









counterparts at far sites, such as e-seminars for sharing research results of LBE teams with researchers and students in EPI, e-lectures by ITS faculty members for students in EPI and so forth. Another is for e-Learning. Naturally, e-Learning by itself helps students and lecturers of remote areas since it makes education materials of resource universities available at local classes. Additionally, the project utilized e-Learning as collaboration agenda; preparing specific e-Learning programs for a partner university requires strong communication paths and collaborative activities based on mutual reliance. As part of the project activities, ITS and Universitas Sam Ratulangi (UNSRAT) started from discussions on what kind of program should be jointly prepared and provided, designed the syllabi, prepared materials for both digital and face-to-face classes and quizzes for everyday self-study, decided evaluation methods, and jointly provided several subjects during the 1<sup>st</sup> phase.

## 5. Results

### 5.1. Outputs of LBE

Enhancement of research capability should primarily be inferred from increased numbers of reserch articles published in international academic journals. Publication of papers, co-authored by master’s students and faculty members, indicates that students should have acquired potential capability to conduct research.

During the 1<sup>st</sup> phase period, 14 LBE teams in total presented 67 papers, whose first author was a master student, at international conferences. In the 2<sup>nd</sup> phase of the project, as Table 3 shows, the average number of co-authored articles of ITS appears largely increased. The first author of these papers was frequently a master’s student.

**Table 3. Number of co-authored papers published in international conference/journal by ITS**

Year	Granted laboratories (Average/lab/year)	51 certified LBE laboratories (Average/lab/year)
2012	5 (0.71)	32 (0.53)
2013	66 (2.75)	86 (1.69)
2014	(45) (n/a)	(53) (n/a)

(Note) The number of granted laboratories is 7 in 2012 and 24 in 2013 and 2014.

Data of 2014 is as of September 2014.

(Source) Prepared by the author based on the project data.

On the other hand, the number of international journal publications by granted laboratories grew at a

considerably slow pace during the 1<sup>st</sup> phase project period; however, as Table 4 shows, the growth sharply speeded up after the 2-year interval. The total number of publications in international journals and patent application by all faculty members at ITS also elevated prominently after the 1<sup>st</sup> phase is closed.

**Table 4. Number of international journal publications and patent applications by ITS**

Year	Publication in international journal		Patent application	
	Granted laboratories	ITS total	Granted laboratories	ITS total
2007	0	27	2	11
2008	1	42	1	4
2009	2	95	7	14
2010	(1)	121	(-)	16
2011	-	-	-	2
2012	6	381	8	53
2013	39	379	6	35
2014	(47)	759	(8)	91

(Note) Research grants were provided as follows:

1<sup>st</sup> phase

Batch 1 (3 teams) August 2006-July 2007

Batch 2 (4 teams) August 2007-July 2008

Batch 3 (7 teams) August 2008-July 2009

2<sup>nd</sup> phase

Batch 1 (7 teams) July 2012-June 2013

Batch 2 (7 teams) February-November 2013

Batch 3 (10 teams) July 2013-June 2014

Granted laboratories’ data in 2010 is as of March 2010 and in 2014 is as of September 2014.

(Source) Prepared by the author based on the project data.

### 5.2. Establishment of academic network with local universities

One of the visible outputs of the academic collaboration is establishment of the EPI-UNET of Figure 1. As described in 4.2., ITS voluntary led this initiative based on the project activities and has been providing the member universities with small research grants. EPI-UNET is now documented as part of ITS’s official development strategy.



**Figure 1. Major member universities of EPI-UNET**

(Source) Rencana Strategis Penelitian Institut Teknologi Sepuluh Nopember 2016-2020, p.20

In terms of capacity building of faculty staff in EPI, 52 co-authored research articles were internationally published by 14 granted LBE teams during the 1<sup>st</sup> phase project period and 38 by 24 granted LBE teams during the 2<sup>nd</sup> phase. Table 5 shows the growth of papers, co-authored by ITS and EPI members of 51 certified LBE teams and nationally and internationally published, during the 2<sup>nd</sup> phase.

**Table 5. Number of co-authored papers with EPI faculty members by 51 LBE teams (2<sup>nd</sup> phase)**

	2011	2012	2013	2014
Publication in journal and conference (international/national)	10	11	25	44

(Note) Co-authors of EPI universities are either in-service lecturers or those who are studying as postgraduate students at ITS.

(Source) Prepared by the author based on the project data.

## 6. Evaluation of LBE introduction and academic cooperation

### 6.1. LBE at a resource university

The increased number of international research papers co-authored by master's students and faculty members at ITS concededly proves that master's students of ITS took an active role in the research of his/her supervisor's laboratory; authorship of a research article is the evidence of considerable contribution to the research outputs. In the laboratory, different from earning credits by attending classes and/or receiving skill training for vocational purposes, students should have understood his/her research task as part of PI's research project, made logical thinking and took practical actions in order to carry out the research task.

Considering that there was no research duty for master's students before the technical cooperation, the result strongly supports the hypothesis that introduction of LBE nurtures potential research capability of master's students at universities in developing countries, enabling them to solve practical problems.

On the other hand, the enhancement of international journal publication by faculty members of granted laboratories was relatively gradual. Taking into consideration that there was no research team before the technical cooperation project, the increased number of co-authored papers however suggests that faculty members conducted research with colleagues and students; the fundamental idea that research is the basis for education, in other word faculty members are researchers, is sinking in.

Successful model activities also encouraged surrounding faculty staff to follow what LBE teams

were doing, though many of them were originally reluctant to get involved in additional work without additional salary. LBE at model laboratories eventually nurtured research culture at all departments of ITS through visible outputs such as international publications.

Patent application, which must be done before any publication of research outputs, was sometimes difficult in conflict with the priority of paper publication. Complicated and unfamiliar procedures also discouraged faculty members to embark in patent application, even though ITS put much effort in preparing better environment for faculty members such as providing guidelines and strengthening functions of relevant campus-organizations. Notwithstanding this situation, as the result shows, awareness of the significance and necessity of intellectual property rights management rose up, almost from scratch at ITS. Universities must produce new ideas through research, while technologies must bring forth value-added goods in order to contribute to economic growth. Inclusion of patent application besides paper publication is therefore one of the crucial issues in introducing LBE.

As to the driving force of LBE introduction, it is understandable that provision of research grants worked as incentives for faculty members to tackle the additional tasks. At the same time, some internal factors were also critical for enabling LBE despite the difficult situation; the issue is directorates' strong motivation to upgrade their institution to an established research university. ITS organizationally supported the project activities through allocating small budget exclusively for LBE teams, awarding PIs who made excellent progress in LBE, selecting promising research proposals as targets for financial and technical assistance in patent application, and so forth. Such policies and actions strongly pushed forward LBE.

### 6.2. Academic cooperation with local universities through LBE

From the viewpoint of simultaneous capacity building of both resource and local universities in developing countries, impact of LBE implementation at ITS, as described in 6.1, naturally supports this approach, since many of postgraduate students of ITS were faculty members of EPI universities. Educational effects of LBE should be evaluated in a longer-term and it may take long to nurture research culture in EPI; the holistic approach of the project however resulted in potential research capability of total 123 lecturers of EPI universities.

Additionally, LBE requires postgraduate students to make frequent research discussion with team members and to logically defend their research result against severe comments by seniors at regular

meetings of the laboratory. They also have to follow rules and role-sharing assignments of the team, once he/she becomes a member of an LBE team. Most importantly, students learned that working hard for better research outputs would bring fruit such as international journal publication. This environment should have invisibly transformed their way of thinking from traditional to international style. Communication skills also should have improved. It may also need time to disseminate this working culture in EPI; however, those who have been exposed to international atmosphere might work as transmitters in EPI.

Finally, it is well known, especially in science and engineering fields, that supervisor-supervisee relationship goes on even after the student has left the laboratory: faculty members in EPI universities should keep in touch with their supervisors, namely the PI of the laboratory, to which he/she had once belonged. This partnership should help remote universities collaborate with the resource university and continuously upgrade education and research in EPI. Involving lecturers of local universities in LBE teams of the resource university also has an impact in this way.

As described in the previous chapters, human capital that has ability to interpret advanced technical information as local recipes is crucial for industrial catching-up of late-coming countries; technological assimilation needs well-founded intelligent actions. Besides acquiring knowledge on basic science and technology in the classroom, LBE enables students, supposing that considerable number of lecturers of local universities are included, to utilize the knowledge for practical purposes including problem solution and, after reaching a certain level, value creation. This makes the fundamentals of industrialization of developing countries and simultaneously upgrades the quality of engineering education in local areas with the prospect of reducing disparity between central and peripheral areas. LBE is thereby advantageous for achieving the SDGs.

## 7. Conclusion

This research has firstly clarified that LBE introduction at the master's level in the engineering field helps universities in developing countries carry out their mission; universities must provide industries with capable human resources and new technology. Taking into considering the current situation of local universities in developing countries, strong resource universities should make a commitment to fulfill this mission. Secondly, the research results supported the hypothesis regarding effectiveness of the holistic approach to simultaneously enhancing capability of both resource and local universities in developing countries.

From the practical aspect, the research also presented some lessons for deploying the holistic approach in developing countries. The project design was relevant to the social needs that request ITS to strengthen its research and education besides establishing substantial academic network with universities in EPI. The project thereby laid duties on PIs of granted LBE teams to involve postgraduate students who are lecturers of universities in EPI as their research team members. Consequently ITS established EPI-UNET and, at the same time, enhanced capability of faculty members of ITS itself and local universities. Government policies and arrangements for supporting local universities to improve education and research are also vital for active participation of both resource and local universities. As for the LBE implementation, the research demonstrates effects of strong motivation to become a prestigious research university. The analysis also indicates impact of good practices by successful models in terms of disseminating LBE inside and outside the resource university.

There are also remaining issues. First, considering that research is the basis for education, self-sustaining enhancement of research capacity of faculty members is imperative in order to assure the quality of LBE. Especially at a resource university, quality of LBE affects nationwide superiority of human resources and thus their contribution to socio-economic development. With this regard, sustaining partnership between a resource university and local universities should be more difficult, compared to keeping collaboration between the resource university and its international partners; both resource and local universities lack financial resources for research and sometimes motivation for improvement.

Second, assuming that quality research is done at universities, from the viewpoint of universities' mission to contribute to industrial development, industry-university collaboration for creating new value is still limited. This is partly due to the low motivation of industries in developing countries for technological innovation, which is an external condition for academic institutions. At the same time, universities' awareness of mutual-beneficial collaboration with industries is not strong enough or even weak. Awareness raising should also be elaborated for actualizing sustainable industry-university collaboration, especially collaboration for value creation. Driving force of economic growth is continuous technological progress in production. Research output, namely new technology, must be utilized for industrial development.

Accelerating sustainable LBE implementation for research and development along with productive industry-university collaboration is a challenging yet crucial issue of higher education in developing countries. International education cooperation for

this purpose should therefore contribute to the achievement of SDGs.

The ideas and opinions expressed in this paper are entirely those of the author and should not be attributed in any manner to the organization that the author belongs to.

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