in local and international development programs to achieve the related outlook and experiences in science and science education beyond schools • As a world-class and networked teacher	**School-bounded Science Teaching:** • Schools are the major venue for science teaching and teachers are the major source of science knowledge • Separated science teaching • School-bounded science teaching • Limited opportunities for science teaching • The science teachers and their teaching are alienated from the fast changing local and global communities • As a school-bounded and separated teacher

New Quality Assurance in Science Education

Since the traditional paradigm of science education emphasizes the delivery of science knowledge and skill, the quality assurance of science education is often focused on how well science learning and teaching are organized to deliver the necessary knowledge and skills of science to students; how well the delivery of science knowledge and skills to students can be ensured through the improvement of teaching and learning; how well teachers' science teaching can be improved in a given time period; and how well students can arrive at a given standard in science examinations.

Clearly, the paradigm shift towards triplization induces a new conception of quality assurance of science education. The new quality assurance can be based on the following major questions:

1. How well science learning and teaching are triplized? (This question aims to ensure that student learning and teacher teaching in science can be well placed in a globalized, localized, and individualized context.)
2. How well students' science learning opportunities are maximized through the IT environment, networking, teachers, and schools? (This question intends to ensure the maximizing of opportunities for students' science learning in a triplized environment.)
3. How well students' self learning in science is facilitated and sustained as potentially life long? (This question tries to ensure the maximized opportunities for students' self-learning in science are sustainable to life long.)
4. How well students' contextualized multiple intelligences and their ability to triplize their self learning in science are developed? (This question focuses on ensuring the relevance and outcome of student' science learning in terms of multiple intelligences and ability of triplizing self-learning)

From the above discussion, we can see that the new paradigm of science learning and teaching is completely different from the traditional thinking and practice. The new paradigm is really important to reforming the curriculum and pedagogy of science education in different parts of the world if globalization, localization, individualization, and contextualized multiple intelligences are all considered to be necessary in education for the new millennium.

Finally, I have a dream in science education:

All our students will become triplized (globalized, localized, and individualized) in science learning and fully enjoy self exploration and actualization in the learning process; and

All our teachers will become triplized in science teaching and share the joy of triplized learning and teaching with their students and pursue life-long learning and professional development.

All our schools will become triplized in science education and create unlimited opportunities for all students' life-long science learning in the new century.

References & Note

*Cheng, Y.C. (2000). A CMI-Triplization Paradigm for Reforming Education in the New Millennium. *International Journal of Educational Management*. **14**(4), 156-174. Or Cheng, Y. C. (2000). Educational Reforms in the New Century: Multiple Intelligence and Globalization, Localization and Individualization. In the Chinese Educational Research Association (ed.), *New Vision of Educational Development in the New Century*, (pp. 1-41). Taiwan: Taiwan Books Store. (Chinese)

** Contextualized Multiple Intelligences: They refer to Technological Intelligence, Economic Intelligence, Social Intelligence, Political Intelligence, Cultural Intelligence, and Learning Intelligence. Please see Cheng (2000) for the detail. This conceptualization or classification is different from that proposed by Howard Gardner (1993). He suggested that there are seven human intelligences, including musical intelligence, bodily-kinesthetic intelligence, logical-mathematical intelligence, linguistic intelligence, spatial intelligence, interpersonal intelligence, and intrapersonal intelligence.