VALIDITY ASSESSMENT OF THE P-B-P MODEL ACROSS VARIOUS ENGINEERING DISCIPLINES FOR BETTER TEAM LEARNING RESULTS

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ABSTRACT

Promoting and enhancing team learning is one of the essential tasks in improving the quality of education using the CDIO framework. The Pull-Balance-Push (P-B-P) model, which was first presented at the 10th Annual International CDIO Conference at Universitat Politècnica de Catalunya, Barcelona, Spain (June 16 - 19, 2014), has been deployed at Duy Tan University in various CDIO projects at the senior level of different majors, including Software Engineering, Information Systems, Civil Engineering, and Electrical Engineering. The model is basically a set of approaches to bring about better team learning by improving students' communication skills, learning capability and in-class participation as well as emphasizing the instructor's role in guiding teamwork efforts. However, while the advantages of this model have become widely-appreciated by the Faculty of Electrical & Electronics Engineering and its students, other faculties like Civil Engineering and Information Technology are still cautious in their adoption of the model, partly because of their own CDIO-project structures, which were designed and adopted a long time ago. In addition, to effectively carry out the P-B-P model, students and instructors would need to spend extra time and effort for reports, meetings and other documentation work, which raised concern about the already heavy workload during the final year. Through a series of in-person interviews and surveys, this paper will help analyze and benchmark the pros and cons of the P-B-P model across the four disciplines of Electrical Engineering, Software Engineering, Information Systems, and Civil Engineering in order to assess the validity and sustainability of this model under different learning settings.

KEYWORDS

Active learning, CDIO Framework, CDIO Standard 7-8, FSNPA model, individual learning, team learning

INTRODUCTION

Team learning is the process of sharing knowledge and complementing for each other amongst members of a team, who are working collectively to achieve some common goal (Decuyper et al, 2010). Under such settings, in "Team-Based Learning: A Transformative Use of Small Groups", Michaelsen said there are always dependencies between the work and roles of team members, hence, a high level of commitment toward the common goal, reasonable work distribution among the members and effective responsibility delegation by the team leader are some of the key factors to a team's success (Michaelsen, 2002). Successful team learning usually helps with the learning capability of its members in various areas. As a result, team learning is now widely adopted by many universities and institutions in the teaching of many subjects (Tran, 2014). Applying and enhancing team learning is one of the important activities in improving the quality of education within the CDIO framework.

At Duy Tan University (DTU), team learning is at the heart of our CDIO deployment, but many times, we observed that our engineering students did not realize the benefits of team learning because of various break-downs in the process of team development. Therefore, in an effort to improve team learning and teamwork efficiency, our instructors from the Faculty of Electrical & Electronics Engineering and Civil Engineering have created a better way for teamwork approach in their CDIO projects. It is the Pull-Balance-Push model, which is called the "P-B-P" model in short, and which includes a series of tactics focusing on improving students' communication skills, individual learning and participation as well as the instructor's role in guiding teamwork effort (Tran et al, 2014). In Figure 1, the Push, Balance and Pull tactics is applied to the Forming, Storming, Norming, Performing, and Adjourning stages of the FSNPA model. The FSNPA model for team development of Bruce Tuckman also provides the big picture about what stages of team development is of the most focus for Pull or Balance or Push tactics (Tuckman, 1965).

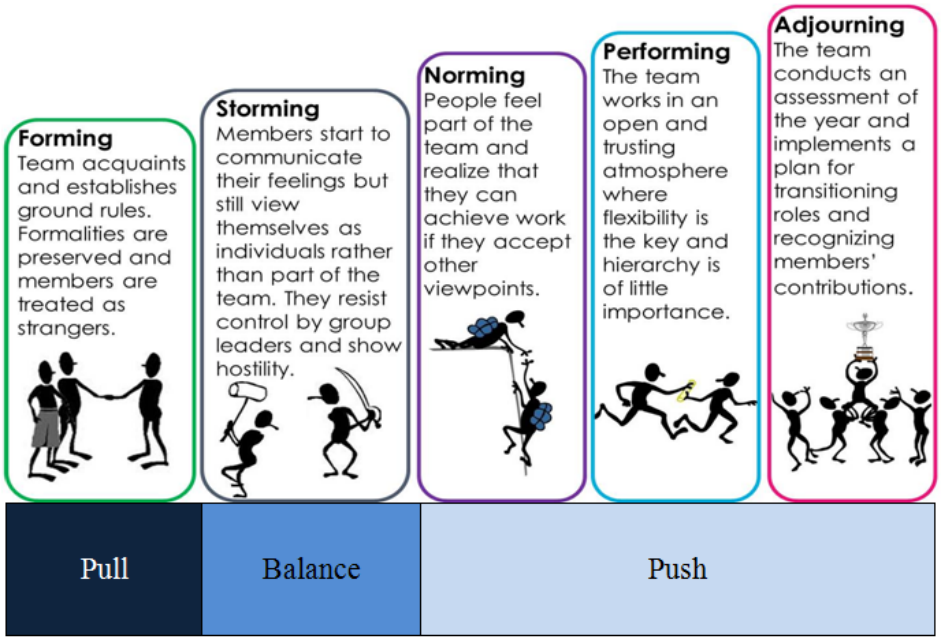

Figure 1. The FSNPA Model of Team Development

Up to this point, our P-B-P model has been adopted for four engineering tracks of Software Engineering, Information System, Electrical & Electronics Engineering and Civil Engineering at DTU and has received various feedbacks from both students and instructors. However,

besides the good results recognized by the Faculty of Electrical & Electronics Engineering, the P-B-P model is not completely accepted at other faculties such as Information Technology or Civil Engineering, which have their own CDIO project structures designed long ago or proprietary models, forms and checklists (e.g., "imported" from Carnegie Mellon University - CMU) already being used. In addition, many students signified the shortcomings of the P-B-P model as they have to spend extra time to write up reports or to hold additional meetings with their instructors or mentors. Given those problems, this paper will build on our previous work to carry out additional analysis of the pros and cons of the P-B-P model as seen in reality, and to propose a number of changes which will help enhance the validity and sustainability of the P-B-P model across various engineering disciplines.

This paper has an introduction in the first section, an overview of our previous work in the second section, and then, in the third section an analysis about the pros and cons of the P-B-P model will be carried out before the proposed improvement model to help enhance the validity and sustainability of the model. The last section of conclusion will draw upon comments and directions for future studies.

PREVIOUS WORKS

In our previous paper of "Improvement of Individual learning and Instructor's role for better Team learning" at the 10th Annual International CDIO Conference at Universitat Politècnica de Catalunya, Barcelona 2014, we looked into various inadequacies of team learning at DTU and found that the most number of teamwork breakdowns were due to communication problems. To arrive at such a finding, we carried out a series of interviews with the questions as listed in Table 1 below:

Table 1. Interview Questions for Team Learning Shortcomings at DTU

No.	Questions
1	What do you think about team learning?
2	Do you think team learning is important?
3	How many members do you usually have in your project team? How many males and females?
4	What is the biggest obstacle of team learning in your experience?
5	Do you usually have problems with your team leader? Does he/she have a good management style?
6	Do you usually have "free riders" in your teams?
7	What kind of arguments do you usually run into in your teams? Explain.
8	Do you and your team members share the same goals and vision during the course of the project?
9	Did your instructors help facilitate and support good teamwork practices?
10	What was the biggest shortcoming of your instructors when it comes to team learning effort?

The results obtained in previous study highlighted the following points:

- Responses to the importance and effectiveness of team learning were usually at the two extremes: either Very Satisfied or Very Dissatisfied.
- The percentiles of males and females in many engineering project teams at DTU are usually uneven and the opinions of the minority in the teams are mostly ignored.

- The biggest obstacles in team formation which hinders team learning at DTU include:
    - Team members are usually too busy trying to protect their ideas that the team wastes a lot of time and effort in heated discussions and arguments.
    - Some team members have to do everything while others do nothing.
    - The team leaders are usually chosen because they are good students, not necessarily because they have experience or training in team management.
    - Outstanding team members usually try to impose their ideas on other members.
    - Team members mostly focus on "getting the project done" that they usually lose track of the shared vision and goals, which require regular discussion and revision.
- While most students refused to recognize themselves as "free riders", some complained that they could not catch up with other team members, and became passive in teamwork, as a result.
- Instructors at DTU tried hard to help with teamwork activities, but they still believed that there are many aspects that they could improve on to better support team learning.
- Instructors focused so much on the outcomes and quality of the projects that more than often, they ignored team learning.
- Instructors usually paid extra attention and time with outstanding team members while ignoring other team members.

Given the problems above, we had proposed a series of changes in which the tactics of Pull, Balance and Push will be emphasized at different stages of the FSNPA model (Tuckman, 1965):

- Pull tactics are to be emphasized in the Forming stage to help improve the instructor's role in helping team members get along with each other and in enhancing participation in interactive team activities.
- Balance tactics are to be focused on in the Storming stage to help improve the communication between team members, enhance individual learning, and provide an equal opportunity for every team member to present himself or herself as well as his or her ideas. Communication incentives and conflict-resolution methods will be the focus of the instructor in this stage.
- Push tactics are to be spread out in the remaining stages of FSNPA model, including Norming, Performing and Adjourning, in order to push the team's efforts toward their goals. Specific tactics include checking on the overall progress of the teams, moving up the due dates for certain teams if they are doing well, or extending the due dates again for some teams that cannot keep up with the deadlines.

PROPOSED IMPROVEMENT MODEL TO ENHANCE THE VALIDITY AND SUSTAINABILITY OF THE P-B-P MODEL

In order to assess the effectiveness of the changes proposed in our last study, within the scope of this paper, we will carry out another survey with students coming from different engineering disciplines to assess their experiences of the P-B-P tactics being used in their CDIO projects under the context of the FSNPA model of team development. The questionnaire for this survey can be found in Table 2 in the Appendix.

A. Analysis of Survey Results:

Our survey was carried out on a sample of 100 students, spreading equally across 4 classes of Civil Engineering, Electrical & Electronics Engineering, Information Systems and Software Engineering with 25 students for each class. The same number of students for each class would allow us to easily compare and contrast on different feedbacks of students for some specific issue.

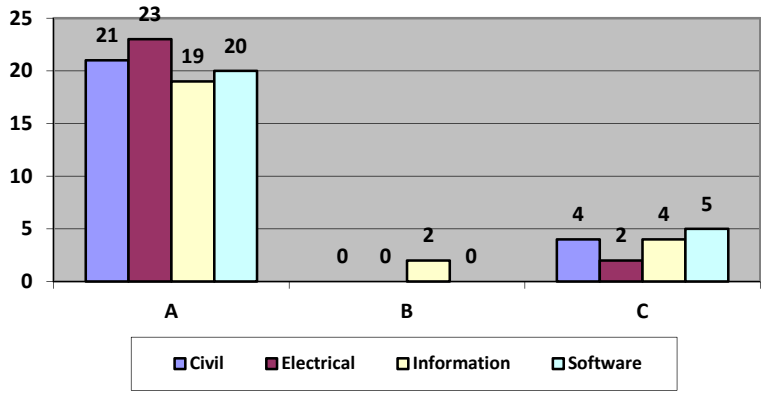

Figure 2. Survey Result for Question 1

In Figure 2, there are up to 83 responses of “Yes” on the question of whether students notice of any improvement in the CDIO project course; only 2 responses are “No”. The similarity in the responses of students from four classes signified the fact that our proposed changes have been well adopted in different engineering tracks.

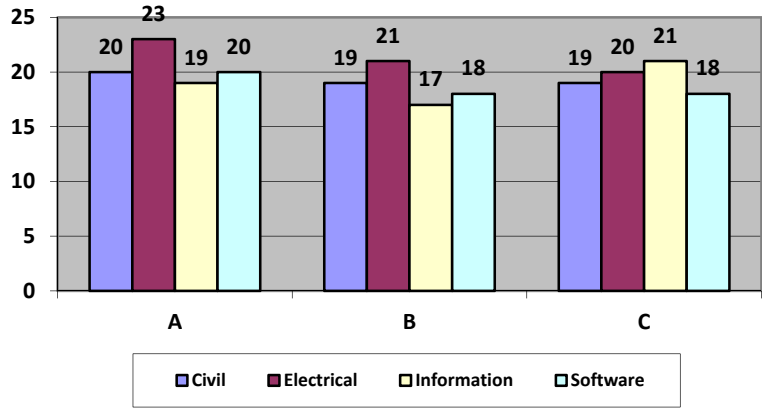

Figure 3. Survey Result for Question 2

Figure 3 demonstrates students’ satisfaction and enjoyment with the new settings for our CDIO project with a fairly equal selection for all 3 options in their responses. While most students agreed that there were more teamwork interaction, group games/activities, and instructor’s support, the benefit of teamwork interaction was slightly greater than the other two. Some students also indicated that they felt more comfortable with the new atmosphere and excitement of the CDIO project.

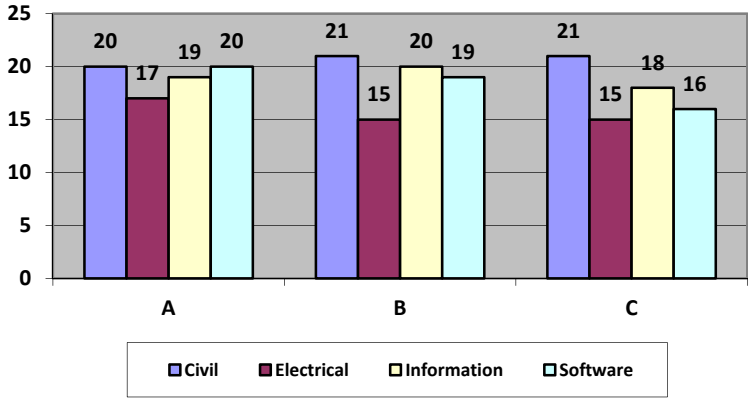

Figure 4. Survey Result for Question 3

In Figure 4, we can see many students complained that they could not manage their schedules well because of additional requirement in time and effort for the project (75/100). This is the biggest shortcoming given the significant extra amount of time students now have to spend for weekly checklists, reports and additional meetings with the instructors or mentors. In addition, up to 70 out of 100 students are not that open to conflict resolution practices, which is most apparent in the Civil Engineering class at a ratio of 21 out of 25 students, who complained about this problem. Since the field of Civil Engineering is very much project-oriented, it seems the new project settings simply add more to the already heavy workload of this discipline. And as a result of the increased requirement in the time and effort spent, most students did not keep good record of their work to support other members (76/100). This may hinder our measurement of support efforts in the new teamwork settings, which calls for some better mechanism, e.g., a software utility, to help keep track of this.

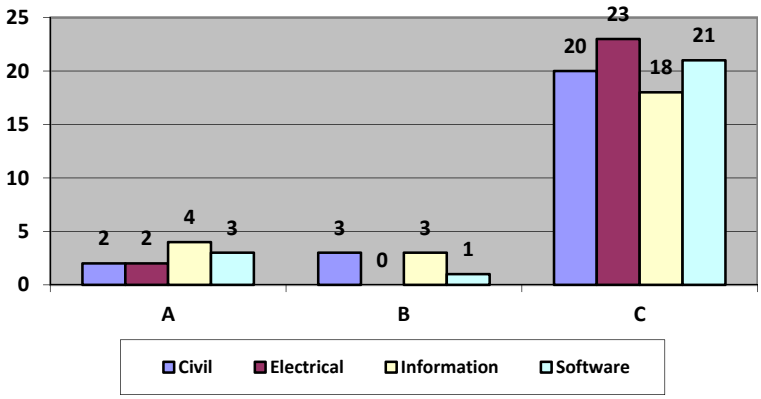

Figure 5. Survey Result for Question 4

The new class organization appears to help instructors significantly improve their role of support for students in their projects. Up to 82 out of 100 students said that their instructors seemed to understand ahead of time the team's problems and offered help as a result rather than stopping at showing their willingness to help or offering help only when asked. This is a major lift from the traditional approach, which requires a great deal of instructors' involvement with their team projects. Again, the instructors of the Faculty of Electrical & Electronics Engineering were perceived (23/25) to have done better than those of other faculties.

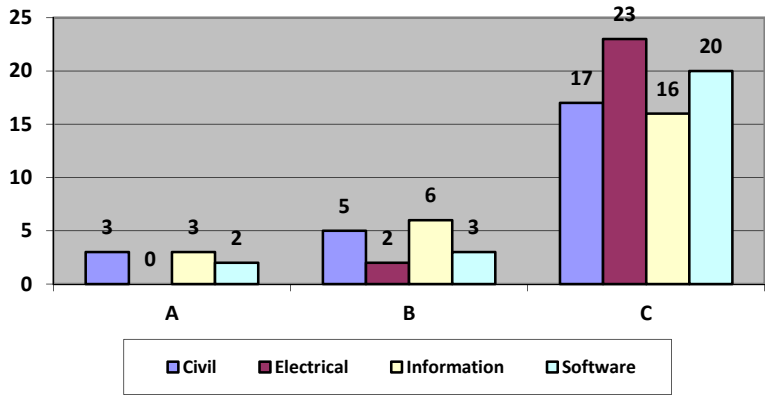

Figure 6. Survey Result for Question 5

The adoption of the P-B-P model has brought about a more proactive manner on the part of students in their offer to support other team members. Up to 76/100 students commented that their team members were willing to offer help anytime they were available and/or noticed of the need for help and support. This means team members are now more concerned about the overall outcome of the whole project rather than only trying to finish what was assigned to them, individually. Still, there were 16/100 students who believed they need to offer help in order to get help in return when needed.

With respect to the analysis of the validity and sustainability of the P-B-P model, feedbacks from Questions 6 to 10 are to be accounted for. For this analysis, we also switch to the line charts so as to clearly compare and contrast on the feedbacks of students of different engineering majors.

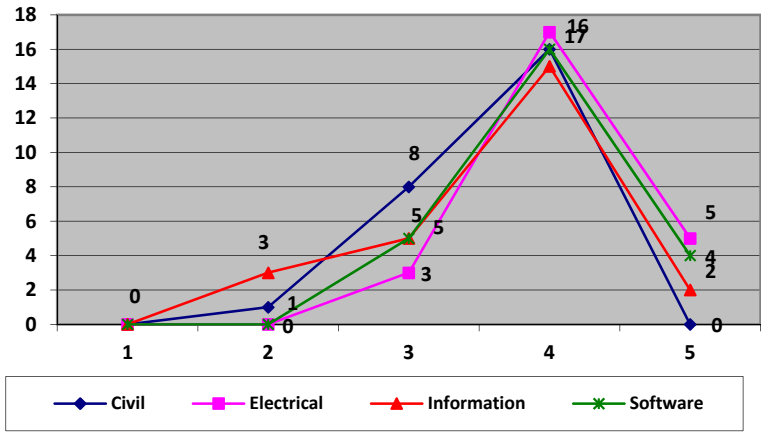

Figure 7. Survey Result for Question 6

In question 6, we asked students about their perceived level of respect from other team members. The question aims to assess whether the working environment in our CDIO projects is healthy and whether each team member is confident of their own capability. Unexpectedly, we received very positive feedbacks from this question with most students in different engineering tracks agreeing that they received good respect from other team members. This shows that the P-B-L model has brought about a more collaborative atmosphere for our CDIO teamwork. Amongst students of different disciplines, Civil Engineering students again showed most indifference about this matter, possibly due to the significant specialization in the role of each team member in the project.

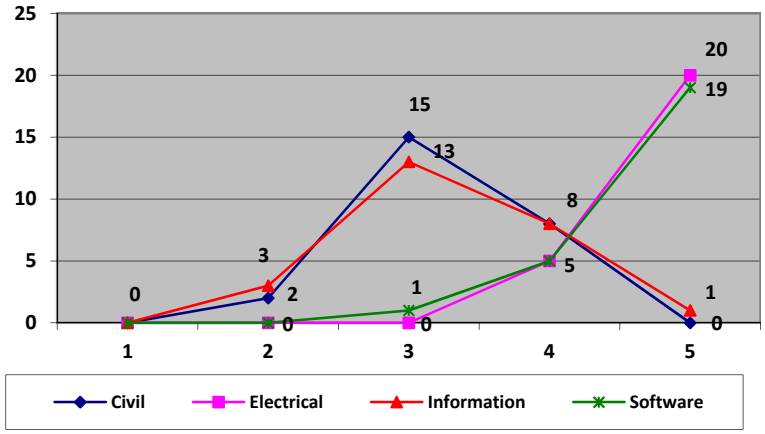

Figure 8. Survey Result for Question 7

When asked about students' commitment and engagement in the CDIO project, results in Figure 8 show that most of the Electrical & Electronics Engineering and Software Engineering students are highly committed with 20/25 and 19/25 showing their full commitment while contrary to that, most students in Civil Engineering and Information Systems are quite neutral. The complex nature and difficult grading standards of Civil Engineering projects may have been one of the reasons which discouraged Civil Engineering students from their full commitment while not all Information Systems students are prepared to be well-disciplined in engineering projects because they come from a mix of both IT and business students.

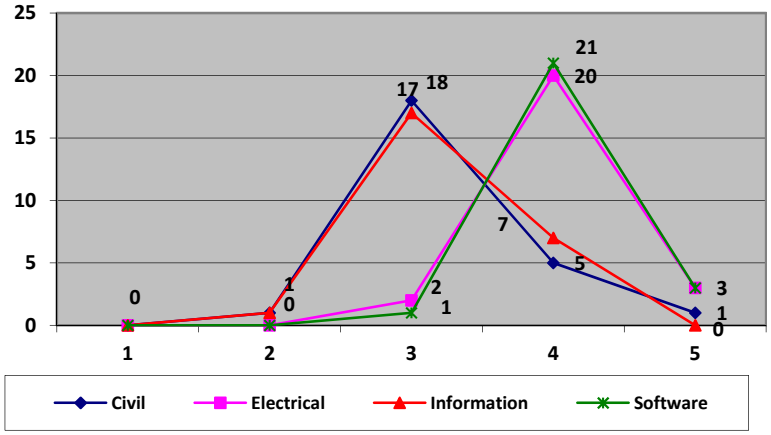

Figure 9. Survey Result for Question 8

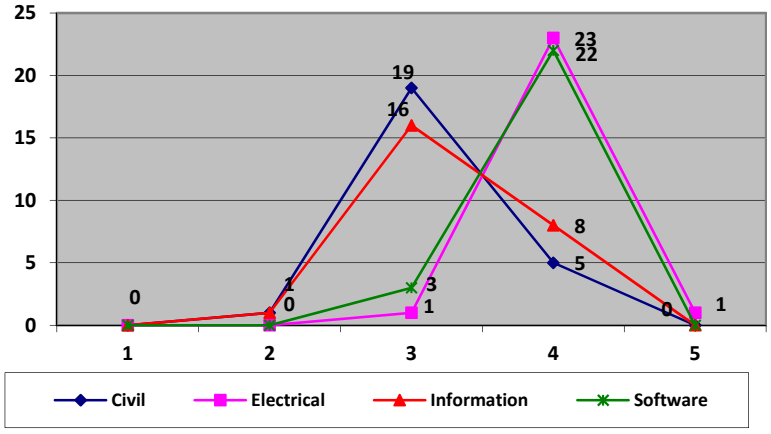

Figure 10. Survey Result for Question 9

Figures 9 and 10 show similar patterns in the feedbacks of Civil Engineering and Information Systems students versus of Electrical & Electronics Engineering and Software Engineering students. Civil Engineering and Information Systems found the P-B-P model to be useful for individual and team learning but not as much as Electrical & Electronics Engineering and Software Engineering students. Besides Software Engineering students slightly found more benefit of the model for individual learning than Electrical & Electronics Engineering students who realized more benefit of the model in team learning.

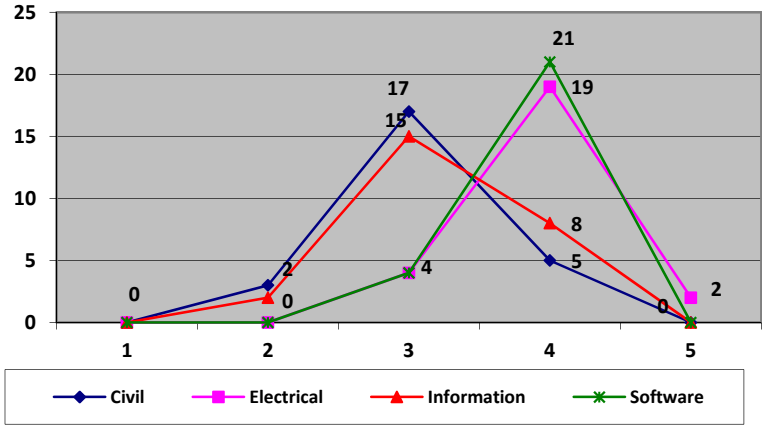

Figure 11. Survey Result for Question 10

Most of the students across different study disciplines perceived the P-B-P model to be suitable for their engineering studies. However, it seems to be more suitable for Electrical & Electronics Engineering and Software Engineering. The difference between Software Engineering and Information Systems is strange considering the closely-related nature of the two disciplines. This raised the need for further refining of the model through detailed procedures to produce more consistent deployment results.

Results from the rest of the questions provide additional information for the refining and restructuring of the P-B-P model, especially to better match up with the FSNPA model:

- Regarding Question 12 about which FSNPA stage students learned the most through the use of P-B-P tactics, interestingly enough, the Storming stage received up to 58% of the votes. On the other hand, the Norming and Performing stages received almost the same percentiles of votes at 17% and 16%, respectively. Given the fact that the CDIO projects lasted for only a semester, the P-B-P model may not have provided the full team-learning experience that it was designed for. Students instead would remember the various hassles that they had to sort out with each other during the Storming stage.
- For Question 13 about who was the key in resolving team conflicts, up to 82% of the students believed that all team members need to work together to help resolve any group conflict. This is a good sign since students had come to see themselves as the ones being responsible for any success or failure of their team and project.
- For additional comments about the P-B-P model, students suggested that the new group games should be designed to relate closely to the content of the projects being carried out. Students also requested additional support on the part of instructors to help them build essential skills for future career.

B. Proposed Improvement Model:

In so far, based on the results acquired from the survey, it seemed we have only focused on improving the instructor's role, individual learning, and team interaction (rather than team learning) at various stages of team development based on the FSNPA model. The P-B-P model was also matched up with the FSNPA model only, there has not been any match-up between the P-B-P model and different stages of the CDIO model like Conceive, Design, Implement and Operate to accurately assess the validity and sustainability of the P-B-P model in the scope of a CDIO project. The improvement model as discussed subsequently will help fix our current shortcoming.

P-B-P Validity:

The validity of the P-B-P model is its compatibility and effectiveness for various study disciplines. Since CDIO projects are at the heart of many engineering disciplines, how we match up the P-B-P model with the CDIO model will provide the basis for later tests of whether the P-B-P model is truly compatible or effective for any one specific discipline.

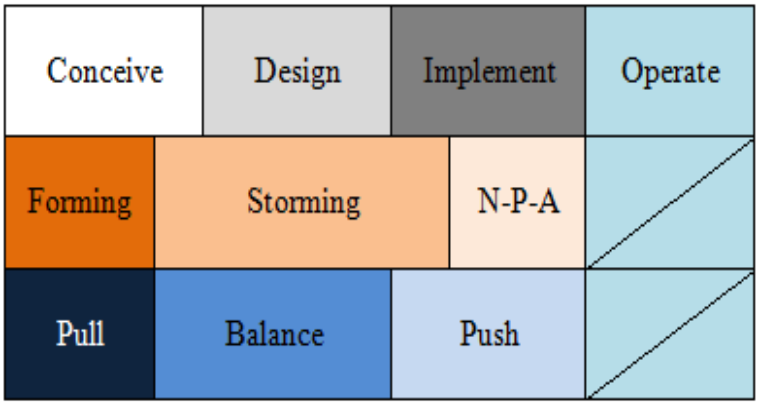

Figure 11. New Match-up between CDIO model and P-B-P tactics

With the new match-up, the P-B-P tactics are rearranged as followed:

- **Pull tactics**: Most of the Pull tactics are still applied completely for the Forming stage of the FSNPA model. On the other hand, they will be used for 2/3 of the Conceive stage of the CDIO model. The implication has to do with the fact that except for senior students who have become creative and dynamic, most junior and sophomore students need additional time and efforts to go through the team development process. As a result, by having the instructors "pull" them forward during the Forming stage, students will have more time for conceiving a project idea or solution, which in a typical CDIO project also occurs during the Forming stage.
- **Balance tactics**: Usually at the end of the Conceive stage of the CDIO model, team development will be in transition to the Storming stage of the FSNPA model, when team members are fighting to protect their ideas. As a result, Balance tactics will be necessary to keep the team focus on their goals or from falling apart. Balance tactics should help students get accustomed to structured reports and checklists so as to get them more organized and prepared for the later Design stage of the CDIO model. Past experiences have shown that team members who did not learn to get adapted usually felt overwhelmed and fell behind in later stages of the project. Even though the Storming stage of the FSNPA model will slide on to the early part of the Implement stage of the CDIO model, we will stop our Balance tactics by the end of the Design stage. At this point, with most of the major designs being already settled, students will

move back to individual learning, trying to complete their assigned tasks. Conflicts at the end of the Storming stage of the FSNPA model and the beginning of the Implement stage of the CDIO model are mostly minimal or unimportant; otherwise, it must be due to negligence of the involved stakeholders.

- **Push tactics**: Early in the Implement stage of the CDIO model, there is a strong likelihood that students will move totally back into their individual learning that they forget to regularly communicate or carry out team activities with other team members. This will lead to coordination problems later on when students try to put together their work into a comprehensive product or prototype. As a result, at the end of the Storming stage of the FSNPA model and shortly after the beginning of the Implement stage of the CDIO model, Push tactics need to be adopted to keep the team informed of their development processes and schedules. Push tactics will also help the team detect early on any shortcomings or delays as their projects progress to meet different deadlines.

P-B-P Sustainability:

The sustainability of the P-B-P model, by our definition, is its ability to deliver the same positive results across time and across different schools and universities (e.g., not only at Duy Tan University) for the same study discipline. That said, the P-B-P model can also be used for other non-engineering disciplines at Duy Tan University, which have adopted the PBL (Problem-based Learning) model, as long as it stands the test of time for a specific discipline (Dewey, 1997). Clearly enough, that sustainability can only be attained over time by the use of detailed practices and procedures. From our experience thus far, the following proposed evaluation forms, checklists and technical documents would help build that sustainability if they are adopted in the sequence described in Table 3.

Table 3. New Distribution of Evaluation Forms, Checklists and Documentation Materials in P-B-P

Documents for P-B-P Model (Detailed forms and checklists can be found online as listed in the REFERENCE section.)	Conceive	Design		Implement
	Pull	Balance		Push
1. Weekly Checklist for Team Leaders				
2. Knowledge Evaluation Form				
3. Relationship between Knowledge and Project Evaluation Forms				
4. Weekly Check List For Individual Team Member				
5. Project Proposal				
6. Project Plan				
7. Product Backlog Document				
8. Architecture Document				
9. Technical Design Document				
10. Test Plan				
11. Time Log				
12. Checklist for Technical Review				

Generally speaking:

- Evaluation Forms will be the focus during the Conceive stage to collect basic information about students' skills and knowledge as well as the goals and scope of the

project. This piece of information will help instructors classify students into different groups and assign them to specific teams.

- Various Checklists will be utilized throughout the project to help instructors and students monitor the progress of the project besides ensuring that students are actually participate in different activities for individual and team learning.
- Technical Documentation is important in determining how well individual and team learning is going on. It also provides a series of tools for the project leader and team members to re-assess the design and organization of their project from time to time so as to make any necessary changes or improvements. The instructors should check the Technical Documentation of their students' projects on a weekly basis to give proper advice and to make in-time adjustment. Technical Documentation should be openly shared amongst team members.

CONCLUSIONS

Improving individual and team learning in CDIO projects has always been in the interest of many researchers in different engineering fields. Finding a way to deploy and measure individual and team learning practices is, however, not an easy task. The early success at Duy Tan University in applying the P-B-P model for CDIO projects under the context of the FSNPA model of team development has offered room for further research on the topic. Specifically, we need to look for ways to improve on the use of the P-B-P model for Civil Engineering projects; or else, we would need to opt for some other model for the Civil Engineering track in the long run. On the other hand, while the P-B-P model is widely successful in Electrical & Electronics Engineering and Software Engineering tracks, our research has only stopped at proving the validity of P-B-P tactics for CDIO across a number of engineering tracks. The sustainability of the model while visible through recent experiences and modifications in our approach has not been proved systematically through some statistical tests between our original adoption of P-B-P tactics and the current improvement model. Further studies should look into these aspects as well as making a more detailed analysis of how specific forms or checklists may help with the process of individual learning and team learning.

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APPENDIX: Table 2. Questionnaire for the Validity and Sustainability Test of the P-B-P Model

Student's name:	**Student's ID no.:**		
Student's major:			
No.	**Option**	**Weekly check list for team leaders**	**Tick √**
1	Did you notice any change or improvement in the CDIO projects of this semester? (Tick only 1 Option)		
	A	Yes	
	B	No	
	C	A little	
2	What do you enjoy the most in the new CDIO project settings and class organization? (Tick as many as applicable)		
	A	There are more interactions between team members.	
	B	There are more interactive group games & activities.	
	C	The instructor offers more support to group work.	
	List other things you enjoy:		
3	What do you dislike the most in the new CDIO project settings and class organization? (Tick as many as applicable)		
	A	Not all the team members keep good record of their work to support others.	
	B	I cannot manage my schedule well because of additional requirement in time and effort.	
	C	Not all the team members are open to conflict resolution practices.	
	List other things you dislike:		
4	How did your instructor/mentor support the work of your team? (Tick only 1 Option)		
	A	The instructor was proactive in offering help to the team.	
	B	The instructor only offered help when asked by the team.	
	C	The instructor seemed to understand ahead of time our team's problems and offered help as a result.	
	List other ways the instructor supported your team:		
5	With the adoption of the PBP (Pull-Balance-Push) model in our CDIO projects, how did you get help from your team members? (Tick only 1 Option)		
	A	I still had to seek for help from my team members when needed.	
	B	I offered help to my team members first and then got help in return.	
	C	My team members offered help to me anytime they were available or noticed that I needed help.	
	List other ways you got help or your team members offered help:		
6	Rate your perceived level of respect by other team members. (Tick only 1 Option)		
	1	No respect	
	2	Little respect	
	3	Moderate respect	
	4	Much respect	
	5	Full respect	
7	Rate your level of commitment and engagement in the CDIO project of this semester. (Tick only 1 Option)		
	1	Not at all committed and engaged	
	2	Not very committed and engaged	
	3	Moderately committed and engaged	
	4	Very committed and engaged	
	5	Fully committed and engaged	
8	Rate your perceived level of usefulness of the P-B-P model to individual learning. (Tick only 1 Option)		
	1	Not at all useful	
	2	Not very useful	
	3	Useful	
	4	Very useful	
	5	Absolutely useful	
9	Rate your perceived level of usefulness of the P-B-P model to team learning. (Tick only 1 Option)		
	1	Not at all useful	
	2	Not very useful	
	3	Useful	
	4	Very useful	
	5	Absolutely useful	
10	Rate your perceived level of suitability of the P-B-P model for your engineering major. (Tick only 1 Option)		
	1	Not at all suitable	
	2	Not very suitable	
	3	Suitable	
	4	Very suitable	
	5	Absolutely suitable	
11	Which group of tactics in the P-B-P model that was most effective for your CDIO project? (Tick only 1 Option)		
	A	Pull tactics	
	B	Balance tactics	
	C	Push tactics	
	Provide the reasons for your choice above:		
12	At which stage in the FSNPA model that you managed to learn the most knowledge and skills about your CDIO project? (Tick only 1 Option)		
	A	Forming	
	B	Storming	
	C	Norming	
	D	Performing	
	E	Adjourning	
	Provide the reasons for your choice above:		
13	Who do you think is the key in resolving group conflicts in your CDIO project?		
	A	All the team members	
	B	The team leader	
	C	The instructor	
	Other opinions:		
14	**List any shortcomings that you noticed about the P-B-P model:**		

BIOGRAPHICAL INFORMATION

Tran Le Thang Dong, received B.S degree Electronics and Telecommunication Bachelor from Duy Tan University, Viet Nam in 2009, and M.S.degree in Computer Science from Duy Tan University, Vietnam, in 2012. He is currently the Vice Director at Center of Electrical Engineering (CEE), Duy Tan University. His research interests include image processing, design automation of embedded systems, FPGA design. He joined the CDIO program as a lecturer of Introduction to Electrical & Electronics Engineering course in 2013.

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