Developing Instructional Materials to Promote Investigative Research Using Interactive ICT Tools: An Experience from a Continuing Professional Development (CPD) Programme

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Abstract

The current global digital era and knowledge-based society calls for the continuous upgrading of professionals and skilled workers in the society with a clear commitment towards lifelong learning. As science professionals play the major role in training future leaders in the field of science, mathematics and technology education to achieve the aspiration of a developing nation, it becomes of utmost importance to upgrade their knowledge and skills through Continuing Professional Development (CPD). This article reports a case from the authors’ involvement in a CPD programme that included in-service trainings supervised by the first author with input from the second co-author on the use of interactive information and communication technology (ICT) tools to develop instructional materials that promote investigative research. The research and development (R&D) activities were mainly anchored on an e-learning platform, namely ‘Science Project/ problem/ programme-based Activities inCorporating Experiment MANagement’ (SP3ACEMAN) [http://sp3aceman.net], a programme that was founded in 2004 with off-line resources and incorporated with blended learning activities since 2009. The first workshop was conducted in 2011 to replicate some of the project-based activities (PBA) and problem-based learning (PBL) adapted from previous research findings by the first author as researcher. The third to fifth co-authors with nine other science and mathematics teachers were also involved as advisor(s), curriculum developers, workshop and e-forum participants. During the first workshop in June 2011, the participants were administered with pre-test to explore their prior knowledge and skills related to the objectives of the CPD programme. The indicators of their performance were measured from the change of their perception on “‘Learning Activities Management System (LAMS), ICT skills to develop e-learning objects, evaluation rubric guide to facilitate PBA/PBL, current trends, blended learning, and so forth” as reflected from their responses using Likert Scale and the qualitative feedback collected from their pre-/post-test questionnaires. Their improvement in perception and mastery of knowledge or skills using LAMS and other ICT tools were also evaluated through their responses to the open-ended questionnaire and facilitators’ observation of classroom activities. Some examples on the flowchart of lesson ideas incorporating LAMS and brief outline of PBL lessons guided by support tool were illustrated. The research activities and findings will serve as guidelines for the future planning of teacher education towards developing instructional materials for investigative research. Educational implications and future direction that included the implementation of second ‘Lesson study’ workshop are also elaborated.


Introduction

A leading-edge workforce in any nation requires not only new talent, coming out of schools and colleges with the appropriate training, education and skills to drive the economic engine. It also needs the continuous upgrading of the current knowledge and skill of the existing personnel as well as citizens with scientific and technological literacy (STL) to respond to the demands of the current global digital era and
information or knowledge-based society we live in today. To achieve the aspiration of a developing nation focusing on the advancement in science and technology, it becomes of utmost importance to upgrade the knowledge of science professionals through Continuing Professional Development (CPD). This article reports a case from the authors’ involvement in a CPD programme that included in-service trainings supervised by the first author with input from the second co-author on the use of interactive information and communication technology (ICT) tools to develop instructional materials that promote investigative research. The research and development (R&D) activities were mainly anchored on an e-learning platform, namely ‘Science Project/ problem/programme-based Activities inCorporating Experiment MANagement’ (SP3ACEMAN), an international flagship programme that was founded in 2004 with off-line resources and incorporated with blended learning activities since 2009.

**Literature Review on Framework and Background**

**Use of e-portals for blended learning for PBA/PBL with enrichment/networking activities**

The advancement of technology education through e-learning portals allows teachers to employ various constructivist strategies that could actively engage learners’ interest and motivation to learn through diverse approaches. Literature revealed that technology plays an important role to facilitate science and mathematics learning in the recent years. Cognitively-guided research in science education shows that teacher-centred pedagogy with lecture and demonstration is not effective at securing student’s understanding in subject matter. Effective and sustainable use of e-learning platforms supported by innovative technological tools are important to facilitate science/mathematics education with the sharing of exemplary practices. Hence technology-enhanced learning activities supported by ICT tools and e-portals were identified as important components in the training programmes of RECSAM, a regional training institution for science and mathematics education for the SEAMEO member countries and beyond since its inception forty years ago.

‘Science Project/problem/programme-based Activities inCorporating Experiment MANagement’ (SP3ACEMAN) (URL: http://sp3aceman.net) is a student-centred learning programme founded in 2004 as an off-shoot of the post-graduate research studies aiming at promoting investigative research. These investigative research activities mainly emphasize on contextual problem-solving skills as reflected in project-based activities (PBA), problem-based learning (PBL) and participatory inquiry (PI). All these approaches combine investigation, education and purposeful action with knowledge creation and transformation through shared learning (using blended learning mode) in contrast with transmission approach. Participants of PBA/PBL activities gained enriched experience with change of identity and enhanced creativity (Briton et al, 2010). In 2004, an off-line web-portal was designed initially as platform for sharing of resource materials such as support tools for project-based activities (PBA)(studies between 2003 and 2008) that were also compiled using CD-ROM being distributed among students participated in the PBA programme. The e-portal was later made available since 2009 and officially launched in 2011 for problem-based learning (PBL)(studies between 2007 to 2011) and PBA as aforementioned.

Blended learning was incorporated in SP3ACEMAN programme to promote PBA/PBL with enrichment and networking activities. This was implemented in response to the research findings in science learning that revealed that learners and teachers need highly interactive conversational environments around media-rich artifacts to provide common grounds for fostering learning communications (Pea, 1995). The review of literature also showed the possibility of interactive e-learning initiatives and other technology as useful tools for effective and ever-expanding global web-based cooperative learning projects.

**Involving all types of learners in SEARCH for science and mathematics researchers**

SP3ACEMAN programme is one of the six sub-portals being hyperlinked to an official portal entitled ‘South East Asia Regional Capacity-enhancement Hub’ (SEARCH) (http://www.recsam.edu.my/search/index.html). This on-line learning hub was developed to involve students from diverse background in search for science and mathematics researchers towards Education for Sustainable Development (ESD) and Education for All (EFA) (Figure 1). The SP3ACEMAN site (Figure 1 and Figure 2) is designed for students from diverse background with various levels of background knowledge and academic achievement to explore more about investigative research activities. A guided tour with scaffolded activities are specially
designed for beginners with support rendered [for example, ‘Teachers’ and students’ guide for the use of support tool’ as illustrated in Figure 2]. Using ‘WordPress’ as an open source, this e-portal supported by a closed forum is also developed to facilitate wider groups of participation towards EFA and fostering creativity with sharing of more Open Educational Resources (OER). Whereas more challenging activities are also prepared for advanced learners for self-directed/self-paced/self-accessed learning. Some of the research evidences related to SP3ACEMAN were disseminated by Ng (2009) and Ng (2010) with the resources downloadable as OER through URL http://forum.sp3aceman.net.

This programme was monitored and evaluated using POSITIVE rubric guide (an acronym for ‘Planning, Objective/organization, Skills, Information procurement, Training/transfer of HOT, Involvement/Incorporating pedagogical-content knowledge (PCK), Values with enhanced motivation and Evaluation/exchange/enrichment/ever-lasting exposure’. It was designed for PBA and PBL using scaffolded instruction (SI) activities (or abbreviated as PBL-SI). Generally all types of learners especially those with moderate and low academic performance were involved in SP3ACEMAN with project teams of students from heterogeneous background were formed to facilitate their PBL-SI. It is believed that the children’s potential development working alone is less than what they can achieve when working in collaborative teams as explained from Zone of Proximal Development (ZPD) theory. ZPD is a concept defined by Vygotsky (1978) to represent the difference between a child’s independent problem-solving activity and the level of problem-solving possible under the guidance of an adult, a more capable peer or ‘More Knowledgeable Others’ (MKO) (McCormick & Paechter, 1999). It is expected that these learners' abilities will be enhanced when they work closely with someone who are more skilled.

The support tool is used to guide teachers and non-gifted learners with low motivation in learning science and mathematics when implementing PBA/PBL activities in Community of Practice (CoP). The following aims are identified for the activity, ie. using the support tool:

- To guide the reflective practice of teachers towards more in-depth understanding before they introduce and assess PBL-SI activities among learners of diverse backgrounds.
- To support teachers to scaffold the students’ practice in PBL-SI, continually adjust the level of their help in response to the students’ level of performance with feedback of results; thereby instill the skills necessary for their future independent problem-solving ability as explained in Zone of Proximal Development (ZPD) theory.

According to this support tool that is anchored on social constructivist theoretical framework, ‘Planning and Objectives’ are considered as two important components. This is because literature revealed that “setting clear learning objectives at the start of a lesson and encouraging pupils to assess their own understanding following each lesson” (Spavold, 2005, p.119) was effective to enhance the motivation of...
students who appeared to be more engaged throughout the lessons. Various cognitive/psychomotor and affective factors contributing to effective learning are considered in the tool. It was also assumed that all types especially non-gifted learners (who were involved in CoP and could successfully design investigative projects guided by MKO) would develop beliefs about the extent to which their tasks in PBL are useful and enjoyable according to ‘Expectancy-Value Theory’ (Palmer, 2007).

The essential elements of PBL were outlined with the translation of the researcher’s knowledge from literature review and understanding on various aspects of problem-solving behaviours including the mastery of conceptual and procedural knowledge in PBL. Apart from the aforementioned, the researcher has in the support tool and rubric, requested the respondents to reflect on their learning through developing scientific/ICT skills (S); Information gathering (I) using non-digital/digital mode of resource procurement; Transfer of learning from trainings (T) through higher order or critical/creative thinking, metacognitive thinking, decision making and problem-solving skills that are related to cognitive/psychomotor aspects. Moreover, the aspects of ‘values’ emphasis and motivation in STES via PBL (V) are included. Hence this tool cover 3 vital aspects of problem-solving in PBL, i.e. cognitive, psychomotor and affective domains, with evaluation/exchange supported by ICT tools.

**Research Aim, Implementation and Data Collection Process**

**Aim of study, research focus and indicators of performance**

Apart from promoting on-line discussion and exchange through e-forums (Figure 2), face-to-face workshops were also organized to develop resource materials that enhance science and mathematics student-centred learning through PBA and PBL, that will also be uploaded onto its e-forum (http://forum.sp3aceman.net). The main aim of this article is to report a case from the authors' involvement in a CPD programme. This research focuses mainly on the evaluation of participants' learning performance and the impact of the first in-service training workshop with input on the use of ‘Learning Activities Management System’ (LAMS). The following were the objectives for the implementation of the first workshop:

- To prepare teaching and learning materials related to Education for Sustainable Development (ESD) using LAMS as platform to develop e-learning objects.
- To develop a global learning platform supported through e-learning objects that enhance student-centred learning and to develop investigative activities focusing on PBA/PBL in search of future talents/researchers using the curriculum developed to promote ESD (topics such as values-based water education, climate change).
- To widen enrichment opportunities involving wider groups of learners towards EFA and extend networking activities using technological tools leveraging on ever expanding digital learning technologies and available Open Educational Resources (OER).

At the end of the input through workshop/seminars, the participants should be able to:

- register as member of e-forum under the account provided for their respective project school with participation in threaded discussion topics in the SP3ACEMAN e-forum.
- prepare action plans for teacher resource manuals with outline of intended curriculum being planned for particular age groups including evaluation guided by POSITIVE rubric and flow-chart for e-learning objects incorporating science, mathematics and social science curriculum focusing on ESD-related issues to promote PBA/PBL activities.
- develop e-learning objects or interactive resource materials that promote student-centred PBA/PBL using support tools and scaffolded instruction (SI) activities guided by evaluation rubric involving wider groups of students [as illustrated in Appendix B, i.e. the lesson outlines developed by third to fifth authors in collaboration with team members, details downloadable from: http://forum.sp3aceman.maays.net/viewforum.php?f=18]
- reflect on own learning experience as will be shown in their pre-/post-test responses.

The indicators of learning performance for the in-service teachers are measured from the change of their perception on the following topics introduced in workshop/seminar. All these content topics were
reflected in the pre-/post-tests to be responded by the participants prior to and after the CPD programme. The pre-test questionnaire was administered on the first day (21/6) of the course whereas the post-test questionnaire with the same content was administered before the closing ceremony at the end of the course (27/6/2011). The participant respondents were requested to indicate by ticking (v) on the column reflecting their level of perception using the Likert scales “1=very low, 2=low, 3=moderate, 4=high, 5=very high” on the following statements:

1. Learning Activities Management System (LAMS) in PBA and PBL workshop
2. Essential ICT skills for the development of e-learning objects
3. The evaluation rubric guide to facilitate PBA/PBL activities
4. Current trends and development of Science and Technology Education (STE)
5. Blended learning
6. Branding of educational services
7. E-portals and project work to develop interactive e-learning objects for the facilitation of PBA and PBL
8. SP3ACEMAN portal and e-forum
9. SEARCH portal and its 6 sub-portals

If their choice of responses were 3 and above, they were requested to respond to the open-ended questions in the 'Comments' column. For example, what are the “useful features of 'LAMS', essential skills to develop e-learning objects, main areas of rubric to facilitate PBA/PBL, major trends of science and technology education, e-learning objects that are useful for PBA/PBL”, and the definition or meaning of “blended learning, branding educational service, SP3ACEMAN and SEARCH”.

**Research process and intervention activities**

The research process in this study involved the social constructivist framework by first identifying the participants’ prior knowledge for the aforementioned 9 aspects, followed by the design of a relevant curriculum with appropriate pedagogies, implementation of intervention activities and finally evaluating the outcome of learning (Kemmis & McTaggart, 1988). The first PBL workshop was conducted from 21 to 24/6/2011 [as illustrated in Figure 3 to Figure 8] as part of the global learning initiatives towards ESD and EFA. It was partly funded by UNESCO and Japan Funds-in-Trust, also facilitated under the official SEARCH portal [URL: http://forum.maays.net/viewtopic.php?f=29&t=145] supported by the centre’s short-term grant. Interactive ICT tool i.e. ‘Learning Activities Management System’ (LAMS) is the main platform for the development PBA/PBL lessons. Teaching and learning resource materials or e-learning objects were developed by participants mainly science and mathematics teachers or lecturer from local secondary or primary schools and teacher training college, some of whom are the co-authors of this paper.

Figure 3  Input from facilitator on ‘Learning Activities Management System’ (LAMS) during SP3ACEMAN workshop to develop e-learning resources (21 to 24 June 2011) that promote ‘Project-based activities’ (PBA) and ‘Problem-based Learning’ (PBL)

Figure 4  Workshop participants listening attentively to the facilitator’s input
The first workshop with blended learning intervention activities consisted of:

1. Interactive input with workshops and cooperative project team work activities incorporating the use of ICT tools that covered:
   - Integration of ICT tools with student-centred pedagogies mainly through Problem-based Activities (PBA) and Problem-based Learning (PBA) from the aspects of Science, Mathematics and Social sciences (i.e. Geography, Language/Arts, Physical/Health/Moral Education, etc.). The areas discussed include Learning Activities Management Systems (LAMS) and use of ICT tools for the development of e-learning objects; essential scientific and Higher Order Thinking (HOT) skills for investigation; problem-solving and critical/creative thinking skills; values-based and issues-based approaches; constructivist and contextual learning; interdisciplinary/cross-curricular approaches incorporating active learning strategies considering various aspects of multiple intelligence; and so forth.
   - Planning and assessment/evaluation skills supported by rubric as guide towards ‘Planning, Objective setting/organizing, Skills (scientific/ICT), Information, Training/transfer of HOT, Involvement/incorporating pedagogical-content knowledge (PCK), Values-emphasis to promote motivation, Evaluation/exchange/ enrichment/ever-lasting exposure’ (POSITIVE) implementation of PBA/PBL.
   - Planning activities with implementation of primary and secondary science and/or mathematics curriculum including the preparation of (a) Pedagogical Content Knowledge (PCK) required for PBA/PBL; (b) flow diagrams and action plans for the development of e-learning objects; (c) forum
posts and e-learning output being uploaded onto the closed forum site of SP3ACEMAN (http://forum.sp3aceman.net) and LAMS (http://lamsfoundation.org).

(2) Enrichment activities with input via seminar presentation and video viewing included:

- Seminar entitled 'Blended learning: Rebranding learning for the 21st Century' by Prof. Zoraini Wati Abas, the Professor of e-learning from Open Universiti Malaysia and Dr. Kim Phaik Lah, the founder of MAAYS.net, another sub-portal of SEARCH.

- Video presentation on topics including (a) 'Did you know' and 'What is next generation learning' (part of seminar presentation on 'Blended learning' by Prof. Zoraini) (b) 'South East Asia Regional Capacity-enhancement Hub' (SEARCH) portal and its six sub-portals in SEARCH for science and mathematics researchers' (part of the launching ceremony of SEARCH portal).

Data collection, curriculum introduced and evaluation on the outcome of learning

Various topics related to the focus of this study were introduced using various active teaching and learning strategies by the first author which involved cooperative and constructivist learning approaches [such as forming heterogeneous project teams with support from More Knowledge Others (MKO) and non-digital/digital resources]. The main intervention activity incorporating the use of ICT tool in science and mathematics teaching to introduce PBA/PBL through scaffolded instruction (SI) activities was the introduction of LAMS by the second author. Participants were exposed with this innovative ICT tool and they were requested to prepare lesson ideas summarized initially using the flow-chart (Figure 3 and Figure 4) that will later be used as guide for their planning of instructional materials and e-learning objects for PBA/PBL.

For the workshop participants who intended to prepare PBL lesson plans, they were required to create problem scenarios in accordance with science/mathematics curriculum to enhance students’ investigative skills using the PBL support tool and evaluation rubric (downloadable from the e-forum as illustrated in Figure 2). Reference was made to existing resources or materials adapted from secondary and primary school science, mathematics and social science curricula that were developed in previous phases. Adaptation was also made with reference to ESD/EFA-related topics implemented in the international programmes participated by the participants prior to the workshop such as ‘Science across the World’ (SAW) (Ng et al, 2010). Another international programme was the ‘Human Values-based Water, Sanitation and Hygiene Education’ (HVWSHE) or ‘Water and Values Education’ (WAVE) (SEAMEO Secretariat, 2007) with publication by, e.g. Ng (2007), Ch’ng et al (2009). Several ESD/EFA-related publications e.g. ‘Climate Change related issues’ were also developed in collaboration with SEAMEO centres (e.g. Ch’ng et al, 2010; Toh et al, 2010). During this first workshop, the participants went through self-directed/self-paced/self-accessed learning using blended learning mode, i.e. with reference to off-line resources from RECSAM’s library or other available references. They also participated in hands-on/minds-on activities using on-line resources through surfing Internet and web-links related to PBA/PBL under SEARCH and its six sub-portals.

Observations on the project team members’ skills to use LAMS in planning science, mathematics and social science lessons, together with the responses collected from the open-ended questions in the post-tests were used as data for the evaluation on the outcome of learning. The indicators of their performance were measured from the Likert scales showing their enhanced levels of perception on the 9 topics as aforementioned. Evaluation was also made on their responses in the open-ended questions in the ‘Comments’ column of the 9 topics, and also their learning output integrating LAMS in lesson planning aforementioned.

Data Analysis and Evaluation on Learning Output

The analysis of data collected from pre- and post-test questionnaires will be presented in this section with illustrations of some selected learning output using alternative assessments techniques including course assignments such as outline of lesson ideas guided by support tool and flowchart for the e-learning object using LAMS.
As shown in Figure 1, there was an increase for the average gain scores [comparing the pre- and post-test scores] in the first SP3ACEMAN workshop participants’ perception on their perceived levels of knowledge and skills in the 9 topics as focus of this study. These topics are (1) LAMS in PBA/PBL; (2) Essential ICT skills to develop e-learning objects; (3) Evaluation rubric guide to facilitate PBA/PBL; (4) Current trends and development of STE; (5) Blended learning; (6) Branding of educational services; (7) E-portals and project work to develop interactive e-learning objects for PBA/PBL; (8) SP3ACEMAN portal and e-forum; (9) SEARCH portal and its 6 sub-portals.

![Figure 1](image1.png)

**Figure 1**  The mean scores of the course participants’ perceptions on the various topics before (pre-test) and after (post-test) the input from SP3ACEMAN workshop

Figure 2 also depicts the improvement in the level of perception for each workshop participant in the 9 topics comparing the pre-test before the workshop started and post-test after the input from the first SP3ACEMAN workshop.

![Figure 2](image2.png)

**Figure 2**  Graphical Presentation For Participants’ Overall Perceptions On Their Knowledge For Various Workshop Contents
The analysis of quantitative data from the survey on participants’ enhanced perceived levels of perception through pre-/post-tests was triangulated using alternative assessment technique. For example, participants were requested to respond qualitatively their understanding of the topics which were considered to be ‘high or very high’ in terms of their enhanced levels of perception after the workshop. The following selected verbatim responses were extracted from the ‘Comments’ column of post-test questionnaires on (1) ‘LAMS’:

LAMS module seems promising and offers a lot of options; is user friendly and useful for PBA/PBL; is able to integrate different modes of teaching and learning approaches, can control the learning activities; with template for learning activities and interactive environment; it is useful for planning, storing and editing lesson; for designing (x3) learning activity creatively, managing (x2) and delivering on-line (x2) resources, to promote learner-centred collaborative learning activities (x3) and personalized learning; LAMS is flexible, allows the author to decide the flow of lessons and where the learners stop, allow to sequence and control the learning activities; is a self-learning system that can help the students based on their intelligence and personalities; The useful features of LAMS are the ability to produce activities that are informative (notice board, resources, task list), evaluative (MCQ, submit files), collaborative (chat, forum, conference), reflective (Q&A, survey, voting)  

(Workshop participants, post-test questionnaire feedback, 27th June 2011).

Qualitative responses were also extracted authentically from the feedback on (2) ‘Rubric for PBA/PBL’ and (3) ‘The essential skills required to develop e-learning objects’:

The main areas of rubric to facilitate PBA/PBL involve data collection (mode), learning objective and presentation (statistic), skills, planning and information gathering, procedures, problem scenarios; Rubric tells what are the essential components that have to be considered, how to attain and how well the ‘performance of actions’ is; The essential skills needed are creativity (x2), ICT skills (x2), downloading skills, images, websites; knowing ways to access on-line in order to gather information or knowing how to access online in order to get information; web search, computer literacy; intuitiveness, sense of preparedness; basic word processing, Internet skills, multimedia; self initiative of the teacher; planning, strategies, patience.  

(Workshop participants, post-test questionnaire feedback, 27th June 2011).

The participants had also responded on their understanding of (5) ‘blended learning’; (7) ‘e-learning objects useful for PBA/PBL:

Sharing of the technological base with integration of teaching, learning and assessment using different modes of media; Use of digital media in conventional learning together with self-paced learning; Mixture of different types of learning, face-to-face, self paced, on-line collaborative learning; Incorporating ICT/forum/tool/curriculum/students; Visual and graphical effects for fast and slow learners; Learning through various ways using various resources; Integration of different skills; Web images (multimedia, courseware), web forums/blogs, video clips, digital courseware, web conference, forum, blog, FB, twitter; Educational portals for global-warming, air pollution, values-based water education, climate change.  

(Workshop participants, post-test questionnaire feedback, 27th June 2011).

In addition, the participants were also evaluated on their skills to integrate LAMS in planning science, mathematics and social science lessons as part of the learning output. Figure 3 and Figure 4 are the flow charts selected for illustration as exemplary learning output showing the participant’s planning of Science and Mathematics/Additional mathematics lessons incorporated with LAMS to introduce PBL lessons entitled ‘Drinking water’ (Appendix A) and ‘Litter-bugs syndrome’ (Appendix B).
**Figure 3**  Learning Activities Management System (LAMS) flowchart for Form 2 science topic on 'Drinking Water'

**Figure 4**  Learning Activities Management System (LAMS) flowchart for Form 4 mathematics topic on 'Litter-bugs Syndrome'
Conclusion and Future Direction

In the efforts to sustain student-centred learning programme through PBA or PBL towards developing sustainable investigative project, the issues of providing quality and equitable opportunities towards Education for All (EFA) and Education for Sustainable Development (ESD) should be the prime concern of any educational initiative. Universal EFA should be interdisciplinary, with integration of the teaching of scientific/mathematical concepts and analytical tools from various disciplines. The advent of the digital globalization era has resulted in an increasing demand for the use of effective and sustainable e-learning platforms with innovative technological tools to facilitate the sharing of best practices in science/mathematics education. In this technologically advanced era, a supportive learning environment with pedagogically enriched teaching strategies integrating interactive ICT is the most appealing contribution for educators who wish to incorporate the e-learning portals in science and mathematics education.

This paper outlines the major activities of SP3ACEMAN.net portal in SEARCH for young science/mathematics researchers. This article also reveals the feasibility of a blended mode to learn the different themes and issues towards building networks for knowledge-exchange and peer learning in science and mathematics education in the region and beyond (Azian et al, 2010). In an effort to develop e-learning resources to promote students’ investigative skills through PBA/PBL as implemented in this workshop, it is expected that this project has provided the participants with hands-on and minds-on experience in developing their lesson using features in LAMS.

The organizer also hopes that the participants are convinced in using blended learning approach while conducting classroom lesson incorporating investigative research that promote ESD. It will also involve all stakeholders especially teachers and students with Internet access in the SEAMEO region and beyond to participate as blog viewers or e-forum participants to share the output of e-learning resources. From the open-ended responses in the post-tests provided by the workshop participants, observation and informal interviews, the workshop supervisor also reflected on the suggestions, remarks and/or issues given by them. For example, there were suggestions that more lessons on ‘Learning Activities Management Systems’ (LAMS) be conducted in the near future. Young scientists movement should be advocated and promoted further with more enrichment. There should be the creative directions by teachers-initiated sub-portals. It was also realized that a common portal should be created for LAMS so that all the workshop participants could share their learning output with feedback which could be viewed together. Hence the LAMS software was later downloaded onto the centre’s server and a common link was created in the LAMS (URL: http://elearn.recsam.edu.my/LAMS).

In brief, the e-learning objects or resource materials with interactive teaching and learning activities being developed as the output of this workshop were deposited into the forum site of SP³ACEMAN portal (URL: http://forum.sp3aceman.net) and were uploaded onto the common account of (URL: http://elearn.recsam.edu.my/LAMS). These e-learning resource materials will continue to serve as Open Education Resources (OERs) to promote global learning towards ESD and EFA. Moreover, all the authors of this paper had also participated actively as advisors, workshop facilitators, participants and/or project teachers of the SP³ACEMAN forum to further enhance science and mathematics education through blended learning approaches with sharing of resources. For example, the ‘Exemplary science and mathematics incorporating technology education lesson plans’ was compiled as the output of the second workshop using ‘Lesson Study’ approach that was conducted from 18/5-19/5 and 21/5-22/5 (for the first workshop) and 17th to 20th October (for the second workshop) [Available from URLs: http://forum.sp3aceman.maays.net/viewforum.php?f=18].

This second follow-up workshop was conducted from 17-18/5 and 21-22/5 to review the draft lesson plans through ‘Lesson Study’ approach with input given by the experts in the fields of Science, Mathematics, PBL, ICT and academic staff of RECSAM, some of whom had also attended the first workshop. After two ‘Lesson Study’ cycles, the refined lesson plans were also posted onto the forum site of the SP³ACEMAN portal (http://forum.sp3aceman.net) for the subsequent e-learning activities focusing on ESD/EFA-related activities. Hopefully the research activities and findings will serve as guidelines for
future planning of teacher education towards developing more instructional materials for investigative research.

Acknowledgement

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Appendix A

‘Drinking water’: PBL lesson for Form 2 science by SMKA Al-Mashoor(L)

(Project teachers: Linda Toh and Wan Mohamman Zulkifli)

[URL: http://elearn.recsam.edu.my/LAMS] (please zoom to 150% for viewing)

(1) Incorporating PCK for Form 2 science, (POSITIVE)SMASH(MS-Word file uploaded onto forum)

‘Little-bugs syndrome’: PBL lesson for Form 4 maths/add maths by SMK Penang Free

(Project teachers: David Ch’ng, Vijaya a/p Parjunan and Ling Jia Yi)

(1) Incorporating PCK for Form 4 mathematics/additional mathematics

Figure A (1) Incorporating Pedagogical Content Knowledge (PCK) for Form 2 science topic on ‘Drinking’ [Refer more details on POSITIVE tool at URL: http://forum.sp3acemanaays.net/viewtopic.php?f=24&t=123]
Appendix B

‘Little-bugs syndrome’: PBL lesson for Form 4 maths/add maths by SMK Penang Free
(Project teachers: David Ch’ng, Vijaya a/p Parjunan and Ling Jia Yi)

(3) SPACEMAN PROJECT_PFS (MS-Word file for sample POSITIVE tool uploaded onto forum)

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</tr>
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<td><strong>P′BL via POSITIVE guide</strong> (Planning procedure/project problem-based P′BL process) Planning the Procedures in carrying out thoughtfully planned P′BL teaching and learning processes with provision of investigation cycles</td>
</tr>
<tr>
<td><strong>Problem-based P′BL</strong> (Scenario or case study adapted from current Science [Atlas Form Year] Topic ‘Little-bugs Syndrome’ Scenario: E.g. You are... As the president of student council, you are asked by the principal to study the problem of Little-bugs Syndrome.)</td>
</tr>
<tr>
<td><strong>Objectives and Organization</strong></td>
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<tr>
<td>Objectives and Outline of issues from scenario:</td>
</tr>
<tr>
<td>Learning tool skills objective:</td>
</tr>
<tr>
<td>Cognitive and procedural: Interpreting students’ weighing, calculating magnitudes.</td>
</tr>
<tr>
<td>Affective: Interpreting data, comparing data, formulating and reasoning.</td>
</tr>
<tr>
<td>Outlines of issues from research base. The school has always been plagued with rubbish being thrown everywhere and the projects wished to know what factors causes this to happen.</td>
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<tr>
<td><strong>Organization of team members’</strong></td>
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<tr>
<td><strong>Information gathering</strong> Information data gathering and resources facilities support procurement via cooperative role taking</td>
</tr>
<tr>
<td><strong>Resources for learning issues</strong></td>
</tr>
<tr>
<td><strong>Involvement</strong> Involvement activity in various context</td>
</tr>
<tr>
<td><strong>Incorporation of PCK</strong> Incorporating pedagogical content knowledge (PCK)</td>
</tr>
<tr>
<td><strong>Evaluation</strong> Evaluating as well as Exchange of class experiences, Enrichment, Evaluating performance, and presentation</td>
</tr>
<tr>
<td><strong>Setting</strong> Setting the classroom, collect data, time and the event (Interaction setting: Discussion, Action: Searching for Literature Backup, Discussions - Presentation Adobe &amp; Recommendations)</td>
</tr>
<tr>
<td><strong>Transfer of HOT or Representation</strong> Reporting a theme project, e.g. Lesson 1: Activity 1, Lesson 2: Activity 2, Lesson 3: Activity 3, Lesson 4: Activity 4</td>
</tr>
<tr>
<td><strong>Transfer of HOT or Representation</strong> Reporting a theme project, e.g. Lesson 1: Activity 1, Lesson 2: Activity 2, Lesson 3: Activity 3, Lesson 4: Activity 4</td>
</tr>
<tr>
<td><strong>Value motiviation in STES</strong> Values emphasis and incorporation of positive attitudes/interests towards Science, Technology, Environment, Society (STES)</td>
</tr>
<tr>
<td><strong>Evaluation and Experiential aspect</strong></td>
</tr>
<tr>
<td>Value statements and emotional aspect (1) Value statements in science and its interaction with technology, environment and society: Does family background and city/region you live have something to do with it? (2) General notes and other aspects that motivate further investigation. Perhaps the general care less attitude of the students and no day?</td>
</tr>
<tr>
<td><strong>List out links to the sites for on-line evaluation rubric.</strong></td>
</tr>
</tbody>
</table>

**Figure B (1)** Incorporating Pedagogical Content Knowledge (PCK) for Form 4 mathematics topic on ‘Litter-bugs Syndrome’ [Refer more details at URL: http://forum.sp3aceman.maays.net/viewtopic.php?f=47&t=106]