

A Study on the Personal Traits and Knowledge Base of Taiwanese Medical Students Following Problem-based Learning Instructions

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Abstract

Introduction: Problem-based learning (PBL), a pedagogic concept using a student-centred approach and problem-solving through small group discussions, has been adopted in varying degrees for years at all 11 medical institutes in Taiwan. Much evidence has shown that a number of factors can seriously affect student performance in PBL courses, such as the design of PBL scenarios, the tutors' character and students' attitudes and efforts. **Materials and Methods:** The aim of this study was to examine how the personal characters or knowledge base of Taiwanese medical students influence their performance in a hybrid-PBL curriculum. A total of 309 (234 male, 75 female) high-school entry undergraduate medical students participated in this survey. Self-assessed personal traits were presented in a 44-item questionnaire with a Big Five factor structure. Knowledge base was assessed by students' score point average (SPA) based on their previous 4-year education in medical school. Peer-assessed performance of students in the PBL curriculum was carried out using a well-developed, reliable and validated evaluation form. **Results:** Each student's peer-evaluated PBL performance can be divided into 5 principal components, which included control-lead, assist-coordinate, written organisation and compromise-comply (Eigen value >1). The consistency and reliability of the Big Five questionnaire on personal traits was analysed and discordant items were deleted (Cronbach's alpha = 0.72 to 0.86 after deletion). The relationship between the personal traits, knowledge base and PBL performance, as analysed by simple regression, showed that "extraversion" and "openness to experience" were positively related to the "assist-coordinate" characteristic in PBL performance, and "conscientiousness" was positively related to the "control-lead" characteristic in PBL performance. The SPA was positively related to the "assist-coordinate" or "control-lead" characteristic in PBL performance. The "agreeableness" was negatively correlated with the "control-lead" characteristic in PBL performance. After stepwise regression between the Big Five and each component of PBL performance, only the correlation between conscientiousness and control/lead, and between extraversion and assist/coordinate remained significant. **Conclusion:** Knowledge and personality characteristics appear to be associated with student performance in a hybrid-PBL curriculum. The implications of this study on the future development and application of this assessment tool in medical schools are presented.

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Key words: Big-Five, Performance, Score point average

Introduction

Problem-based learning (PBL) is a student-centred educational approach which encourages students to explore, inquire, explain, analyse, exchange, debate and manage information using relevant content-related scenarios as triggers for learning in a small group environment.^{1,2} While the purpose of PBL is to gain new knowledge, its spin-off

benefit is the acquisition of problem-solving skills.³ Therefore, a PBL tutor plays the role of a facilitator, who encourages cooperative learning and serves as a "guide on the side" rather than a "sage on the stage".⁴

Since its inception at McMaster University in 1969,⁵ PBL with its characteristic pedagogic principles has been adopted as a major driving force pushing waves of

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evolutionary as well as revolutionary reforms in medical education in all kinds of medical and healthcare institutes across the world. Medical education in Taiwan has also been a part of this trend. In past decade, all 11 medical schools in Taiwan have one by one incorporated forms of innovative curriculum bearing some characteristics of PBL. The newest medical school at the Catholic Fu-Jen University (which opened its doors in 1999) in Taipei has taken a bold step in implementing a broad scope of PBL curriculum. Its first group of graduates has just entered hospitals for their clinical internships this year. In Taichung city, both Chung-Shan Medical University and China Medical University have been carrying out PBL for more than 5 years using a hybrid PBL model, i.e., a smaller modular PBL component embedded in a traditional curriculum, which emphasises an integrative approach to teaching. In the present study, medical students of Chung-Shan Medical School were investigated to determine how personal traits and knowledge base might influence their performance. Instead of self-evaluation, which tends to elicit overestimation of oneself, peers were asked to complete the questionnaires and assessment sheets.

PBL can theoretically enhance students' abilities to understand and solve real-life problems, improve interpersonal skills and reasoning ability and inculcate a sense of responsibility for self-directed learning.^{6,7} Barrows et al⁸ have declared that PBL is superior to conventional subject-based lecturing in imparting medical problem-solving skills, imparting knowledge that is more relevant to clinical practice, and providing students with self-learning skills. In short, this new teaching approach allows knowledge to be understood, remembered and applied better.

Nevertheless, many problems are often encountered at various levels in the practice of PBL. These include eliminating traditional resistance to innovative concepts, investing in and distributing resources, training and maintaining a large number of tutors, promoting group dynamics among students, improving the design of the problems and designing a host of valid and reliable evaluation methods.⁹⁻¹¹ These difficulties have indeed been reported to be important factors influencing the implementation of PBL.¹²⁻¹⁹ Thus, self-evaluation, peer opinion and objective content-based examination have been developed to measure personal and group variables and evaluate performance.²⁰⁻²⁴ The evaluation of students' performance in PBL should be based on their role-play requirement in this curriculum. Studies about role-play in small group learning have been published in previous literature.^{3,6,25-27} The implementation of PBL curricula poses many problems, one of which is the lack of an objective outcome evaluation.^{6,28} Although many studies have described the roles of students in PBL or other types

of small group learning,^{25,26} procedures to evaluate students' performance in PBL, especially for Asian medical students, are still rare. Thus, the first objective of this study was to establish a valid and reliable PBL peer evaluation sheet based on a variety of role-play scenarios in this course.

Since the implementation of PBL requires not just the ability to search, integrate and apply the related knowledge by oneself, but also the interpersonal skills to collaborate and coordinate different viewpoints, it would be reasonable to postulate that students' personality or knowledge characteristics would influence their performance characters in PBL. Thus, the second objective of this study was to assess the influences of students' personality and knowledge, with well-done, valid and reliable tools, in their PBL performance. There have been many well-established and verified personality test in previous literature. The Big Five personality test, a modified form of the Myers-Briggs Type Indicator (MBTI), was selected in this study because it has been used worldwide for over 10 years in many research fields with satisfactory reliability and validity.²⁹⁻³¹ In the literature of Euro-American institutes, grade point average (GPA) was usually used as the evaluation of students' knowledge. Since a score of 0 to 100 is widely used in most Asian countries, the score point average (SPA) was used in this study.

Materials and Methods

From 2003 to 2006, a total of 309 (234 male, 75 female) undergraduate medical students (Year 5 of the 7-year medical school curriculum) (33 females and 91 males) attending a PBL-based course at Chung-Shan Medical University participated in the survey. They were randomly divided into groups of 6 or 7 students and arbitrarily assigned 1 tutor. Each group studied written clinical cases for 2 to 3 hours per week over a whole school year. The process in PBL sessions included initial brainstorming to formulate questions and setting objectives, and subsequent searches for resources such as textbooks, journals and medical websites for relevant information. Students returned in the following session to discuss the information, making a possible diagnosis (when applicable) and/or interpretation and developing a plan for further evaluation and/or action. The tutors communicated the rules and goals of the course to their students, and played the role of facilitators or coordinators, instructing to mediate students' learning processes instead of to impart factual knowledge during tutorial discussions.^{12,18,32} Prior to the end of the tutorial, the students and tutor provided feedback either verbally or as written comments online or in reports.

At the end of the PBL-based course, students were asked to fill out questionnaire and evaluation sheets to assess the performance of their group members and the tutor, as well

as to evaluate their own personal traits. The SPA obtained during their previous 4 consecutive years at the medical school served as a measure of students' knowledge base.

Peer Evaluation of Student Performance

Students evaluated their peers in each group at the end of the PBL course. There were 2 major dimensions of the peer evaluation: contributions to group missions and goals, and interpersonal skills, which have been described in the literature.^{3,6,25,26} These were verified by 5 tutors well-experienced in PBL before performing the survey. Goal achievement in the group learning task often relates to the following characteristics of content-related role-play:

1. *The initiator-contributor*, who often suggests new ideas or sorts out directions in the course of a PBL discussion. For example, the initiator may challenge: "How do we treat pulmonary emphysema patients who are refractory to medical treatment?" In response to the question, a contributor may suggest the flow of direction by asking: "It is reasonable to consider the lung volume reduction surgery or pulmonary transplantation?"
2. *The answer seeker/giver*, who tends to seek or offer a correct answer to a question in the PBL tutorial discussion. For example, an answer seeker may ask a simple and direct question: "What's the normal pH value of a human arterial blood sample?" The answer giver will respond directly with an answer: "7.4".
3. *The opinion seeker*, who tends to challenge and/or offer comments to add more value to the information. For example, an *opinion seeker* may comment: "Some reports in the literature emphasise the value of video-assisted thoracic surgery, in the treatment of empyema". They may also respond to further a comment: "Evaluation using evidence-based principles (level of evidence, level of recommendation) shows the level of understanding of their learning results."
4. *The elaborator*, who explains a concept by actual and adequate examples or metaphors. For example, an *elaborator* may respond to a question such as "What is lung compliance?" by elaborating in the following way: "You can think of the lung as a balloon. If you can blow the balloon up easily, its compliance is said to be high."
5. *The coordinator*, who can summarise different opinions within a group to formulate a consensus. For example, during debates about treatment options for urethral stones, the coordinator may weigh the condition of this patient and the proposed treatment plans, and then describe a cost-effective treatment strategy for the benefit of the patient.
6. *The orientator*, who can direct the pace and issues effectively to help members adequately adhere to the proper course of learning.
7. *The evaluator*, who comments on the content and process of learning and offers feedback for further improvement as an individual or as a group.
8. *The energiser*, who shows enthusiasm and passion in the group process via facilitation and encouragement and persistently helps the group to reach consensus.
9. *The scribe*, who records the content and process of learning during the discussion. A scribe may also prepare reports or summaries on behalf of the group.

The items about interpersonal skills included:

1. *Encourager*. A member who encourages and appreciates other colleagues' comments or attitudes.
2. *Harmoniser*. A member who intervenes in the conflict or disagreement between other members.
3. *Compromiser*. A member who maintains group harmony.
4. *Gatekeeper*. A member who maintains the balance of opinion expressed among members.
5. *Standard setter*. A member who reminds the other members of the need to meet the goals and follow the rules. This behaviour is usually observed at the feedback stage.
6. *Group observer*. A member who analyses the interactions of the members. This is also observed at the feedback stage.

Two or 1.5 points were added to the score of any student rated "the best" or "second best" respectively in a particular item. Each student's score for a particular item was the sum of the scores given by their peers. The group sum for each item was then calculated, and the ratio of each student score for an item to the group score for that item was calculated to correct for inter-group differences in response (standardisation).

Big Five Personality Factors

Paper-and-pencil measures were included in our study to evaluate the personality variables. The Big Five personality test, a modified form of the MBTI, has been used worldwide for over 10 years in many research fields with satisfactory reliability and validity.²⁹⁻³¹ It includes the following 5 dimensions: I) Extraversion vs introversion. Extraversion means a person is talkative, sociable and assertive. II) Agreeableness vs antagonism. Agreeableness means a person is good-natured, cooperative and trusting. III) Conscientiousness vs undirectedness. Conscientiousness means a person is responsible, orderly and dependable. IV) Neuroticism vs emotional stability. Neuroticism means a person is anxious, prone to depression and worries a lot. When this score was reversed in the following analysis, it was renamed "emotional stability." V) Open to experience vs not open to experience. Openness means a person is imaginative, independent-minded and has the ability to think divergently. A modified 44-item questionnaire was

used and the items were scored on a Likert 5-point scale ranging from 5 (strongly agree) to 1 (strongly disagree). The “negative” trait items were reverse-scored so that high scores indicated more positive traits.

Score Point Average

SPA over the last 4 years at the university was used. The grades (scores) were separated on the basis of content courses (e.g., basic and clinical medical courses) and method courses involving memory (e.g., anatomy), operation (e.g., chemistry laboratory course) and reasoning (e.g., physics). These scores were weighed on the basis of the number of teaching hours, and the average score of the above 3 groups of subjects for every student was calculated for analysis.^{33,34}

Study Design

The study was designed to determine how personality and learning characteristics influence student’s performance.

Analyses and Statistics

Internal consistency reliability was measured in the Big Five personality evaluation. Initially, item-total correlations were obtained, and items yielding negative effects on the alpha values of the total evaluation were excluded. Coefficient alpha was determined by the revised evaluation sheets.³⁵ Test-retest reliability was measured in the PBL performance by peer evaluation. The test-retest interval was 8 weeks in this study.

Content and construct validity of the PBL evaluation sheets were assessed by 5 experts in this field. The effectiveness of each question was assessed and scored from 5 (strongly effective) to 1 (not effective). The content validity and significance level were calculated using the method developed for ordinal data.³⁶ Validity coefficient (Vi) >0.78 was regarded as significant at the 0.05 level for 5 evaluators using a 5-point ordinal scale.

PBL performance (peer evaluation) and SPA were subjected to principal component analysis, and variables were subtracted to identify the mutually independent factors. Naming these factors depended on the original variables and the loading values of the new independent factors after varimax rotation. Factors with eigen value more than 1 would be retained in this analysis.^{37,38}

The mean and standard deviation of scores was determined. The response rate was defined as the ratio of the number of respondents to the total number of members in the group. The purpose of the ratio of the scores used in the peer evaluation, described above, was to minimise differences in response rates between groups.

Simple correlation between the items of the revised

evaluation sheets, between peer evaluations and Big Five personality characteristics or SPA were obtained. Big Five personality factors and SPA were used to predict students’ performance (rated by peers and the tutor). Factors were included or excluded step by step in this analysis. The statistical tests were performed using SPSS 13.0 and Excel for Windows XP.

Results

Descriptive Statistics for PBL Performance (Fig. 1)

Peer-evaluated PBL performance scores were standardised and ranged from 0 to 0.63 (elaborator and compromiser) to 1.00 (information seeker, coordinator, recorder, gatekeeper and standard setter), with the median value ranging from 0.095 to 0.139. Response rates for the 44 groups ranged from 0.75 (recorder) to 0.85 (opinion seeker).

Descriptive Statistics of Big Five Personality Factors (Fig. 2) and SPA (Table 1)

Two hundred and sixty-three students (85.1%) completed the Big Five personality questionnaire. The mean and standard deviation of each item and dimension (before exclusion of items) is listed in Figure 2. Three hundred and one students (97.5%) had SPA information, and the mean value and standard deviation was 77.5 ± 7.2 (range, 60.2-90.7) (Table 1).

Reliability of the Big Five Personality Questionnaire

The Cronbach’s alpha values of the original 44-item, 5-dimension questionnaire ranged from 0.6594 to 0.7662. These values increased from 0.7008 to 0.7662 after deletion of 2 items. The reliability of this questionnaire improved after this deletion, and the revised data could be applied to subsequent correlative study on the students’ PBL performance.

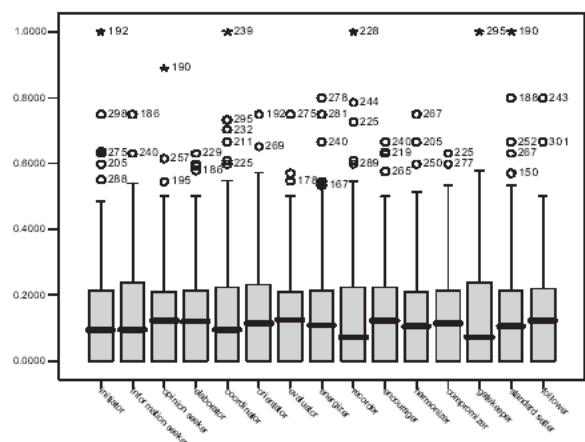


Fig.1. Boxplot distribution (Boxplot) of scores of peer evaluation (n = 309).

Table 1. SPA Data Distribution [n = 301 (97.5%)]

Dimensions	Average score (range)	No. credit hours.	Total score (Σ Score * credit hours) Mean \pm SD
Common/memory	77.4 (56.8-89.7)	9	697 \pm 59
Calculate/reasoning	75.7 (56.5-90.9)	14	1061 \pm 93
Common/operation	84.1 (71.5-90.1)	8	673 \pm 29
Basic/memory	77.9 (58.4-93.6)	53	4128 \pm 446
Basic/operation	81.9 (67.6-88.7)	9	737 \pm 35
Clinical/memory	77.1 (60.2-88.2)	25	1928 \pm 148
Total	77.5 (60.2-90.7)	118	9148 \pm 78

SD: standard deviation; SPA: score point average

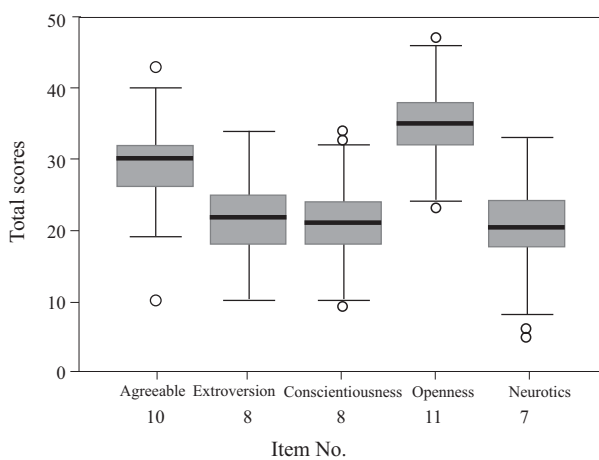


Fig. 2. Descriptive statistics of Big Five personality test (n = 263).

Test-retest Reliability of the PBL Performance Peer Evaluations

One hundred and 21 students effectively completed the test-retest reliability test of PBL performance by peer evaluation. These ranged from 0.4889 (compromiser) to 0.8282 (initiator).

Content Validity of the PBL Performance Evaluation Sheet

The content validity (V_i) of the 15-item PBL performance evaluation sheet (from 5 evaluators) ranged from 0.80 to 0.95 (significantly powerful at the 0.05 level). The mean score of each item (using a Likert 5-point scale) ranged from 4.2 to 4.8, with standard deviation of 0.45 to 0.84.

Factor Analysis of the PBL Performance Peer-evaluation Sheets

Factor analysis identified 4 mutually independent principal factors: assist-coordinate (PC No. 1) with 7 highly correlated items in which the loading values ranged

from 0.439 (information seeker) to 0.758 (coordinator), control-lead (PC No.2) with 5 highly correlated items in which the loading values ranged from 0.578 (elaborator) to 0.762 (opinion seeker), written organisation (PC No.3) with 2 related items named recorder (0.850) and follower (0.491) and compromise-comply (PC No. 4) with only 1 related item (compromiser, loading value 0.829).

Factor Analysis of the SPA

Factor analysis of SPA found only 1 principal component (loading value ranging from 0.163 to 0.214). In Taiwan, most medical schools still use the written test, which mainly assesses the content knowledge of students, to determine the performance of their students. This score may therefore not properly reflect their true abilities in the tested subject. Thus, a variety of abilities, such as operational, reasoning or calculation, which should be emphasised in some experimental or specific basic sciences (such as physics, calculus) courses, cannot be measured through these tests.

Simple and Stepwise Regression Between the Personality/SPA and PBL Performance (Table 2 and 3)

Simple correlation between personality/SPA and peer-evaluated performance (Table 2) showed that “extraversion” and “openness to experience” were positively related to the “assist-coordinate” characteristic in PBL performance, and “conscientiousness” was positively related to the “control/lead” characteristic in PBL performance ($P < 0.05$). The SPA was positively related to “assist-coordinate” and the “control-lead” characteristic in PBL performance ($P < 0.05$). The “agreeableness” was negatively correlated with the “control-lead” characteristic in PBL performance ($P < 0.05$). After stepwise regression between the Big Five and each component of PBL performance, only the correlation between conscientiousness and control/lead and between extraversion and assist/coordinate remained significant (Table 3).

Table 2. Relationship Between Personality/SPA and Peer-evaluated Student Performance (n = 263)

Personality/SPA items	PBL peer evaluation principal components			
	Assist/coordinate	Control/lead	Written organisation	Compromise/Comply
Agreeableness	0.004	-0.145**	0.051	0.100
Openness to experience	0.158*	-0.037	0.030	0.015
Emotional stability/neuroticism	0.092	0.162*	0.045	-0.064
Extraversion	0.132*	-0.040	-0.008	-0.067
Conscientiousness	-0.021	0.048	-0.030	-0.044
SPA principal components	0.161*	0.443*	0.045	0.022

PBL: problem-based learning; SPA: score point average

* $P < 0.05$ on positive correlation ** $P < 0.05$ on negative correlation

Table 3. Stepwise Regression Between Personality and Peer-evaluated Student Performance (n = 263)

Personality items	PBL peer evaluation principal components			
	Assist/coordinate	Control/lead	Written organisation	Compromise/Comply
Agreeableness	-0.013	-0.158**	0.051	0.100
Openness to experience	0.045	-0.096	0.030	0.015
Emotional stability/Neuroticism	0.068	0.076	0.045	-0.064
Extraversion	0.158*	-0.099	-0.008	-0.067
Conscientiousness	0.046	0.162*	-0.030	-0.044

PBL: problem-based learning

* $P < 0.05$ on positive correlation ** $P < 0.05$ on negative correlation

Discussion

Characteristics of the group members, such as their knowledge and personality, will also influence the outcomes of PBL implementation. Schmidt³ has found that students with better prior content knowledge or reasoning skills perform better in PBL. Wilkerson¹⁸ found that students with better attitudes or interpersonal skills, who actively participate in the course and give appropriate feedback, allow for successful PBL implementation. Tutors also play significant roles for the successful implementation of PBL. Tutors have been reported to be more effective when playing guided, probed, or supporting roles rather than directed or governing roles. The length of time (the number of sessions) needed to form good PBL group dynamics varies but usually the group needs some time to get together. Therefore, the group members in PBL would not be changed except if personality clashes or other dysfunctional behaviour emerges.¹⁹

In our study, we modified the role-play in the small group learning found in previous literature²⁵ to design a new evaluation sheet of students' PBL performance in medical school. Although there has been much literature describing the role of students in PBL and other types of small group

learning,^{3,6,19,25,26} there is still no related quantified studies after reviewing previous literature. In our present study, the 15-item evaluation sheet has been verified by 5 specialists in the field of medical education. To test the α -value stability of these evaluation sheets, we have implemented a test-retest reliability evaluation this year, and the preliminary results were satisfactory. We then performed factor analysis on these 15 role-play items to extract 4 mutually independent principal components (PCs). These PCs can be properly named according to their factor components and loading as described in Figure 3. In our later studies, we have collected more samples for similar analysis and noted that the previous classification and nomenclature of these PCs was consistent and reliable. Our results disclose the multidimensional factor structure of PBL performance. We think that this carefully constructed evaluation sheet is not only a tool for conducting an objective and multidimensional assessment but also a means of reminding the members in this course to regulate their roles. The other important benefit of PC analysis is that subtraction and mutually independent variables will make the subsequent comparison between their correlations with many other variables, such as personality or knowledge

characteristics, simpler and more reliable. Furthermore, we found that (not described in this paper) peer evaluation provides more valuable and discriminating information on student performance than our previous literature on tutor evaluation. Tutors, and to a lesser extent peers, in PBL curricula are usually reluctant to give low scores to students and thus tend to give higher, less incriminating scores than necessary.

The other benefit of establishing this PBL performance evaluation is achieving feedback from self and group members. Reviewing previous literature, students in the PBL curriculum can not only learn the concepts of PBL through feedback evaluation using this evaluation sheet after the course, but can also learn more objective evaluation methods in this course.^{5,9,27}

Research has shown a linkage between personality and performance^{8,30} and between knowledge and performance of pre- and post-graduates.^{23,34} Our results described how to modify the personality (Big Five) evaluation sheets and their correlations with PBL performance. In this study, we used the investigated sample for item selection/deletion in the same dimension. We deleted only a very small number of “discordant” items to get better consistent reliability (the higher Cronbach’s alpha value in Table 2). In this study, we also found that some personality characteristics, such as conscientiousness and extraversion, can influence performance. The negative correlation between the agreeableness and control/lead performance in PBL is puzzling, yet may explain how “respect others’ opinion” might be an obstacle in the control of sessions in PBL, and that will need to be recognised as a weaker control/lead performance. Through this and our ongoing studies, we can establish and compare these databases and realise the influences of personality not only in the individual student’s performance of the PBL, but also the group dynamics and their future career development. These results can provide us with guidelines to help the students not only in PBL courses but also in other aspects of their learning in school.

This study had some limitations. The GPA has been widely used as students’ knowledge indicator in previous literature.^{33,34} In this study, we used the SPA to replace the GPA because there were cultural differences between the Asian and Euro-American countries. We realised that there were differences between subjects, while some excelled at reasoning and calculation abilities (such as calculus and physics), others excelled at memory abilities (anatomy), while others still excelled at operational abilities emphasise the ability of operation (experiment or bedside practice). However, since most courses in Asian countries still use the written test as one of the important methods to evaluate students’ performance, the PCs would be difficult to extract

not because of the content of the courses themselves, but rather because of the methods of evaluation. In our school, the curriculum including the methods of evaluation have been undergoing reform. Content knowledge is not the only determinant to evaluate the ability of a student. The ability to search, integration, application and actual operation are also important, and these would replace the former as the main criteria for evaluation. The other limitations of this study are that the number and representativeness of these samples are insufficient. We have now begun a 3-year medical education research project supported by the National Science Council in Taiwan and have prioritised this study as one of the important missions in these few years. We will collaborate with 2 other medical schools in Taiwan and include more medical students into the study.

In this study, we developed a new evaluation sheet for PBL performance. In the future, we should perform related activities. Firstly, compare results between different PBL curricula (focused on basic, clinical or other topics). Secondly, collect more samples from other students taking the same course. Also to collect samples from other medical schools and compare their differences. Lastly, develop methods to evaluate inter-group differences. Group dynamics [such as leaderless group discussion (LGD) dynamics] or demonstrations of individual abilities (such as ability to analyse cases and simulate interviews)¹⁹ should be recorded for evaluation by third-party specialists. We believe that a reliable and valid method of evaluation of PBL as well as predictive models of individual performance or future career success can be developed in the future with the use of personality, knowledge and other variables such as the tutor characteristics. Through these models, group composition can be optimised so as to lead to the most effective group dynamics.

In summary, knowledge and personality characteristics appear to be associated with student performance in a hybrid-PBL curriculum. In this study, “extraversion” and “openness to experience” were positively related to the “assist-coordinate” characteristic in PBL performance, and “conscientiousness” was positively related to the “control-lead” characteristic in PBL performance. The SPA was positively related to the “assist-coordinate” or “control-lead” characteristic in PBL performance. The “agreeableness” was negatively correlated with the “control-lead” characteristic in PBL performance. More related studies should be conducted to verify and explain these phenomena.

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REFERENCES

1. Norman GR, Schmidt HG. The psychological basis of problem-based learning: a review of the evidence. *Acad Med* 1992;67:557-65.
2. Savery JR, Duffy TM. Problem-based learning: an instructional model and its constructivist framework. *Educational Technique* 1995;35:31-5.
3. Schmidt HG. Problem-based learning: rationale and description. *Med Educ* 1983;17:11-6.
4. Johnson DW, Johnson FP. *Joining together: group theory and group skills*. Boston, MA: Allyn & Bacon, 2003.
5. Berkson L. Problem-based learning: have the expectations been met? *Acad Med* 1993;68:S79-S88.
6. Albanese MA, Mitchell S. Problem-based learning: a review of literature on its outcomes and implementation issues. *Acad Med* 1993;68:52-81. Erratum in: *Acad Med* 1993;68:615.
7. Schmidt HG, Dauphinee WD, Patel VL. Comparing the effects of problem-based and conventional curricula in an international sample. *J Med Educ* 1987;62:305-15.
8. Barrows HS. A taxonomy of problem-based learning methods. *Med Educ* 1986;20:481-6.
9. Colliver JA. Effectiveness of problem-based learning curricula: research and theory. *Acad Med* 2000;75:259-66.
10. Fenwick TJ, Parsons J. A critical investigation of the problems with problem-based learning (Research Report No.143). US Department of Education (ERIC Document Reproduction Service No. ED 409 272), 1997.
11. Jaffarey NA. Problem based learning. *J Pak Med Assoc* 2001;51:266-7.
12. Barrows HS. Problem-based learning in medicine and beyond. A brief overview. In: Wilkerson L, Gijsselaers WH, editors. *Bringing Problem-based Learning to Higher Education: Theory and Practice*. San Francisco, CA: Jossey-Bass, 1996.
13. Davis MH, Harden RM. Planning and implementing an undergraduate medical curriculum: the lessons learned. *Med Teach* 2003;25:596-608.
14. General Medical Council. *Tomorrow's Doctors: Recommendations on Undergraduate Medical Education*. London: GMC, 1993.
15. General Medical Council. *Report on Visit to Dundee Medical School*. London: GMC, 2000.
16. Harden RM. Approaches to curriculum planning. *Med Educ* 1986;20:458-66.
17. Harden RM, Davis MH. The continuum of problem-based learning. *Med Teach* 1995;17:125-48.
18. Wilkerson L. Tutors and small groups in problem-based learning: Lessons from the curricula. *Ann Intern Med* 1998;129:734-97.
19. Wood DF. Problem based learning. *BMJ* 2003;326:328-30.
20. Mayes BT, Belloli CA, Riggio RE, Aguirre M. Assessment centers for course evaluations: A demonstration. *J Soc Behav Pers* 1997;12:303-20.
21. Rynes SL, Trank CQ, Lawson AM, Ilies R. Behavioral coursework in business education: Growing evidence at a legitimacy crisis. *Acad Manage Learn Educ* 2003;2:269-83.
22. Smith CM. Using student feedback on examination questions to promote fairness, item validity and learning. *J Clin Pharmacol* 1997;37:379-87.
23. Waldman DA, Korbar T. Student assessment center performance in the prediction of early career success. *Acad Manage Learn Educ* 2004;3:151-67.
24. Williams PB, Lathers CM, Smith CM, Payer A, Volle RL. Evaluation of student achievement and educational outcomes. *J Clin Pharmacol* 2001;41:1259-70.
25. Benne KD, Sheats P. "Functional roles of group members". *J Soc Issues* 1948;2:42-7.
26. Luh SP. The creation of small group teaching and the roles of its members [Chinese]. *J Med Educ* 1999;3:416-8.
27. Barrows HS, Tamblyn RM. *Problem-based Learning: An Approach to Medical Education*. New York: Springer, 1980.
28. Neufeld VR, Barrows HS. The "McMaster Philosophy": An approach to medical education. *Med Educ* 1974;49:1040-50.
29. Hogan R, Johnson J, Briggs S. *Handbook of Personality Psychology*. New York: Academic Press, 1999.
30. Hough LM. The millennium for personality psychology: New horizons or good old daze. *Applied Psychol Int Rev* 1997;47:233-61.
31. Howard PJ, Howard JM. The Big-Five Quickstart – An introduction to the five factor model of personality; 1995. Available at: <http://www.centacs.com/quickstart.htm>. Accessed 2007.
32. Neufeld VR, Woodward CA, MacLeod SM. The McMaster MD program: a case study of renewal in medical education. *Acad Med* 1989;64:423-32.
33. Bartels LK, Bommer WH, Rubin RS. Student performance: Assessment centers versus traditional classroom evaluation techniques. *J Educ Business* 2000;75:198-201.
34. Cohen PA. College grades and adult achievement: A research synthesis. *Res High Educ* 1983;20:281-3.
35. Cronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika* 1951;16:297-334.
36. Guion R. "Content validity" in moderation. *Pers Psychol* 1978;31:205-14.
37. Kalaian HA, Mullan PB. Exploratory factor analysis of students' ratings of a problem-based learning curriculum. *Acad Med* 1996;71:390-2.
38. Kao MY, Lee YJ, Lue BH. Assessment of the group learning factor scale used in small-group tutorial mode [Chinese]. *J Med Educ* 1997;1:397-410.