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The Effects of Teamwork on Competency Building in Manufacturing–PBL (Project-based Learning)

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Abstract

Enhancing students' competency through team activities has become a social demand. Previous studies in higher education claim that Manufacturing--Project-based Learning (M-PBL) enhances students' competencies, although empirical studies are limited. Therefore, this study addresses the following questions in M-PBL: 1) how do the input and throughput components of teamwork influence each other, and 2) does "working in a team" per se facilitate competencies? Our purposes are 1) to clarify the teamwork factor structure in the M-PBL by factor analysis, 2) to create a process model that shows how both input and throughput components of teamwork affect competency building, and 3) to empirically verify the model by structural equation modelling (SEM). Our methodology included: 1) the revision of questionnaire items on existing teamwork, scaled for a non-manufacturing industry, and 2) collection of data from fourth-grade students of three polytechnic colleges (N = 157) who had finished 972 hours of industry-academia collaborative M-PBL. The students came from different departments (machinery, electricity, and programming) and were organised into teams. The factor analysis results revealed two "team-orientedness" factors, three "team leadership" factors, three "team process" factors, and two "competency-building" factors. The SEM results showed that input components of teamwork enhanced throughput components and throughput components enhanced competency building. The relationships among teamwork components were clarified, such as "work-norm--orientedness" and "human relation leadership" enhanced "problem coping". The influence of teamwork on competency building was illustrated by the throughput components of teamwork, which enhanced both technical and attitudinal competency building at the individual level.

Keywords: Manufacturing-PBL; teamwork components model; competency building.

1. Introduction

Enabling students to develop job-related competencies through a variety of team activities has become a social demand of higher education. The OECD (Organization for Economic Cooperation and

Development) defines three key competencies by the DeSeCo project for the international standardisation of competency (Rychen & Salganik, 2003), all of which are involved in interactions with the environment. This suggests that a considerable part of competencies is formed by interpersonal interaction.

This is particularly important in manufacturing education. It can be easily understood if we think about the fact that even one ballpoint pen is the result of a combination of different industrial technologies. Recently, practices of project-based learning (PBL) have increased rapidly in the engineering faculty, and it is mentioned that "PBL facilitates students' competency" (Neo, 2005; Ngai, 2007; Walters & Sirotiak, 2011; Lockrey & Johnson, 2013). However, most of these are case studies, and empirical research based on psychological theory is limited. In contrast, previous studies in psychology have been interested in the motivational effect of PBL, but they do not address PBL's effect on competency building (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991; Helle, Tynjälä, Olkinuora, & Lonka, 2007; Minnaert, Boekaerts, & de Brabander, 2007; Cheng, Lam, and Chan, 2008).

Therefore, this study presents a model to theoretically explain the mechanism of competency development by teamwork and empirically verifies it by analysing data acquired from a questionnaire for fourth-grade students of polytechnic colleges who finished the M-PBL (real production system development by teams).

2. Problem Statement

2.1. Difference between PBL and M-PBL: Division-of-labour system

PBL is an instructional approach that requires teamwork and creates a finished product. Manufacturing–PBL (M-PBL) is a one-year PBL course in which the fourth-grade students from different academic departments (e.g., mechanical engineering, electrical engineering, and informatics) form cross-disciplinary teams and produce authentic production systems, which are used in local firms' manufacturing lines.

In M-PBL, members engage in each assigned task within the team using a division of labour, a characteristic of manufacturing (a nested team structure, as shown in Fig. 1).

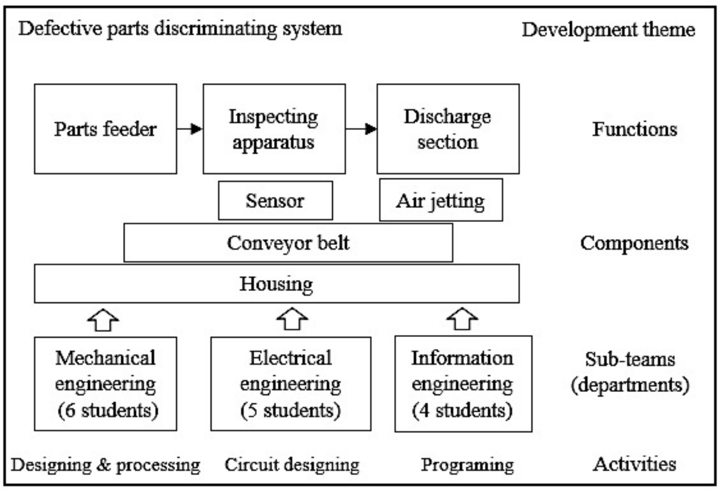

Fig. 1. "Nested" team structure in M-PBL.

2.2. Competency building by M-PBL

Previous studies in engineering education claim that students are able to build various competencies by experiencing M-PBL. In a PBL task of building a class website, Neo (2005) divided the class into three groups of 20-30 people, and each group had sub-groups of four to five people. The members produced interactive multimedia teaching materials on each theme for three weeks and finally integrated it with the class website. In the post-questionnaire, 68.4% to 81.0% of students answered, "I improved teamwork and communication competencies". Ngai (2007) conducted an e-commerce site-building PBL, 14 times for 120 students three hours a week. Through subsequent interviews, it was proved that the students had learned teamwork. Walters and Sirotiak (2011) performed a pre-post comparison of self-evaluation in a construction simulation PBL. Using a *t*-test, they found that the leadership and communicative competencies of students had improved.

2.3. Limitations of the PBL approach

Previous studies on PBL in psychology mainly have empirically verified the hypothesis that "PBL motivates learning". Blumenfeld et al. (1991) insisted that the result of PBL was "reinforcement of learning motivation" and "promotion of cognitive processing". To confirm this claim, Helle et al. (2007) collected data from a questionnaire from students of the information system design department (N = 58) who had accomplished a systems design project of 400 hours for seven months with teams of four to five people. The results from ANOVA (analysis of variance) demonstrated that intrinsic learning motivation significantly improved among the participants both before and after PBL. Minnaert et al. (2007) conducted a practical business PBL (N = 114), where they arranged groups of four to five people and collected data by questionnaire. SEM analysis indicated that students' psychological needs (autonomy, ability, and social relationship) influenced task interest, which led to motivation. Cheng et al. (2008) conducted a multilevel analysis of data collected from high school students (N = 1,921; 367 PBL teams). The results showed that the quality of the group process influenced students' collective efficacy, which led to motivation.

The gap between practices in engineering education and theories in educational psychology is caused by the premise that the purpose of PBL is to promote learning of curriculum contents rather than developing competencies required for industries. This suggests a necessity to apply other theories in psychology to empirically verify the suggestions through practice.

2.4. Teamwork components model

Through their literature review, Dickinson and McIntyre (1997) presented the teamwork components model, in which teamwork's input components (team orientation and team leadership) influence throughput components (monitoring, feedback, and backup), and then such team processes lead to output (coordination as team effectiveness). Based on this framework, Misawa, Sasou, and Yamaguchi (2009) verified data obtained from nursing teams. Multiple regression analysis revealed that input components of teamwork influenced throughput components in different ways. In addition, there was a correlation between most of the teamwork components (input and throughput) and the rate of minor incidents at the team level.

Dickinson and McIntyre (1997) named the iterative path from input to output a "learning loop". This suggests the possibility that input components of teamwork promote teamwork and competencies that are necessary for the work are developed because of teamwork. Takeshita, Okuaki, Nakamura, and Yamaguchi (2015) conducted interviews of the students who had finished the M-PBL course to create a teamwork scale for M-PBL and compared the developed questionnaire items with the nursing version. Based on the comparison, they argued that students' skills were tested by physical feedback from objects (e.g., the precision of material processing and the quality of part production) and that the interactions among students from different academic departments required them to improve their communication skills.

2.5. Competency building

Competency is a concept with numerous meanings, and it is difficult to measure one's competency externally. Moreover, students work at distant workspaces in the M-PBL field, and teachers cannot always observe all students.

Accordingly, we decided to ask students about job satisfaction after M-PBL. Because job satisfaction contains a sense of the ability to do something through the accomplishment of some work. Other constructs have constraints from the job-related viewpoint. For example, self-efficacy tends to include daily life aspects other than M-PBL. In addition, self-evaluation of knowledge and skills may be influenced by the grades of relevant classroom lectures and practical training.

At the end of the M-PBL, students may perceive their developed competency by having developed an authentic production system to be used on site. Okamoto (2012) extracted subscales including "demonstration and development of individual ability and skill" in a preliminary investigation (N = 1,793) to explore the job-satisfaction factor structure.

3. Research Question

The hypotheses of this study provided by the aforementioned arguments are (Fig.1) as follows:

H1: Input components of teamwork positively influence Throughput components of teamwork.

H2: Throughput components of teamwork positively influence members' competency building.

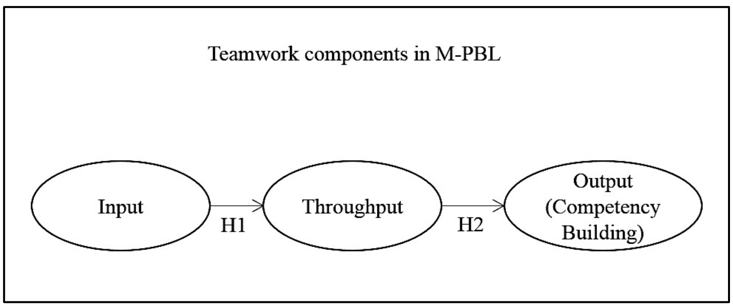

Fig. 2. Competency building through manufacturing teamwork.

4. Purpose of the Study and Research Method

4.1. Preliminary research

4.1.1. Purpose

In previous studies, no teamwork measurement scale has been developed in the manufacturing field.

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Therefore, in this preliminary research, we develop a teamwork measurement scale for M-PBL by revising the questionnaire items of a teamwork measurement scale for nursing (Misawa et al., 2009).

4.1.2. Method

We carried out semi-structured interviews of fourth-year students (N = 6) who had finished a one-year M-PBL (54 units, 972 hours) in a polytechnic college and asked them to retrospectively describe their team activities during the M-PBL. Then, we analysed the verbatim record qualitatively and 34 items were prepared. Next, we reviewed both the newly developed items and existing items for nursing with four different students who also finished the M-PBL, individually.

4.1.3. Data

Items that did not correspond to the actual situation of M-PBL (e.g., "We are learning based on the incident cases that happened at other hospitals") were deleted. Following correction of some expressions (e.g., switching "colleagues" to "members"), 32 items (preliminary investigation version) were adopted, in addition to 41 items for nursing, for a total of 73 items.

4.2. Main research

4.2.1. Purpose

First, we clarify the factor structure of teamwork in the M-PBL by factor analysis. Second, we empirically verify how various components of teamwork affect competency building using SEM.

4.2.2. Method

We asked the fourth-year students who had finished M-PBL at three polytechnic colleges to answer our questionnaire for the teamwork scale (developed by the above procedure) and the job-satisfaction scale (Okamoto, 2012), and we were able to collect 157 answers (data collection ratio = 100%; effective answer ratio = 91%). The ratio of their specialties is as follows: mechanical engineering (37.6%), electronics and informatics (16.6%), electronics (17.2%), and informatics (26.8%). The survey was conducted from February to March 2015.

5. Results

5.1. Structure of teamwork measurement scale in M-PBL

We conducted an item analysis on 73 teamwork scales and excluded seven items that had the ceiling effect. Then, we conducted factor analysis on each subscale to examine the factor structure. We determined the number of factors, considering both the eigenvalue decrement and content validity. We repeated the factor analysis and deleted items, holistically considering the commonality, factor loading, construability, and α-coefficient. We used IBM SPSS Statistics software package (Ver. 22.0) for statistic processing. The results are explained below.

5.1.1. Team orientedness

We adopted two factor solutions (56.0% of explanation rates) and deleted two items (Table 1). The first factor comprised nine items, indicating that "orientation for completing tasks" and "orientation for interpersonal relations" (Misawa et al., 2009) were integrated cognitively. This shows that working on a task and collaboration with others are not discriminated in M-PBL. Therefore, we named it "work-execution oriented". We named the second factor (nine items) "work-norm oriented", as these items showed manufacturing-specific rule observance, such as self-discipline and safety consciousness. The questionnaire items denoted with "(*)" were developed by the preliminary research. Tables 2, 3, and 4 show the results of naming of other factors in a similar manner.

Table 1. The results of FA (team orientedness) (maximum likelihood method, Promax rotation).

Questionnaire items ("In our team...")	*F1*	*F2*
"Work-execution orientedness" (α＝.88)		
Everyone recognizes each other's good points.	**.86**	-.18
Members say hello to each other comfortably.	**.78**	-.21
Everyone joined the team of his or her own interest. (*)	**.66**	-.08
There is an attitude to work on a new thing positively.	**.63**	.20
We encourage and compete with each other, regardless of differences in high school and department.	**.60**	.24
There is enthusiasm in "trying to achieve the goals of the team".	**.54**	.27
Even if there are likes and dislikes in human relations and dissension, we control ourselves slightly. (*)	**.51**	-.07
We try hard to raise our knowledge and skills.	**.51**	.34
Members surely accomplish the work requested.	**.43**	.28
"Work-norm orientedness" (α＝.77)		
Everyone feels we cannot be loafing. (*)	-.22	**.91**
Everyone tries not to be absent. (*)	-.18	**.81**
When members become dull, somebody warns. (*)	.07	**.64**
We are strict in complying with the work procedures.	.21	**.43**
	Correlation	*F2*
	F1	.60

5.1.2. Team leadership

We adopted three factor solutions (explanation rate = 60.9%) and deleted two items (Table 2). The "leader" here includes both official leaders and informal (emerged) leaders.

Table 2. The result of FA (team leadership) (maximum likelihood method, Promax rotation).

Questionnaire items ("Our leader...")	*F1*	*F2*	*F3*
"Human relation leadership" (α＝.83)			
Provides necessary information to every member.	**.85**	-.24	.11
Listens carefully to all members.	**.56**	.26	-.03
Clearly shows the roles and responsibilities of each member.	**.55**	.19	.02
Mediates between teachers and members. (*)	**.49**	.06	-.05
Deals appropriately when a conflict of opinions emerges in our team.	**.48**	.38	.02
Treats members impartially.	**.46**	.17	-.02
"Technical leadership" (α＝.85)			
Helps members technically. (*)	-.01	**.75**	-.00
Can judge calmly and give instructions, even in an emergency.	.36	**.64**	-.20
A person who can do and understand tasks takes the lead. (*)	-.11	**.59**	.16
Is trusted by the members.	.23	**.48**	.16
He instructs and comments concisely and directly.	.37	**.44**	.09
"Knowledge & information leadership" (α＝.82)			

Is active in interactions among different themes and departments.	-.24	.18	**.76**
Tells us about other teams. (*)	.31	-.29	**.64**
Teaches his knowledge to the members. (*)	.23	.05	**.53**
Puts forth ideas when we face trouble (the product does not move, etc.). (*)	.10	.23	**.49**
He knows what members are skilful and are not. (*)	-.09	.38	**.47**
	Correlation	*F2*	*F3*
	F1	.70	.61
	F2		.61

5.1.3. *Team process*

We adopted three factor solutions (explanation rate = 63.8%) and deleted 20 items (Table 3).

Table 3. The result of FA (team process) (maximum likelihood method, Promax rotation).

Questionnaire items	*F1*	*F2*	*F3*
"Mutual understanding & support" (α=.86)			
We mind each other so that work burdens are not too biased towards a particular member.	**.89**	-.04	-.09
If there is a member having to work a lot alone, we help.	**.85**	-.20	.05
We confirm each other's roles and purposes.	**.76**	.03	.08
We talk each other until everyone is convinced.	**.61**	.23	.02
If any member works wrongly, we tell him or her.	**.52**	.39	-.11
We try to know about different departments. (*)	**.49**	.10	.02
"Work execution" (α=80)			
We advise a working procedure based on past experiences. (*)	-.06	**.87**	-.04
We devise and adjust the ways of work according to mutual circumstances and progress.	-.09	**.73**	.13
We communicate clearly about on-going work and requests to others without saying "that".	.12	**.60**	.04
"Problem coping" (α=.79)			
We discuss if there are any problems. (*)	.25	-.16	**.77**
We may review the goals and plans of the team depending on the circumstances.	-.10	.19	**.65**
We ask the teachers if troubled. (*)	-.07	.00	**.61**
We advise each other to improve our knowledge and skills.	.06	.22	**.54**
	Correlation	*F2*	*F3*
	F1	.57	.67
	F2		.61

5.1.4. *Competency building*

We deleted two items that had the ceiling effect, adopted two factor solutions (explanation rate = 73.4%), and deleted one item.

Table 4. The result of FA (competency building) (maximum likelihood method, Promax rotation).

Questionnaire items ("The M-PBL is...")	*F1*	*F2*
"Technical competency" (α=.85)		
The M-PBL was fun work for me.	**.97**	-.06
The M-PBL fit myself.	**.71**	.14
In the M-PBL, I made use of my skills.	**.59**	.14
"Attitudinal competency" (α=.77)		
In the M-PBL, I felt the meaning of work and a sense of mission.	-.05	**.87**

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I took responsibility for the work in the M-PBL.	.18	**.60**
I exerted my ability and ingenuity for the M-PBL.	.16	**.54**
	Correlation	*F2*
	F1	.73

5.2. The relationship between teamwork and competency building in M-PBL

We verified the hypothetical model by structural equation modelling (SEM) with the maximum likelihood estimation method using the Amos software (Version 22.0). The final model is shown in Figure 2. The numerical values show the standardised pass coefficients and coefficients of correlation. We judged the conformity of data and the model to be the tolerance level, as the goodness-of-fit index was GFI = .95, CFI = .98, and RMSEA = .084.

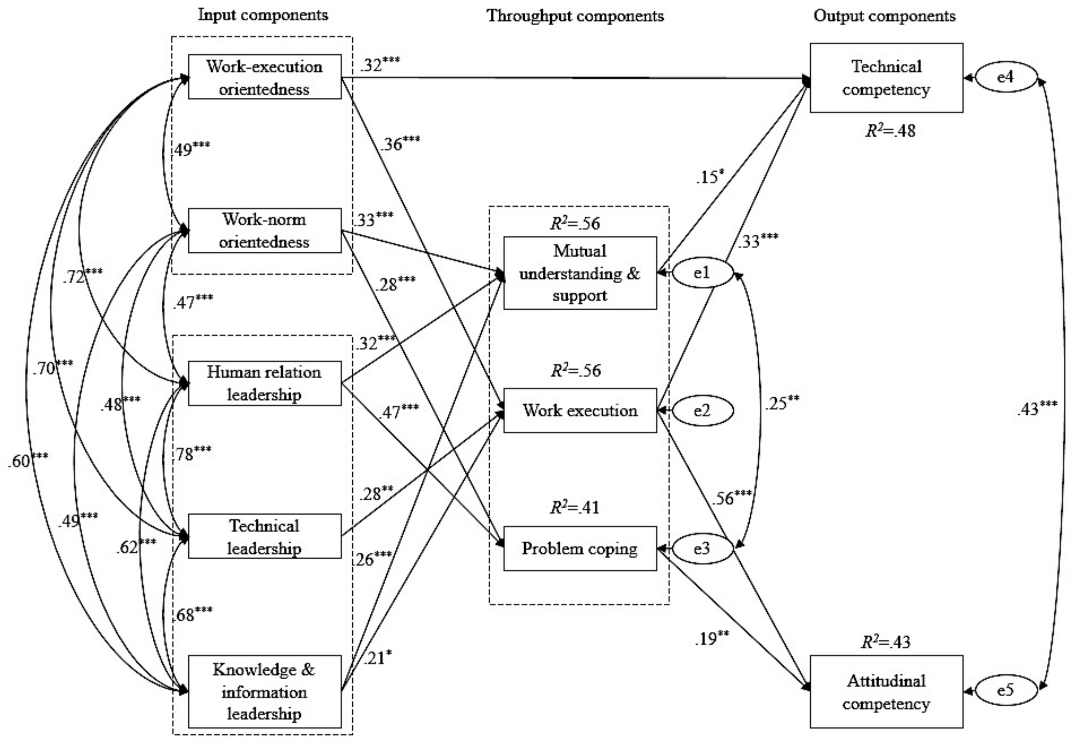

Fig. 3. Relationship between teamwork and competencies in M-PBL

5.3. Examination of multilevel analysis appropriateness

We calculated *DE*, *ICC (1)*, and *ICC (2)* (Table 5), with criteria of *DE* > 2.0 (Peugh, 2010), *ICC(1)* > .12 (James, 1982), and *ICC(2)* > .70 (Bliese, 2000, Klein et al., 2000). The results did not show sufficient values, except for technical leadership and technical competency. The result of a multi-level correlation analysis showed that the technical leadership and technical competency had a significant positive correlation (r_i = .25*, r_g = .88*) at both the individual and group levels.

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Table 5. Validity examination of variable aggregation.

	DE	*ICC(1)*	*ICC(2)*
Team orientedness:			
Work-execution orientedness	1.71	.102*	.468
Work-norm orientedness	1.72	.103*	.474
Team leadership:			
Human relation	1.50	.072†	.372
Technical	**2.47**	**.213*****	**.674**
Knowledge & information	1.57	.082†	.405
Team process:			
Mutual understanding & support	1.35	.050	.285
Work execution	1.38	.054	.302
Problem coping	1.28	.041	.246
Competency building:			
Technical competency	**2.74**	**.252*****	**.721**
Attitudinal competency	1.59	.086*	.420

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

6. Discussion

6.1. Impact of input components on throughput components

6.1.1. Team orientation

"Work-execution orientedness" positively influenced "work execution". It is logical that intentionality to work influences actual work activities. "Work-norm orientedness" positively influenced "mutual understanding and support" and "problem coping". In addition to concentrating on one's task, being conscious of connectedness with others may lead to supportive behaviour and problem coping.

6.1.2. Team leadership

"Technical leadership" positively influenced "work execution". This shows that technical initiative is indispensable in manufacturing. "Human relation leadership" positively influenced "mutual understanding and support" and "problem coping". It is revealed that, if members are merely dedicated to assigned tasks, it does not automatically lead to mutual support and problem solving, and building a good relationship is a necessity in M-PBL. "Knowledge and information leadership" had a positive influence on both "mutual understanding and support" and "work execution". Knowing who has what knowledge and skills and understanding the order of each production process are indispensable to the division-of-labour system.

6.2. Impact of teamwork process on competency building

6.2.1. The individual level

At the individual level, "technical competency" was positively affected by both "mutual understanding and support" and "work execution" behaviours. It can be thought that tackling the actual task with understanding of manufacturing holistically facilitates the development of technical competency. "Attitudinal competency" was positively affected by both "work execution" and "problem coping", contributing not only by the accomplishment of the assigned task but it is also conceivable that addressing emerging problems jointly reinforces one's readiness "to work in a team".

6.2.2. The collective level

At the collective level, it was confirmed that technical leadership affects technical competency. A team in which members who have task-required knowledge and skills work proactively and can be said to be a team of high technical competency at the team level.

6.2.3. The difference between the individual and collective levels

In M-PBL, a division-of-labour system exists, unlike in non-manufacturing activities. Hence, only a few subscales of the model could be aggregated to the collective level. Because the degrees of collaboration differ by task, the perceptions of such subscales vary among the members.

6.3. The difference between M-PBL and existing pedagogical methods

The results of this study suggest that students can develop their conceptual competency (Winterton Delamare-Le Deist, & Stringfellow, 2006) by cognitive effort in a conventional lecture, and authentic team activity is necessary in order to develop operational (technical and attitudinal) competency.

7. Conclusion

The originality of this study is summarised below. First, we extended the existing teamwork scale to the manufacturing context. Accordingly, applicability to other PBL and OJT in manufacturing has increased. Second, our study exhibited a problem in that most teamwork components were not aggregated to the collective level in M-PBL because of the existence of the division-of-labour system. Third, we suggested the limit of the conventional pedagogical methods and the possibility of M-PBL from the viewpoint of competency building.

For educational practices, we suggested a new evaluation method for PBL. For example, appropriate evaluation of teamwork and the consideration of necessary intervention will be enabled by using this scale at the mid-point of a project.

Future challenges and limitations of this study are twofold. The first is a measurement of the objective variable. For this study, we used a self-report to measure competency building, whereas development of an objectivity measurement by third-party evaluation is expected in future. The second is the refinement of the model. Solving the difficulty of variable aggregation in the division-of-labour system would allow for further multi-level considerations. Further investigation about mediating processes (shown in Figure 3) is also necessary.

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References

Bliese, P. D. (2000). Within-group agreement, non-independence, and reliability: Implications for data aggregation and analysis. In K. J. Klein & S. W. J. Kozlowski (Eds.) *Multi level theory, research, and methods in organizations: Foundations, extensions, and new directions*. San Francisco: Jossey-Bass. pp. 349-381.

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar A. (1991). Motivating project-based learning: sustaining the doing, supporting the learning. *Educational Psychologist*, **26**, 369-398.

Cheng, R. W., Lam S., & Chan, C. (2008). When high achievers and law achievers work in the same group: The roles of group heterogeneity and processes in project-based learning. *The British Journal of Educational Psychology*, **78**, 205-221.

Dickinson, T. L. & McIntyre, R. M. (1997). A conceptual framework for teamwork measurement. In M. T. Brannick, E. Salas, & C. Prince (Eds.), *Team performance assessment and measurement: Theory, methods, and applications*. Mahwah, NJ: Lawrence Erlbaum Associates, 19-43.

Helle, L., Tynjälä, P., Olkinuora, E., & Lonka, K. (2007). 'Ain't nothin' like the real thing'. Motivation and study processes on a work-based project course in information systems design. *British Journal of Educational Psychology*, **77**, 397-411.

James, L. R. (1982). Aggregation bias in estimates of perceptual agreement. *Journal of Applied Psychology*, **67**, 219-229.

Katz, R. L. (1955). Skills of an Effective Administrator, *Harvard Business Review*, Jan.-Feb., 33-42.

Klein, K. J., Griffin, M. A., Bliese, P. D., Hoffman, D. A., Kozlowski, S. W. J., James, L. R., Dansereau, F., Yammarino, F. J., Gavin, M. B., & Bligh, M. C. (2000). Multi-level analytical techniques: Commonalities, difference, and continuing questions. In K. J. Klein & S. W. J. Kozlowski (Eds.) *Multi level theory, research, and methods in organizations: Foundations, extensions, and new directions*. San Francisco: Jossey-Bass. Pp. 512-553.

Lockrey, S. & Johnson, K. B. (2013). Designing pedagogy with emerging sustainable technologies. *Journal of Cleaner Production*, **61**, 70-79.

Minnaert, A., Boekaerts, M., & de Brabander, C. (2007). Autonomy, competence, and social relatedness in task interest within project-based education. *Psychological Reports*, **101**, 574-586.

Misawa, R., Sasou, K., & Yamaguchi, H. (2009). Development of the teamwork measure for nursing teams. *Japanese Journal of Social Psychology*, **24**, 219-232. (In Japanese with English abstract)

Neo, M. (2005). Engaging students in group-based co-operative learning- A Malaysian perspective. *Educational Technology & Society*, **8**, 220-232.

Ngai, E. W. T. (2007). Learning in introductory e-commerce: A project-based teamwork approach. *Computers & Education*, **48**, 17-29.

Okamoto, H. (2012). Challenges of HRM looking from the job satisfaction perspective of full-time employees in medium-sized enterprise: From a survey of full-time employees in Tokyo and environs. *The journal of business management*, **29**, 68-80. (In Japanese, translated by the author of this article)

Peugh, J. L. (2010). A practical guide to multilevel modelling. *Journal of School Psychology*, **48**, 85-112.

Rychen, D. S. & Salganik, L. H. (Eds.) (2003). Key competencies for a successful life and well-functioning society. Gottingen, Germany: Hogrefe & Huber.

Takeshita, H., Okuaki, S., Nakamura, M, & Yamaguchi, H. (2015). Exploring the teamwork measure for manufacturing-project based learning. *Proceedings of the 14th IFToMM World Congress*, 223-228.

Walters, R. C. & Sirotiak, T. S. (2011). Assessing the effect of project based learning on leadership abilities and communication skills. 47th ASC Annual International Conference Proceedings, the Associated Schools of Construction, Winsor, CO. < http://ascpro0.ascweb.org/archives/cd/2011/paper/CERT301002011.pdf> (Aug. 02, 2016)

Winterton, J., Delamare-Le Deist, F., & Stringfellow, E. (2006). Typology of knowledge, skills and competencies: clarification of the concept and prototype. Cedefop Reference series; **64**, Luxembourg: Office for official publications of the European communities.