

Facilitating Sustainability of Education by Problem-Based Learning (PBL) and Information and Communication Technology (ICT)

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Abstract—This paper focuses on two approaches to facilitate sustainability of education development, such as pedagogical approach and technological approach. We regard using Problem-Based Learning (PBL) as a strategy of the pedagogical approach and application of Information and Communication Technologies (ICT) as a strategy of the technological approach. The two approaches are possibility combined in one educational context. From this sense, a case on Web 2.0 employed at Aalborg University, Denmark where has a long history of PBL model is discussed in this paper. This case indicates that ICT may offer students in PBL personal tools for knowledge construction, reflecting, sharing and collaboration in project work, while also connecting to communities, network and resources of their own interest. Relating this case to the challenges of sustainability of education development in developing countries, some practical issues will be discussed in the countries such as India, Thailand and China.

Index Terms—sustainability, education, PBL, ICT

I. INTRODUCTION

Globalization and technological change - processes that have accelerated in tandem over the past fifteen years - have created a new global economy “powered by technology, fueled by information and driven by knowledge” [1]. The emergence of this new global economy has serious implications for the nature and purpose of educational institutions [2], which drives the education to shift its paradigm from “transmissive model” to “transformative model” [3]. Accordingly, educational institutions currently are facing challenges of sustainable development.

Recently, many efforts have been done aiming to enhance sustainability of education in developed countries [4], such as UK, Canada, Australia [3], and Denmark [5], etc. These efforts are mainly followed two trajectories: one emphasizes the new pedagogical practice to build “learned-centered”, “team-based”, and “problem-originated” learning environment[2], for example, strategy of “Problem-Based Learning (PBL)” [6]; the other one emphasizes the role of Information and Communication Technologies (ICT), such as internet, radio, mobile phone, and TV in supporting diverse of pedagogical practice. Furthermore, there is growing number of studies on the junction of the two trajectories, for example, to focus on how ICT facilitates PBL environment [7, 8]. However, many barriers of employing such advanced learning principles and educational technologies exist in some developing countries due to their big population, low-level eco-

nomical traditional educational system, and enlightened cultural influences [2, 9-11].

The above points indicate this paper to propose two approaches to the sustainability of education development: pedagogical approach and technological approach. Meanwhile, the two approaches can be combined in one educational context. Accordingly, a case of using Web 2.0 in education of Humanistic Informatics at Aalborg University, Denmark where has a long history of PBL model will be discussed. Relating this case to the challenges of changes towards sustainability of education development in developing countries, some practical issues of using PBL or ICT will be discussed in the countries such as India, Thailand and China. Therefore, this paper has both theoretical and practical significances of education development towards sustainability.

II. FACILITATING SUSTAINABILITY OF EDUCATION DEVELOPMENT

A. Education Development and Sustainability

Sustainability has been proposed by the World Commission on the Environment, in the 1987 Brundtland Commission, as common goal for the international community [12]. It is defined as respectful use of natural resources in order to leave possibilities for future generations to live on Earth with the same, or better conditions, as present generations. Environmental sustainability has, at least since 1987, been a fashionable term for the international community. However, the term “sustainability” does not only apply directly to the field of environmental relations. For example, for a long time, it was better known to designate the long-term maintenance and development of the firm [13].

Therefore, sustainability has been a sparkling and multi-faceted notion, which means it has multiple meanings related to educational context. According to Sterling [3], “education is not a simple ‘instrument for change’, although good education always involves change in the learner. Engaging education fully in the transition to sustainability requires critiquing much current thinking and practice, but also visioning and designing a credible and practicable alternative-whether you are a policy-maker, lecture, teacher, community educator or parent.” That is, the core values embedded in education should be changed towards a fairer society and better world - an ecological paradigm for education should be emphasized instead of the mechanistic view (Table 1).

TABLE I.
THE DIFFERENCES OF CORE VALUES BETWEEN MECHANISTIC AND
ECOLOGICAL PARADIGMS FOR EDUCATION

<i>Mechanistic View</i>	<i>Ecological View</i>
Preparation for economic life	Participation in all dimensions of the sustainability transition-social, economic, environmental
Selection or exclusion	Inclusion and valuing of all people
Formal education	Learning throughout life
Knowing as instrumental value	Being/Becoming (intrinsic/instrumental values)
Competition	Cooperation, collaboration
Specialization	Integrative understanding
Socialization, integrating to fit	Autonomy-in-relation
Developing institutional profiles	Developing learning communities
Effective learning	Transformative learning
Standardization	Diversity with coherence
Accountability	Responsibility
Faith in 'the system'	Faith in people
Modernity	Ecological sustainability

B. Strategies of Facilitating Sustainability of Education Development

1) PBL: A Strategy of Pedagogical Approach to Sustainability

Related to the core values of ecological paradigm for education, pedagogical practice began to highlight principles of “process, development and action oriented”, “teachers also learners, learners also teachers”, “groups, organizations and communities also learn” and “wide range of methods and tools”, etc. Accordingly, some new pedagogical strategies have been explored, for example, Problem-Based Learning (PBL).

The advantages of Problem and Project Based Learning (PBL) are especially identified as the articulated outcome of education which aims to provide students with the expected professional competencies for future workplace [5]. In general, de Graaff and Kolmos summarize the main learning principles in three approaches: cognitive learning, contents and social learning [14].

1. The cognitive learning approach means that learning is organized around problems and will be carried out in projects. It is a central principle for the development of motivation. A problem provides the starting point for the learning process, places learning in a context, and bases learning on the learner's experience.
2. The contents approach especially concerns interdisciplinary learning, which not only stresses but also spans traditional subject-related boundaries and methods. It is exemplary practice in the sense that the learning outcome provides a good example of the overall objectives. Furthermore, it supports the relation between theory and practice by demonstrating the fact that the learning process involves an analytical approach using theory in the analysis of problems and problem-solving methods.
3. The social approach is team-based learning. The team learning aspect shows the learning process as a social act in which learning takes place through dia-

logue and communication. Furthermore, the students are not only learning from each other, but they also learn to share knowledge and organize the process of collaborative learning. The social approach also covers the concept of participant-directed learning, which indicates a collective ownership of the learning process and, especially, the identification of the problem.

2) ICT: A Strategy of Technological Approach to Sustainability

In parallel with pedagogical development, ICT has drawn much attention on supporting learning communities in education institutions. The new technologies have the potential to fundamentally transform how and what learn throughout their lives. Just as the advances in biotechnologies made possible the “green revolution” in agriculture, new digital technologies make possible a “learning revolution” in education [15]. Generally, there are four ways ICTs can support the basic education: (1) supporting education in school, (2) providing non-formal education for out-of-school children and adults, (3) supporting pre-service distance education of teachers and their in-service professional development, and (5) enhancing the management of schools [16].

Recently, ICT is thought much more than computers and the Internet or even telephony [5]. However, older technologies such as the telephone, radio and television, although now given less attention, have a longer and richer history as instructional tools. The use of computers and the internet is still in its infancy in developing countries due to limited infrastructure and the attendant high costs of access [17]. Thus, the potential of each technology varies according to how it is used. For example, radio and TV broadcasting can be used in direct class teaching, school broadcasting and general educational programming over community; computers and the Internet can be used in distance education; the Internet also provides Web-based collaboration tools, such as email, listservs, message boards, real-time chat and Web-based conferencing, etc. These tools connect learners to other learners, teachers, educators, scholars and researchers, scientists and artists, industry leaders and politicians – in short, to any individual with access to the Internet who can enrich the learning process[18].

3) Supporting PBL by ICT: A Combined Strategy for Sustainability

In the recent 10-15 years, many efforts have been done to combine the pedagogical and technological approaches in educational practice, for example, some universities have employed ICT to support a PBL environment. ICT can play a significant role in the successful deployment of PBL models in universities. ICT as an artifact facilitates information gathering, exchange and make learning more easy and productive. PBL should therefore make the best use of ICT, as tools and access to resources are significant to PBL [19]. According to Kaldoudi et al [20], ICT may facilitate PBL to reach objectives of: (a) support collaboration of remote overspecialized experts in order to devise, develop and deploy didactic problems for problem based learning; (b) deploy problem-based sessions in virtual teams, where both students and instructors may be located in remote institutions; (c) support strong instructor's presence; (d) provide tools for student inquiry and collaboration; and (e) provide mechanisms for continuous monitor-

ing and evaluation, that would address direct knowledge, as well as tacit competencies targeted via PBL.

Among different kinds of technologies of ICT in PBL, web 2.0 has been discussed much in previous work, which is characterized by creation of online content rather than just reading from the web thus focusing on creation and innovation. Kaldoudi et al [20] discussed the usage of Web 2.0 in PBL by a specific example of a multi-stage PBL session on "DICOM basics". The session is being taught to students of the MSc in Medical Informatics at the School of Medicine, Aristotle University of Thessaloniki (<http://iris.med.duth.gr/elearning/>). So they pointed out that the use of wikis and blogs not just for creation and promotion of information, but as active tools to support PBL. In this approach, students and instructors use the web as a virtual place to collaborate and create new knowledge and new educational experiences. More than being a global information space web2.0 contributes to the elements of collaboration, contribution and community thus giving a social angle [21]. Thus the characteristics of PBL like innovation, collaborative and active participation align with that of web 2.0 technologies.

4) *A Case of Web2.0 in PBL Environment at Aalborg University, Denmark*

For more than 30 years, Aalborg University, Denmark has educated scientists and engineers by using a PBL approach. It has been discussed as "Aalborg PBL model" in much previous work [14]. The employment of ICT has brought the new elements to this model development embedded value of sustainability of education development. To explore this we are discussing a case which is an online web 2.0 learning environment called "Ekademia" at Aalborg University [22]. In order to find out how far students make use of ICT technologies in PBL based learning situations, empirical data was collected by questionnaires, interviews and observations from students in Humanistic Informatics since September 2007 [22].

When 180 undergraduate students began their education within Humanistic Informatics in September 2007 they were met with Ekademia as a new educational online environment supplementing the existing system (Lotus Quickr). Quickr acted as a more traditional VLE segmented into semesters and course-pages with schedules and announcements, whereas the Humanistic Informatics faculty intended Ekademia to be more social and interactional. The faculty therefore chose to base Ekademia on the open source software Elgg because the system reflects a social networking or e-portfolio metaphor, and contains a number of web 2.0 features such as blogs, personal profiles, podcasting, widgets, RSS-integration and tagging.

An aim of usage of Ekademia was to support the individual student's creation of personal learning trajectories, where they could connect to communities, networks and resources of their own interest. Another important goal was to support the students in their project based group work. This was very important as the foundational pedagogy of Aalborg University PBL model. However, an additional aim in relation to the group work was to enable more collaboration and transparency between the project groups, so they would be more aware of each other's work and progress.

Based on the questionnaire and the observations, it seems fair to say that the students used Ekademia predominantly for group work in relation to their semester-

projects. It was, however, also used for other purposes e.g. social purposes of inviting others for parties, arranging football matches or for small interest groups like the Mac community. When students were asked about their conception of the roles of Ekademia and Lotus Quickr several of them indicated that they felt that the role and expectations related to the use of Ekademia were not clear from the outset. Most of them commented that they conceived Ekademia more as their own platform for group work and as a "social platform", whereas Quickplace was the more formal place where teachers could upload their material and course descriptions:

- "It is a good alternative to QP. I think Ekademia is a more user friendly for the students because they can create and administer their groups"
- "The groups are gathered through Ekademia".
- "QP is the knowledge database for us where we get our information. But it does happen that I look at Ekademia first. Ekademia is more of a social forum in my opinion."
- "We use it in the group to send material to each other and to read what the others have written. And then social activities with other students."

Only a minority of the students were interested in using Ekademia for "the formal" purposes or in creating stronger links between Ekademia and the courses. While it was very positive that the students found the system useful for their group work, it came somewhat as a surprise to the faculty that this was one of the main functions from the students' perspective.

In summary, QP provides a platform for students to develop learning communities in the context of PBL. However, there is a need for a more concerted pedagogical effort in order to support students in developing professional skills. Students in PBL might need support and education in order to unfold and develop these skills within an academic context.

III. PRACTICAL ISSUES OF SUSTAINABILITY OF EDUCATION DEVELOPMENT IN DEVELOPING COUNTRIES

A. *General Issues in Developing Countries*

From case studies, we get some insights on improving PBL model supported by ICT at Aalborg University. Furthermore, this also gives us some reflection on sustainability in educational development in developing countries. Due to the fact that most developing countries follow traditional "teacher-led education" and factors such as huge population, low-level economic traditional educational system, and enlightened cultural influences [2, 9-11], many barriers exist to employ whether PBL or ICT in institutional change towards sustainability. For example, the reality of the Digital Divide - the gap between those who have access to and control of technology and those who do not-means that the introduction and integration of ICT at different levels and in various types of education will be a most challenging undertaking. Failure to meet the challenges would mean a further widening of the knowledge gap and the deepening of existing economic and social inequalities [18]. In the following sections, some practical issues will be further discussed in the countries including India, Thailand and China.

B. Practical Issues in India, Thailand and China

1) Availability and Affordability: the Determining Factors that Affect ICT in Education in India

Since the early 1950s, India have identified the need to use all modes of media for promoting development and, implicitly, for education. However, availability and affordability are the determining factors for technology adoption in education in India. The main challenges which the country face in the successful use of ICT in the educational sector are deficit power supply, lack of adequate physical facilities, high cost of connectivity, bad maintenance of infrastructural facilities, lack of trained teachers, no proper focus on the digital content in education, not much attention given to the local language content development and deployment. For example, the main requirement for web 2.0 enabled learning environments is availability of internet; however, internet connection in many universities in India is far below the expected levels.

Government of India has realized the relevance of technology in classrooms. For example, National Mission on Education through ICT was launched in 2009 to bring sustainability in education [23]. The main aim of the mission is to provide high quality personalized and interactive knowledge modules over the Internet for all the learners in higher education institutions in 'Any-time Any-where mode'. The scheme seeks to bridge the gap in skills needed for the use of computing devices for the purpose of teaching and learning among urban and rural teachers in the Higher Education domain and empower those, who have not been able to reap the advantages of the digital revolution.

2) Traditional Teaching and Inequality of Resource between University and School Levels in Thailand

Thailand has used traditional teaching approach which teachers are expert on the particular subject. Recently, some universities begun to change to "student-centered learning" approach, for example, Mae Fah Luang University in Chiang Rai (www.mfu.ac.th) is in the framework change towards PBL. However, influenced by the traditional approach, there are barriers of sustainable education development both in pedagogical level and instrumental level.

From the author's experience who had been in academic environment in Thailand for 3 years, it is hard to let students in Thailand to be active in learning process. They would like to follow suggestions of teachers and finish homework instead of finding research problems by themselves. They would like keep silence to listen to the answers instead of asking critical questions. Such situations therefore may prevent any new pedagogical practice which holds on to principles of "student-centered learning", for example, PBL. Furthermore, there is serious inequality of resource between university and school levels education. In level of higher education we have good infrastructure; every student can access to the internet and institutes, they are active to use ICT for teaching activities. Thai government started to build up backbone connection for education since 2002 as called "UniNET". However in school level, a number of schools which locate in rural area, they do not have internet connection but they have mobile. Mostly they are primary school and very few numbers of high schools which do not have connection [23].

3) Limited Space in Classrooms and Huge Numbers of Students in China

Recently, Chinese government has devoted much on sustainability of education development by making a series of policies. For example, creativity has been encouraged in higher education by Ministry of Education of the People's Republic of China and stressed as the major theme in educational reform of China in the 21st century. Accordingly, some change happened in some universities. These changes include different levels from a course to the whole university. PBL has been drawn much attention in such changes. For example, China Medic University is trying to employing PBL model on the whole institutional level [24].

It is similar to the other developing countries that barriers of sustainability of education development come from traditional teaching approach. Due to the influence of Confucius culture, teachers prefer to regard themselves as authority of knowledge, which is rooted in "teacher-led education" currently. Moreover, a big problem in education changes towards "student-centered learning" model is to deal with the conflict between limited classroom space and huge number of students. For example, based on the authors' experience, in practice of PBL in China, it is easy to find there are about 30 students in one huge group; the student groups even have discussions in their dormitories due to the limited space in classrooms. This situation has driven students to use ICT such as Skype to discuss online. However, it is similar to India and Thailand that the common challenges of ICT in education in developing countries also exist in China.

IV. CONCLUSIONS

This paper forms a framework for facilitating sustainability in educational development through PBL and ICT. Accordingly, a case on Web 2.0 employed at Aalborg University is introduced and discussed. The findings show that ICT contributes in a major way to support PBL model by connecting to communities, network and resources of students own interest. However, some effort on pedagogical practice should be done in order to make good usage of ICT in PBL. Based on the findings of case studies, challenges of sustainability in education development in developing countries (India, Thailand and China) are discussed. The methods and style of teaching and learning vary from country to country. Cultural beliefs often have a tremendous impact on the teaching and learning styles. Technology can play a major role in transforming the teaching and learning irrespective of the country into which it is introduced, but a lot of attention need to be taken on the social context into which technology is introduced. Instead of copying ICT integration projects to education that is successful in the West, importance should be given to understand and study the implications of how it can get the expected outcomes if introduce in developing countries are lot of infrastructural, social and economic barriers which makes access to technology difficult.

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