# PROMOTING EDUCATION FOR SUSTAINABLE DEVELOPMENT VIA STUDENT-CENTRED LEARNING PROGRAMME

**Ng Khar Thoe**

R&D Specialist, SEAMEO RECSAM

<nktrecsam@gmail.com>

**Chona Quezon Sarmiento**

R&D Specialist, SEAMEO RECSAM

<chona@recsam.edu.my>

**Cheah Ui Hock**

Head of R&D Division, SEAMEO RECSAM
<uhcrecsam@yahoo.com>

and

**Wahyudi**

R&D Specialist, SEAMEO RECSAM

<wahyudi_yososutikno@recsam.edu.my>

*Abstract*:
One of the various initiatives to promote student-centred learning includes the implementation of problem-based investigative projects being presented in science fairs or congresses. The "Search for SEAMEO Young Scientists"(SSYS) Congress biennially organized by RECSAM is a platform for exchange of experiences and ideas among young researchers in the region. This paper explores the concept of *Education for Sustainable Development*(ESD) and reports findings from evaluative studies on 4th(2004) and 5th(2006) SSYS congresses that incorporated "*Sustainable Development*" as themes. The SSYS teachers and students delegates' responses to evaluation questionnaires administered on various aspects, i.e. their participation in event with impact on teaching and learning from socio-cultural perspectives were examined. Content analysis was also done on selected projects to illuminate how students in the Community of Practice(CoP) were guided by more knowledgeable others(MKO) in developing projects which reflected the philosophy of the "*Decade of Education for Sustainable Development*"(2005-2014). The findings revealed that student delegates hold positive views of the SSYS Congress. They reported "enhanced awareness of the interrelationship among Science, Technology, Environment, Society(STES); feelings of competence to conduct investigations; and motivation to participate in the event". This paper further discusses and recommends the follow-up actions on research ideas initiated by the young scientists.

## INTRODUCTION

As we enter the 21st century, the rapid progress in the field of science and technology is evident. However, some of the excessive developments and harmful scientific/technological inventions have also resulted in the imbalance of the ecosystem which is also threatening the Earth's life systems. The image of science has since been tarnished by a succession of inconsiderate scientific and technological developments with no human values that has resulted in unforeseen degradation of environmental or societal consequences and life-threatening hazards. It is a pressing concern in the global world on issue of how to achieve a civilized society consists of public with broad understanding of major scientific ideas appreciating the values of science? Obviously science education that place major emphasis on the teaching of values in the school curriculum is an important factor in this aspect with teachers play the most critical role to bring about behavioural and attitudinal changes in their students who will be the future citizens of the world.

In recent years, educational institutions and teachers are often called upon to help assuage society's problems with student-centred learning programmes that are relevant to promote a sustainable future. Various attempts have been made at the policy level in many countries to emphasize the need to teach values in Science, Technology, Environment and Society (henceforth referred to as STES) education as the world move toward sustainable development. The objectives of the establishment of "Decade of Education for Sustainable Development" (henceforth referred to as DESD) to follow the UN Decade for Human Rights Education from the year 2005 to 2014 are to promote education as the basis for a sustainable human society and to strengthen international cooperation toward the dissemination of environmental information (Ikeda and Earth Charter, 2002). A dedication to learning and a holistic education underpinned by a holistic ethics encompassing the integrated aspects of STES could act as a model for a broader education which could play a fuller part in the social transformation critically needed in this century.

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This paper explores the concept of *Education for Sustainable Development* (henceforth referred to as ESD) with exemplary student-centred learning programme initiated by RECSAM. Research findings from evaluative studies were reported on 4th(2004) and 5th(2006) SSYS congresses that incorporated "*Sustainable Development*" as themes. The evaluation feedback from SSYS teachers and students delegates collected from questionnaires administered on various aspects, i.e. their participation in event with impact on teaching and learning were examined. Content analysis was done on selected projects to illuminate how students participated in the Community of Practice (CoP) being guided by more knowledgeable others (MKO) in developing projects which reflected the philosophy of the DESD.

## BACKGROUND OF STUDY AND LITERATURE REVIEW

### Education for Sustainability and Student-Centred Learning Approaches: Various Concepts, Definitions, Issues and Key values

ESD involves the teaching of values and other moral ethics in STES education to ensure the creation of *sustainable environments* in which people can live and work, with the *natural environment*, *economic development* and *social life* are seen as mutually dependent, and the interaction between them contributes to the *sustainability* and enhancement of the quality of people's lives and the natural environment (Fien, 1995). While there is much debate around the world about the means and mechanisms for achieving this transition, there seems to be wide agreement that *education* has an important role to play in transforming values as well as empowering individuals and groups to participate in *environmental improvement* and *protection*. Sustainable development cannot exist as some static equilibrium state. Permanent *scientific* and *technological* innovation necessitate that sustainable development exists in some form of dynamic equilibrium. One reason is the ongoing tension between *social* interests and *environmental* interests in practical sustainability projects (Robottom, 2003). Thus the aspects of *environmental sustainability* with *ecological and economic sustainability* should also be emphasized in the discussion of ESD.

The World Conservation Strategy was quite explicit about the role of *education* in bringing about changes in *social values. Caring for the Earth: A Strategy for Sustainable Living* which was prepared as the World Conservation Strategy for the 1990s (IUCN, UNEP and WWF, 1991) also argues that education has a vital role to play in ensuring that people learn, accept and live by the principle that '*living sustainably* depends on accepting a duty to *seek harmony* with other people and with nature' (p.8). *Agenda 21* (the internationally agreed report of the United Nations Conference on Environment and Development or 'Earth Summit' which was held in Rio de Janeiro in June 1992) states the role of environmental education in relation to sustainability that :

> "*Education* is critical for promoting *sustainable development* and improving the capacity of the people to address environ-goals in the light of contemporary thinking on the role of environmental education in promoting a *sustainable environment.*"
>
> (Fien, 1995).

The abovementioned group calls this as '*education for sustainability*', i.e. a *process* which :

- enables people to *understand the interdependence of all life* on this planet, and the repercussions that their actions and decisions may have, both now and in the future, on resources, on the global community as well as their local one, and on the total environment.
- increases *people's awareness* of the economic, political, social, cultural, technological and environmental forces which foster or impede *sustainable development*.
- develops *people's awareness*, *competence*, *attitudes* and *values*, enabling them to be effectively involved in *sustainable development* at local, national and international level, towards more *equitable or sustainable future*, integrating environmental and economic decision-making.
- affirms the *validity of the different approaches* contributed by environmental education, including the need for further development and integration of the concepts of *sustainability* in these, other related cross-disciplinary educational approaches, as well as in established disciplines.

(Sterling/EDET Group, 1992 in Fien, 1996).

Five interrelated categories of objectives may be proposed to foster these goals :

*Awareness* : to help social groups and individuals acquire an awareness and sensitivity to the total environment and issues, questions and problems related to environment and development.

*Knowledge* : to help individuals, groups and societies gain a variety of experience in, and acquire a basic understanding of what is required to create and maintain a *sustainable environment*.

*Attitudes* : to help individuals, groups and societies acquire a set of values and feelings of concern for the environment, and motivation for actively participating in environmental improvement and protection.

*Skills* : to help individuals, groups and societies acquire the skills for identifying, anticipating, preventing and solving environmental problems.

*Participation* : to provide individuals, groups and societies with an opportunity and the motivation to be actively involved at all levels in working toward creating a *sustainable environment*.

(adapted from UNESCO-UNEP, 1978, p.3; and UNESCO and Australian Association for Environmental Education, 1993, p.34 in Fien, 1996).

The above five categories of objectives to foster the goals of ESD may be achieved through the incorporation of effective strategies into teaching "Sustainable Development" towards meeting aspirations of curriculum in STES education at schools or educational institutions. The National Science Teachers' Association (NSTA) takes the position that two major goals of science education are:

(i) to achieve scientific literacy for all citizens who are prepared to understand and deal rationally with the issues and opportunities of a scientific and technological world;

(ii) to ensure an adequate supply of scientists, engineers and science teachers for the 21st century.

According to the NSTA, the scientifically and technologically literate citizen should acquire a substantial knowledge and understanding of the framework, and nature of science. They must possess knowledge of the interrelationships among science, technology, environment and society (STES) (NSTA, 1990). They should be able to recognize the richness of and the challenges derived from exploring the natural world and its phenomena through scientific and technological activities. They should also be able to recognize the limits of science and use appropriate science in decision making possibly integrating technological intervention. There is a need to establish patterns of lifelong curiosity and learning, which are essential to prepare individuals for the changing workplace of the 21st century. Competent individuals need to be prepared to pursue careers in science and engineering as a result of having been exposed to appropriate pedagogies, accelerated programs or enriched curricula, and opportunities to pursue individual interests.

Various approaches and models are found to be suitable for student-centred learning investigative learning and for designing assessment tasks to address multiple core learning outcomes in STES education which are relevant to ESD. Among the suggested approaches according to the literature including action research, social investigation strategy, investigating environmental issues, cause-and-effect wheel, research projects, computer-based simulations, community projects, self and peer assessment and field study reports (Queensland Government, 1998). One of the innovative practices in ESD to promote student-centred learning includes the implementation of problem-based learning (PBL) with investigative projects being presented in science fairs or congresses. In the absence of any definitive record, it is believed that the first science fair for secondary (high school) students was held in New York in 1928. The science fair movement was established throughout the United States and other countries with considerable curriculum revision within 1960s–70s when there was an acceptance of a much wider range of outcomes in science education, an emphasis on student involvement, and a recognition of science fairs as a means of encouraging investigatory research projects among senior science students. Since then, science fairs were adopted at all levels of the school systems and were spread to various countries around the world with school or regional fairs leading to national and international fairs during

the 1980s. Although many Southeast Asian countries have developed a national science fair tradition, there was no international fair in this region until the Regional Congress for SEAMEO Young Scientists (SSYS) was initiated by RECSAM in 1997.

## Background and objectives of student-centred problem-based learning programme initiated by RECSAM with the aspects of ESD from socio-cultural perspectives

The "Search for SEAMEO Young Scientists" (SSYS) is a regional congress biennially organized for the youth to embark on scientific and technological research projects. It is one of the RECSAM's visionary programmes to achieve excellence via organizing regional or international ranking congress since 1997.

*Objectives and congress themes*

Recognising the significance of investigative science, both in promoting societal well-being and the economy, and in enhancing the development of learners' attitudes, skills and lifelong interest, SEAMEO RECSAM initiated the SSYS Congresses with the objectives of "promoting scientific attitudes and awareness; as well as providing a forum for exchange of ideas and experiences among students in SEAMEO and Associate member countries". More specifically the major objectives were to:

- encourage research and development among youths in SEAMEO Member countries;
- understand and be aware of the relationship between Science/Technology and Environment/Society;
- undertake scientific activities that will develop the youth's analytical mind, creativity, higher order thinking skills and proper values;
- create an atmosphere for a better understanding and appreciation of scientific activities and breakthroughs or important advances in the societies;
- provide a venue for intellectual and social interactions among students and educators; and
- identify and give recognition to outstanding young researchers.

The Centre initiated the First Regional Congress on "Search for SEAMEO Young Scientists" (SSYS) from 20-22 October 1997 with the theme "*Conserving the Environment Through Youth Science Research*". The Second Regional Congress was held from 5-7 July 1999 with the theme "*Technology for US*", whereas the Third Congress was held from 4-6 March 2002 with the theme "*Creating Intelligent Cities for the Harmonious Societies of the New Millennium*". In addition to the above objectives, the Fourth SSYS (8-10 March 2004) with the theme "*Towards A Sustainable Future*" and Fifth SSYS Congress (6-9 March 2006) with the theme "*Sustainable Development for a Better World*" also emphasized on "increasing awareness among youth on the importance of ensuring the sustainable development of the nation, where human needs are met without depleting or damaging the ecosystem".

*Format and nature of participation from social-constructivist/socio-cultural perspectives*

SSYS took the form of a Science Exhibition and Science Congress with three main components:

- *An investigatory project exhibit***.** This took the form of traditional science fair display with most format adopting a three-sided backboard for information, illustrations and graphs behind a table-top display space for accessory items, specimens or apparatus.
- *A written report***.** This was to be submitted ahead of the Congress and to contain a statement of the problem being investigated, a description of the methodology, a summary of results and observations, data analysis, illustrative material, conclusions, discussion, bibliography and acknowledgements.
- *Presentation***.** A formal presentation of projects to the assembled congress of young people and public members. This involves individual or group with audio-visual aids or 'power-point' presentation.

Each SEAMEO member country was invited to send a minimum of one team with each team comprising one or two students at secondary school level, accompanied by one teacher advisor. The student delegates

could either be selected on the basis of success at their respective national science fair or through selection at some other national identification of outstanding ability in investigatory science.

Preparing a scientific/technological research project for display in a science fair not only involves students working together and developing inter-personal skills, but also drawing on different skills in obtaining and presenting data. The final display of research findings gives a public recognition of their work, judging may reinforce their interest in research science and the attendant publicity may also bring kudos to the students, teacher and school. Students experience through investigative project work the rewards and satisfaction gained in 'doing science' via 'hands-on' approach rather than just 'learning science'. Science projects with students working independently, individually or in small groups, encourage the selection of a particular topic of interest and the conduct of a research investigation by applying scientific principles and methods. This may be to heighten interest, reinforce knowledge and increase understanding gained through formal teaching and learning, to add breadth or depth of related areas of the curriculum. Such project work also gives an opportunity to study local examples, to apply general concepts to a particular local situation or problem, thus showing the relevance and importance of formal studies to everyday real life contexts.

The opportunities or enrichment activities for students to carry out scientific/technological research through projects to explore the mysteries and marvels of the world should be provided in the school curriculum with teachers play the roles as facilitators and guide to scaffold student's problem-solving abilities in a social constructivist learning environments. *Social constructivism,* which is rooted from Vygotsky's theory, suggest that the knowledge in a person's mind is constructed by the circumstance or situation. A social constructivist view of learning recognizes that knowledge is constructed by people and the construction of knowledge is both personal and social. Personal construction of knowledge is socially mediated and social construction of knowledge is personally mediated. Learning which is viewed from the social constructivists' or 'social learning' theory focuses on learners' prior knowledge and how they construct their understanding based on their learning *contexts*. This type of learning is elaborated as *social mediation* with *participatory knowledge construction* in which interaction among group members (e.g. peer group) serve as socially shared vehicles of thought with possible support or coach from facilitator (e.g. teacher) that helps an individual to learn (McConnell, 2000).

Research findings revealed a *learning community* or Community of Practice (CoP) with a desirable environment could provide opportunities for students to engage in *solving problems* together with peers. In addition the role of teacher appears critical in supporting students' collaboration with peers and more knowledgeable other. Wenger (1998) defined "*communities of practice*" (CoPs) as "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly". Beside having the three elements or characteristics with the three elements of a domain, a community and a practice, all CoPs are found in a variety of forms in terms of size, feature, context, mode, network and recognition. Wenger (2006) also explained further that CoPs include students and that it can affect educational practices along three dimensions:

- Internally around subject matters in educational experiences that ground school learning in practice;
- Externally by connecting the experience of students to actual practice through peripheral forms of participation in broader communities beyond the school;
- Serving the lifelong learning needs of students with topics of continuing interest.

(Wenger, 2006 in Muniandy, Manickam, Yunus and Fong, 2006).

Literature revealed that the constructivist problem-solving curriculum via shared cognition with guidance of adults, more knowledgeable others (MKO) (Larkin,2002) or capable peers was found to be effective by various science educators/researchers. However, not much research was conducted to illuminate student-centred learning activities guided by MKO in the CoP.

## DELIBERATIONS OF EVALUATIVE STUDIES ON AN INITIATIVE IN TEACHING ESD VIA STUDENT-CENTRED LEARNING PROGRAMME

This section will outline the research aims and methodology with report the findings collected from responses by SSYS teachers and students delegates on the questionnaires administered on various aspects, i.e. their participation in event with impact on teaching and learning. Content analysis was also done on selected projects to illuminate how students were guided by more knowledgeable others (MKO) in developing projects which reflected the philosophy of ESD in view of socio-cultural perspectives in learning. As the themes of SSYS 2004 and 2006 were directly related, only the research findings collected from the evaluation questionnaires being administered during these two congresses will be discussed.

**Research questions, aims, methodology and data collection activities**

The following are the research questions (which were adapted from the evaluation questionnaires administered at the end of each SSYS congress):

- What are the feedback or comments from the SSYS student and teacher delegates with regards to the organization of the SSYS congress as well as the impact on teaching and learning?
- How were the delegates being guided by the more knowledgeable others in developing projects that reflected the philosophy of "Education for Sustainable Development" as the concept of Sustainable Development was incorporated as sub-theme of the 1st, 2nd and 3rd congresses since 1997, also as main themes for the 4th and 5th SSYS Congresses.

The following are the research aims being identified for this study:

- To evaluate the implementation of SSYS congress as a worthwhile activity that serve as platform for students' exchange of ideas and an effective student-centred learning programme to promote Education for Sustainable Development;
- To illuminate findings from selected exemplary practices on how students develop investigative projects being guided by more knowledgeable others in their respective Community of Practice;
- To discuss and recommend follow-up actions on research ideas initiated by the young scientists.

A mixed-research methodology with quantitative and qualitative data analysis was adopted including:

- The evaluation of the responses given by SSYS student and teacher delegates in the evaluation questionnaires being administered in the 4th SSYS (2004) and the 5th SSYS (2006).
- The report of three exemplary PBL practices anchored on socio-cultural perspectives will be made based on the findings from the following research methodologies:

  (a) Content/documentary analysis on two research project(s) with interviews findings to interprete how the students delegates were guided by their respective advisors in their respective learning community to develop investigative project(s) and present their findings in the SSYS congress:
  1. "Any possibility of conserving and sustaining Heath Forest of Bukit Beruang?" (SSYS 2006 project from Brunei, one of the best research report written, henceforth referred as "HFBB")
  2. "The preservation of Singapore forests" (SSYS 2006 project from Singapore winning the award of Best contribution to theme "*Sustainable Development for a Better World*", abbreviated as "SF")

  (b) Case study with findings from observation, interviews during congress and documentary analysis of project developed by students in a school in Penang whereby project students were being observed for a period of about 8 months from the initial stage of students being selected and guided by more knowledgeable others to participate in the investigative project work to the stage when

their investigative project was completed and being presented in SSYS congress. The title of project:

3. "Aerated in vitro culture system as a tool for rapid production of plantlets and plant conservation" (SSYS 2006 project from Malaysia winning the award of "Best in scientific creativity or innovation" henceforth being referred with abbreviation as "AVCS").

**Analysis of data and discussions of findings from evaluation questionnaires**

The SSYS congress evaluative questionnaires were prepared and distributed to the student and teacher delegates on the first day of SSYS events (both SSYS 2004 and 2006). Data were collected on the final day of the Congress. The following are the summarized areas of questionnaire items in the evaluation questionnaires to be analyzed in this section which are related to the focus of this study:

(a) organization of the Congress from the aspects of duration, venue, facilities, congress theme, display, objective met (Items No.1,2,3,4,6,7,15,17 for both 4th and 5th SSYS evaluation questionnaires);

(b) impact on teaching and learning in terms of:
- awareness of relationship between Science, Technology, Environment, Society (Item No.8 for both 4th and 5th SSYS)
- analytical and creative thinking skills (Item No.9 for both 4th and 5th SSYS)
- social interaction (Item No.10 for both 4th and 5th SSYS)
- interest on scientific/technological research and understanding of important scientific advances (Items No.5,11 for both 4th and 5th SSYS)
- application of learned concepts/principles on S&T (Item No.12 for both 4th and 5th SSYS)
- competency in designing investigative S/T research (Item No.13 for both 4th and 5th SSYS)
- motivation for science related career (Item No.14 for both 4th and 5th SSYS)
- enjoyment of congress (Item No.16 for both 4th and 5th SSYS evaluation questionnaires)

Overall, the students have high positive rating of the organization and conduct of the Congress, as summarized in ***Table 1*** on the student delegates' perception in various aspects of both the 4th (8-10 March 2004) and 5th SSYS (6-9 March 2006) congresses. For both events, student delegates stated they "enjoyed the SSYS congress" with average ratings 4.57 (the highest for the items in 2004) and 4.27 (the second highest for the items in 2006) respectively. For SSYS 2006, the students delegates rated lowest (with average 3.06) on item concerning "The duration of SSYS congress is enough". Although the duration of the 5th Congress has increased from the previous (2004) congress with two full days to the present (2006) three full days, some student delegates still considered the duration of Congress was not enough. This implies that the delegates would actually like to be involved more in such events and they would not mind stay longer.

In terms of organization, SSYS 2004 delegates had positive feedback on the item "Facilities provided are enough and comfortable" with average rating of 4.45, whereas SSYS 2006 responded highest on item "The display of project exhibits made me understand better the implications of the activities and developments" with average rating of 4.07. As for the impact on learning for their participation in the event, SSYS 2004 responded with highest rating of 4.40 for item "The congress made me aware of the relationship between Science/Technology (S/T) and Environment/Society (E/S), whereas SSYS 2006 had highest regards (with average rating of 4.42) on the item "SSYS congress has stimulated my interest on scientific and technological research" which is rather a good sign and another encouraging feedback for the organizer. The three other items which were rated highly for SSYS 2004 were "The activities in the Congress made me feel competent to plan and conduct investigative scientific and technological research in the future" (with average rating of 4.33), "The Congress has enabled me to interact socially and intellectually with my fellow students from Southeast Asian countries" (with average rating of 4.28) and "The Congress has stimulated me to be more analytical and creative" (average rating 4.19), whereas for SSYS 2006 these items were "I enjoyed the SSYS Congress" (average rating 4.27), "The Congress has

provided a wholesome atmosphere for a better understanding of important advances in science" (average rating 4.21) and "The Congress has stimulated me to be more analytical and creative" (average 4.18).

As for the responses from teacher delegates as summarized in ***Table 2*** on the various aspects of the 4th SSYS Congress (8-10 March 2004), the items "The Congress provided a wholesome atmosphere for a better understanding of important advances in science" and "I enjoyed the SSYS Congress" were rated highest with average ratings of 4.50 and 4.40 respectively. However, teacher delegates who were more critical than students had rated the lowest (with average ratings of 3.50) on item "The projects presented are supportive of the theme of the Congress". This is considered an important feedback as the authors feel that educators in the SEAMEO region should be given more exposure and information regarding the concept and philosophy of Education for Sustainable Development so that more scientific/investigative projects could be developed in accordance to the UN's aspiration of the "*DESD*" (2005-2014).

Overall, the teacher gave good feedback on the organization of SSYS 2004 with three highest ratings of 4.44 for item "The dates of the SSYS Congress are appropriate", 4.40 for item "The duration of SSYS Congress (3 days) is enough" and 4.30 for item "The SSYS Congress was well organized". In terms on the impact of SSYS on teaching and learning, the apart from the two highest ratings discussed earlier, the teacher delegates of SSYS 2004 had also rated high on the item "The Congress enabled me to interact socially and intellectually with my fellow educators from Southeast Asian countries" and "The Congress enabled me to guide students to apply learned concepts and principles on S&T" (both with average rating of 4.30), also "The activities in the Congress have improved my competence in guiding students to plan and conduct investigative scientific and technological research" (average rating of 4.20) respectively.

For SSYS 2006 teachers' feedback on the aspects of projects as summarized in ***Table 3***, most of them (63.6% of the total 11 respondents) agreed that "The projects require high levels of science knowledge", whereas 2 (18.2%) did not respond and 2 (18.2%) stated "No". When asked about whether "The projects in the SSYS lead students to explore new ideas in learning science", 3 teachers (27.3%) responded "Strongly Agree", 5 (45.5%) responded "Agree", 2 (18.2%) responded "Strongly Disagree" and one did not respond at all. One who responded "Agree" also wrote the feedback "For some only". There was also one additional feedback stated "Depends on the quality of the students' projects". With regards to the question whether "The projects in the SSYS support science learning in school?", 6 teachers (54.5%) responded "Very supportive" and 5 (45.5%) responded "Supportive" and nobody stated "Not supportive at all". Most of them also agreed that the atmosphere during the SSYS Congress is very conducive. However, with regards to the item question, "Do you agree that only very good students should participate in SSYS Congress", there were varied responses. Though most of them agreed with this statement, except some gave the following responses:

- Different students have different strength and weakness. Some though not good in presentation but they may be the one who is creative and the master mind behind the project.
- No, including not highly academic achievement ones but very passionate in their projects allow them to share their work with others. However, still need the very good ones to showcase and be the benchmark for fellow delegates.
- No, should accept the students who are interested in science and active for learning and have project.

These responses had in fact raised the interest of the researchers to explore various initiatives that will make the project/problem/programme-based learning activities to be more widely accessible to include also the participation of underachievers in student-centred learning programmes.

Although most delegates gave good feedback on the impact of SSYS on teaching and learning, the researchers were in fact more keen to find out their involvement and the process they have undergone in developing the projects through the analysis of their project documents (for both local and students from two neighbouring countries, i.e. Brunei and Singapore) focusing on the research activities and reflections by the project team members, their powerpoint presentation and interactive interviews with researcher

during congress (for both local and students from neighbouring countries) and observation by researcher (only for local school students who were being followed up for about 8 months prior to SSYS).

**Analysis of data and discussions of findings from content analysis and case study**

As stated earlier, three research projects were examined under the aspect of "*Conservation of forests and plants with sustainable plan and creative technology*" to illuminate how students were guided by more knowledgeable others (MKO) in developing projects reflecting the themes on "*Sustainable Development*".

"SSYS project team with members of collective competence" was the identity of CoP being defined by a "shared and committed *domain* of interest", not necessarily recognized as expert, but outsider may value and recognize their expertise. Members in the CoP value their collective competence. For example, there were members with expert content knowledge, research/ICT skills for literature review, preparation of powerpoint presentation and writing skills in report writing. They built relationships to help and learn from each other through interaction with joint activities including data collection or analysis, discussions and sharing of information and knowledge including laboratory experiments and fieldwork. Members develop shared practice with a shared repertoire of resources that includes experiences, case stories, tools and ways of addressing a particular problem (Wenger, 1998). The features of these CoPs including core group members who were mainly the SSYS delegates (two project students as non-expert practitioner and one advisor or mentor as expert practitioner per country) working with peripheral members that include non-expert practitioner(s) such as other helpers, project team secondary student(s) [for all three teams], interim member(s) [for HFBB project], primary school students [for SF project] and expert practitioner including research assistants or students and research scientists or university lecturers as discussed below.

For example, for HFBB project team, the peripheral expert members included officials from:

- The Science, Technology and Environment Partnership (STEP) Centre that provide guidance, briefing and pre-congress judging by panel judges with first presentation by interim member;
- Natural History section and Museums Department that provide guide at Ukong Community Forest and Tasek Merimbun;
- libraries of Forestry Department and UBD that provide resources;
- plant taxonomists that provide knowledge and skills related to the study;
- science laboratory technicians that provide technical support;
- college administrative staff, Principal and Deputy Principal(s) of Sultan Omar Ali Saifuddien College who provide administrative support.

Whereas for SF project team, the peripheral expert members include:

- two former mentors as advisors for the project help assisted project mentor to provide valuable information, help and guide the group through initial stage of project,
- Vice-President of Nature Society Singapore who provided valuable information about forest;
- research assistant of National Institute of Education (NIE) who share experience and provide knowledge, advice, skills and assistance in forest or outdoor fieldwork eg. the identification of species;
- National Parks Board with passes to enter the Mandai plot and acknowledging the project;
- Administrative staff of Raffles Girls' Secondary School who provide the group with most of the equipment needed with guidance.

For AVCS team, the following peripheral expert members had contributed to project and exposure:

- USM Professor in School of Biological Sciences who is the advisor for the entire project;
- Tissue culture laboratory assistants for technical assistance;
- Vice Chancellor and dean of university for the support of workshop and research facility/equipments;
- Principal of SMK Sungai Nibong for the administrative and ICT support.

Thus the size of CoP for HFBB and SF teams was considered large whereas for AVCS team was considered medium. All the project research activities were formally endorsed as one of the school enrichment programme (with the fieldwork for SF team was recognized as hands-on learning programme) by their respective institution and Ministry of Education. They were provided with some financial assistance in their respective research activities, also some project allowances in terms of cash awards at the end of the congress presentation. During their research activities, all these three team members met face-to-face within their own respective organization (i.e. school or college), also include the peripheral members from various other organizations as discussed above. Apart from organizing educational experiences that ground school learning in practice through participation in communities around subject matters (i.e. "Understanding and conserving dynamic ecosystem with knowledge on transect; biotic and abiotic components of the environment; and nutrition/biotechnology"), the students' learning experiences were also connected to actual practice through peripheral forms of participation in broader communities beyond the school education, as well as serving the lifelong learning needs of students including the cultivation of scientific research, ICT (e.g. use of Internet, data logger) and writing skills, critical/creative thinking skills and the awareness of seeing the interrelationship among STES. For example,:

- As the students' learning experiences in HFBB project team were connected to actual practice in Ukong Community Forest, Tasek Merimbun, Forestry Department, their lifelong learning topic will be focused on environmental education in studying ecosystem and its conservation;
- In SF team, members explored ways of conducting fieldwork to identify biotic (tree girth and natural recruitment) and abiotic factors (humidity, light intensity and temperature). Students' learning experiences were connected to actual practice in National Parks Board (NPB) and National Institute of Education (NIE). The Annual Nature Learning Camp is an exemplary annual event that brought students from various local primary, secondary and international schools together for a day of hands-on learning experiences, supported by NPB, NIE and Public Utility Board. Students developed good attitudes for learning and values like "patience, discrimination in filtering of information, teamwork, collaboration, seeking clarity, curiosity, open-mindedness, respecting hard work of scientists (e.g. ecologists, etc)" were reported. The study of "environmental education and reforestation" may thus be their lifelong topic of interest.
- In AVCS team, students' experience was connected to actual practice in Tissue Culture laboratory. Through various web-based activities to review literature on topics related to "nutrition/biotechnology", students had developed lifelong learning interest with understanding of the threats of distinction of and the needs to conserve endangered plant species especially those with medicinal values to protect, restore and manage natural heritage.

## CONCLUSION, LIMITATIONS AND RECOMMENDATION

This study is a compilation of findings from evaluation questionnaire surveys, content analysis and interviews data collected from young scientists during the SSYS congresses organized in the years 2004 and 2006. The 5th SSYS Congress (2006) had successfully convened the participation of 37 student delegates and 17 teacher delegates from ten SEAMEO member countries. Although not all the delegates responded to the evaluation questionnaires, it was obvious that in general, these delegates enjoyed attending the SSYS Congress conducted at RECSAM. Almost all students as well as teachers were satisfied with the organization and conduct of the Congress. Most of them agreed that the 5th SSYS Congress enabled them to interact socially and exchange intellectually with their peers from Southeast Asia. Other findings revealed that student delegates hold positive views of the SSYS Congress. In summary, these attributes were shown from the survey findings with SSYS delegates reported:

- enhanced awareness of the interrelationship among Science, Technology, Environment, Society;
- feelings of competence to conduct investigations with scientific/technological inventions; and
- manifested values, attitudes on PBL with interest and motivation to participate in event like SSYS.

Although there were also limitations of study e.g. inability to interview delegates due to time constraints and incomplete information obtained from the reports that hindered more in-depth analysis, the findings revealed the evidence that the objectives of SSYS have been successfully achieved and the Congress provided an excellent opportunity for the delegates to exchange ideas and information with the understanding of the cultural diversity of their counterparts from the Southeast Asia region. This has envisioned the SSYS Congress as a worthy scientific, technological and educational venture that enables young scientists from all over Southeast Asia to present their research findings on scientific projects. While the Centre is cognizant of the successful conduct of the 5th SSYS Regional Congress, it should be taken into consideration that there is still room for improvement The authors feel that some follow-up actions should be made on research ideas initiated by the young scientists and would like to suggest that:

- More networking activities should be made with the young scientists with more exchange of ideas. For example, during the 5th SSYS congress, a Young Scientists Network (YSN) was formed whereby student delegates were registered on-line to participate in web-based exchange via SAW programme (http://www.scienceacross.org) and web-forum of "Malaysian Academy for the Advancement of Young Scientists (http://www.maays.net)" with other young scientists for activities e.g. suggestions for the improvement of existing projects, brainstorming and exchange of new project ideas, etc.;
- The research projects developed by the young scientists should be further refined and published through refereeing process with international scholars participating in the process; and
- Networking should be made with various research institutions and R&D centres in the industries so that opportunities for placement by young scientists could be provided to further extend their research ideas into scientific and technological inventions that could benefit the environment and society.

The roles of teacher advisors or mentors are also important for successful implementation of student-centred learning programme such as SSYS congress. It is also proposed that pre- or post-congress seminar or workshop could also be conducted for teacher advisors to enhance their research capabilities, innovativeness and to introduce them more innovative ideas on how to plan and conduct investigative, scientific and technological research. Professionals in the organizing and participating teams as well as officers from the ministries should take into consideration the various comments and suggestions by the delegates who had participated in the SSYS congresses, of which could serve as valuable inputs for the planning of the forthcoming congresses.

The 6th SSYS Congress with the theme "*Sustaining community development through Science and Mathematics*" is scheduled to be held in 2-6 March 2008. An invitation brochure will be mailed to all SEAMEO Member and Non-Member Countries to invite participation of both Mathematics and Science investigative projects. RECSAM is committed to continuously promote the culture of science learning via investigative project/problem-based learning (PBL) towards achieving scientific literacy for all citizens and to ensure an adequate supply of scientists and engineers for a sustainable future. The Centre welcomes the participation and contribution from various parties with the hope that the Congress could spearhead more innovations or inventions incorporating multidisciplinary knowledge and skills that are essential for the sustainable development of the nation.

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**Table 1 : Student delegates' perception on the various aspects of the SSYS Congress**

| Aspect of the SSYS Congress being evaluated | The 4th SSYS Congress (8-10 March 2004) student delegates [N=21] | | | | | | | The Fifth SSYS Congress (6-9 March 2006) delegates [N=31] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Frequency and percentage (%) of rating | | | | | Missing | Ave. Rating | Frequency & percentage(%) of rating | | | | | Missing | Ave. Rating |
| | SD(1) | D(2) | N(3) | A(4) | SA(5) | | | SD(1) | D(2) | N(3) | A(4) | SA(5) | | |
| 1. The duration of SSYS Congress (3 days) is enough | - | 1 | 5 | 10 | 4 | 1 | 3.85 | 1 | 12 | 5 | 10 | 3 | - | 3.06 |
| | (0) | (4.8) | (23.8) | (47.6) | (19.0) | (4.8) | | (3.2) | (38.7) | (16.1) | (32.3) | (9.7) | (0) | |
| 2. The dates of SSYS Congress are appropriate | - | 1 | 6 | 10 | 3 | 1 | 3.70 | 1 | 4 | 4 | 14 | 7 | 1 | 3.73 |
| | (0) | (4.8) | (28.6) | (47.6) | (14.3) | (4.8) | | (3.2) | (12.9) | (12.9) | (45.2) | (22.6) | (3.2) | |
| 3. The venue of SSYS Congress is appropriate | - | - | 3 | 7 | 9 | 2 | 4.30 | 1 | 1 | 7 | 14 | 7 | 1 | 3.83 |
| | (0) | (0) | (14.3) | (33.3) | (42.9) | (9.5) | | (3.2) | (3.2) | (22.6) | (45.2) | (22.6) | (3.2) | |
| 4. The facilities provided during the Congress are enough and comfortable | - | 1 | 1 | 6 | 12 | 1 | 4.45 | - | 4 | 4 | 18 | 4 | 1 | 3.73 |
| | (0) | (4.8) | (4.8) | (28.6) | (57.1) | (4.8) | | (0) | (12.9) | (12.9) | (58.1) | (12.9) | (3.2) | |
| 5. The SSYS Congress has stimulated my interest on scientific and technological research | - | - | 4 | 5 | 12 | - | 4.38 | - | 1 | 2 | 11 | 17 | - | 4.42 |
| | (0) | (0) | (19.0) | (23.8) | (57.1) | (0) | | (0) | (3.2) | (6.5) | (35.5) | (54.8) | (0) | |
| 6. The projects presented are supportive of the theme of the Congress | - | 1 | 2 | 13 | 4 | 1 | 3.50 | - | 3 | 8 | 12 | 8 | - | 3.81 |
| | (0) | (4.8) | (9.5) | (61.9) | (19.0) | (4.8) | | (0) | (9.7) | (25.8) | (38.7) | (25.8) | (0) | |
| 7. The display of project exhibits made me understand better the implications of activities and developments | - | 1 | 1 | 10 | 9 | - | 4.28 | - | 2 | 5 | 17 | 7 | - | 4.07 |
| | (0) | (4.8) | (4.8) | (47.6) | (42.9) | (0) | | (0) | (6.5) | (16.1) | (54.8) | (22.6) | (0) | |
| 8. The SSYS Congress made me aware of the relationship between science/technology (S/T) and environment/society (E/S) | - | - | 2 | 8 | 10 | 1 | 4.40 | - | 2 | 2 | 17 | 8 | 2 | 3.82 |
| | (0) | (0) | (9.5) | (38.1) | (47.6) | (4.8) | | (0) | (6.5) | (6.5) | (54.8) | (25.8) | (6.5) | |
| 9. The SSYS Congress has stimulated me to be more analytical and creative | - | - | 5 | 7 | 9 | - | 4.19 | - | 2 | 2 | 13 | 11 | 3 | 4.18 |
| | (0) | (0) | (23.8) | (33.3) | (42.9) | (0) | | (0) | (6.5) | (6.5) | (41.9) | (35.5) | (9.7) | |
| 10. The Congress has enabled me to interact socially and intellectually with my fellow students from Southeast Asian countries | - | 1 | 2 | 8 | 10 | - | 4.28 | - | 1 | 3 | 9 | 15 | 3 | 4.14 |
| | (0) | (4.8) | (9.5) | (38.1) | (47.6) | (0) | | (0) | (3.2) | (9.7) | (29.0) | (48.4) | (9.7) | |
| 11. The SSYS Congress has provided a wholesome atmosphere for a better understanding of important | 1 | - | 4 | 7 | 8 | 1 | 4.05 | - | - | 3 | 16 | 9 | 3 | 4.21 |

| Aspect of the SSYS Congress being evaluated | The 4th SSYS (8-10 March 2004) teacher delegates [N=10] | | | | | | | The Fifth SSYS Congress (6-9 March 2006) teacher delegates [N=11] | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Frequency and percentage (%) of rating | | | | | Missing | Ave. Rating | | | | | | | |
| | SD(1) | D(2) | N(3) | A(4) | SA(5) | | | | | | | | | |
| 1. The duration of SSYS Congress (3 days) is enough | - | - | - | 6 | 4 | - | 4.40 | | | | | | | |
| | (0) | (0) | (0) | (60) | (40) | (0) | | | | | | | | |
| 2. The dates of the SSYS Congress are appropriate | - | - | - | 5 | 4 | 1 | 4.44 | | | | | | | |
| | (0) | (0) | (0) | (50) | (40) | (10) | | | | | | | | |
| 3. The venue of the SSYS Congress is appropriate | - | - | 2 | 5 | 3 | - | 4.10 | | | | | | | |
| | (0) | (0) | (20) | (50) | (30) | (0) | | | | | | | | |
| 4. The facilities provided during the Congress are enough and comfortable | - | - | 2 | 4 | 4 | - | 4.20 | | | | | | | |
| | (0) | (0) | (20) | (40) | (40) | (0) | | | | | | | | |
| 12. The Congress has enabled me to apply learned concepts and principles on science and technology | - | 1 | 2 | 10 | 7 | 1 | 4.15 | - | 1 | 6 | 10 | 11 | 3 | 4.11 |
| | (0) | (4.8) | (9.5) | (47.6) | (33.3) | (4.8) | | (0) | (3.2) | (19.4) | (32.3) | (35.5) | (9.7) | |
| 13. The activities in the Congress made me feel competent to plan and conduct investigative scientific and technological research in the future | - | - | 5 | 4 | 12 | - | 4.33 | - | 1 | 6 | 10 | 11 | 3 | 4.11 |
| | (0) | (0) | (23.8) | (19.0) | (57.1) | (0) | | (0) | (3.2) | (19.4) | (32.3) | (35.5) | (9.7) | |
| 14. I enjoyed the Science forum and it has motivated me to take up science related career | 2 | - | 6 | 8 | 4 | 1 | 3.60 | - | 2 | 9 | 11 | 8 | 1 | 3.83 |
| | (9.5) | (0) | (28.6) | (38.1) | (19.0) | (4.8) | | (0) | (6.5) | (29.0) | (35.5) | (25.8) | (3.2) | |
| 15. The SSYS Congress was well organized | - | 1 | 3 | 7 | 9 | 1 | 4.20 | - | 1 | 7 | 16 | 6 | 1 | 3.90 |
| | (0) | (4.8) | (14.3) | (33.3) | (42.9) | (4.8) | | (0) | (3.2) | (22.6) | (51.6) | (19.4) | (3.2) | |
| 16. I enjoyed the SSYS Congress | - | - | 1 | 7 | 13 | - | 4.57 | - | 1 | 3 | 13 | 13 | 1 | 4.27 |
| | (0) | (0) | (4.8) | (33.3) | (61.9) | (0) | | (0) | (3.2) | (9.7) | (41.9) | (41.9) | (3.2) | |
| 17. The objectives of the SSYS Congress were met | - | 1 | 3 | 7 | 9 | 1 | 4.20 | - | - | 5 | 18 | 6 | 2 | 4.03 |
| | (0) | (4.8) | (14.3) | (33.3) | (42.9) | (4.8) | | (0) | (0) | (16.1) | (58.1) | (19.4) | (6.5) | |

**Table 2: Teacher delegates' perception on the various aspects of the SSYS Congress**

**Table 3: Teacher delegates' perception on various aspects of projects**

| Aspect of the SSYS projects | Frequency (freq.) and percentage (%) of rating | | | | |
|---|---|---|---|---|---|
| (a) The theme of the SSYS is related to science learned in school | Yes (freq.) | (percent, %) | No (freq.) | (percent %) | Mis-sing |
| | 10 | (90.9) | 1 | (9.1) | - |
| | Open-ended feedback for "No" response: N/A | | | | |
| (b) The projects | Yes (%) | No response (%) | No (%) | | Mis-sing |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5. The SSYS Congress has stimulated my interest on scientific and technological research | - | - | 2 | 5 | 3 | - | 4.10 |
| | (0) | (0) | (20) | (50) | (30) | (0) | |
| 6. The projects presented are supportive of the theme of the Congress | - | 1 | 4 | 4 | 1 | - | 3.50 |
| | (0) | (10) | (40) | (40) | (10) | (0) | |
| 7. The display of project exhibits made me understand better the implications of activities and developments | - | - | 3 | 7 | - | - | 3.70 |
| | (0) | (0) | (30) | (70) | (0) | (0) | |
| 2. The SSYS Congress made me aware of the relationship between science/technology (S/T) and environment/society (E/S) | - | - | - | 8 | 2 | - | 4.20 |
| | (0) | (0) | (0) | (80) | (20) | (0) | |
| 3. The SSYS Congress has stimulated me to be more analytical and creative | - | - | - | 9 | 1 | - | 4.10 |
| | (0) | (0) | (0) | (90) | (10) | (0) | |
| 10. The Congress enabled me to interact socially and intellectually with my fellow educators from Southeast Asian countries | - | - | - | 7 | 3 | - | 4.30 |
| | (0) | (0) | (0) | (70) | (30) | (0) | |
| 11. The SSYS Congress provided a wholesome atmosphere for a better understanding of important advances in science | - | - | 1 | 3 | 6 | - | 4.50 |
| | (0) | (0) | (10) | (30) | (60) | (0) | |
| 12. The Congress enabled me to guide students to apply learned concepts and principles on S&T | - | - | 1 | 5 | 4 | - | 4.30 |
| | (0) | (0) | (10) | (50) | (40) | (0) | |
| 13. The activities in the Congress have improved my competence in guiding students to plan and conduct investigative scientific and technological research | - | - | 1 | 6 | 3 | - | 4.20 |
| | (0) | (0) | (10) | (60) | (30) | (0) | |
| 14. I enjoyed the Science forum and was motivated with the discussions | - | - | 3 | 6 | 1 | - | 3.80 |
| | (0) | (0) | (30) | (60) | (10) | (0) | |
| 15. The SSYS Congress was well organized | - | - | 1 | 5 | 4 | - | 4.30 |
| | (0) | (0) | (10) | (50) | (40) | (0) | |

require high levels of science knowledge

| | | | | |
|---|---|---|---|---|
| 7 | 2 | 2 | - |
| (63.6) | (18.2) | (18.2) | |

Open-ended feedback for "No" response:

Not for most of the projects.

(c) The projects in the SSYS are:

| Very Interes-ting (%) | Inte-res-ting (%) | Somewhat Interes-ting (%) | Not In-teresting at all (%) | Mis-sing |
|---|---|---|---|---|
| 6 | 4 | - | - | 1 |
| (54.5) | (36.4) | (0) | (0) | (9.1) |

(d) The projects in the SSYS are also:

| Very challe-nging (%) | Chal-len-ging (%) | Somewhat challen-ging (%) | Not chal-lenging at all (%) | Mis-sing |
|---|---|---|---|---|
| 4 | 6 | - | - | 1 |
| (36.4) | (54.5) | (0) | (0) | (9.1) |

(e) The projects in the SSYS lead students to explore new ideas in learning science

| Strong-ly agree (%) | Agree (%) | Strongly disagree (%) | No response (%) | Mis-sing |
|---|---|---|---|---|
| 3 | 5 | 2 | 1 | - |
| (27.3) | (45.5) | (18.2) | (9.1) | (0) |

(f) The projects

Suppor-

Not suppor-

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16. I enjoyed the SSYS Congress | - | - | 1 | 4 | 5 | - | 4.40 | | in the SSYS | Very | tive | tive at all | Mis-sing |
| | (0) | (0) | (10) | (40) | (50) | (0) | | | support science | supportive | (%) | (%) | |
| 17. The objectives of the SSYS Congress were met | - | - | 1 | 7 | 2 | - | 4.10 | | learning in | (%) 6 | 5 | - | - |
| | (0) | (0) | (10) | (70) | (20) | (0) | | | school | (54.5%) | (45.5%) | (0) | (0) |

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