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Development and Validation of an Inventory that Measures Motivated Behavior in Chemistry

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Abstract
The purpose of this study was to develop an inventory that measures students' motivation toward chemistry (MBIC). In total, 127 students from Technological University of the Philippines were asked to respond to the inventory. Principal component analysis with varimax rotation yielded four factors namely, choice behavior, persistent behavior, study approaches and strategies and resilient behavior. The factor loadings of the items ranged from 0.426 to 0.718, 0.513 to 0.820, 0.457 to 0.718, and 0.441 to 0.621, respectively. The Cronbach alpha for the entire inventory was 0.90; for each scale, alpha ranged from 0.74 to 0.84. High motivators and low motivators showed a significant difference ($p < 0.01$) on their MBIC scores. Correlations between the students' motivation in chemistry measured using MBIC and students' achievement in chemistry, cheating behavior and students' motivation in English are moderate to weak but they are all statistically significant. Findings of the study confirmed the validity and reliability of the MBIC questionnaire. Implications for using the MBIC in research and in class are discussed in the paper.
Keywords: Principal component analysis, varimax rotation, cronbach's alpha, Chemistry achievement, English Motivation, Cheating Behavior, Motivated Behavior Inventory

1. Introduction

Usually, if teachers are asked what is the most important student characteristic associated with successful studies, they mention traits such as motivation (Dalgety et al.,2003). According to teachers, students' motivation plays an important role in their conceptual change processes (Lee 1989, Lee and Brophy 1996, Pintrich et al. 1993), critical thinking, learning strategies (Garcia and Pintrich 1992, Kuyper et al. 2000, Wolters 1999) and science learning achievement (Napier and Riley 1985). Thus, this trait (Covington, 2000) has been investigated by many educational researchers.

Many motivation questionnaires like the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich et al. 1991) and the Multidimensional Motivation Instrument (Uguroglu et al. 1981) were used during their investigations, but these questionnaires only assesses college students' motivational orientation and learning strategies and focused only to contextual factors influencing students' motivation like students' own interests toward the subjects and the grades they received in class; students' interpretations of the nature of the task; students' success or failure to make progress in scientific understanding; and students' general goal and affective orientations in science class and achievement of scientific understanding (Lee 1989, Nolen and Haladyna 1989, Pintrich and Blumenfeld 1985, Urdan and Maehr 1995). Hence, it is important to develop a questionnaire that will measure motivated behaviors that can be used as indicators of motivation.

Pintrich (1994) model for student motivation indicated that to measure student motivated behavior, one must assess student choice behavior, persistent behavior, study approaches and strategies and resilient behavior. Choice behavior means looking chemistry as thrilling and interesting subjects and not as fear-provoking subjects. Persistent behavior means maintaining effort in face of difficulty, boring tasks and even when fatigued. In study approaches and strategies, students do variety of techniques to do well in class. Resilient behavior means students' ability to deal effectively with academic setbacks, stress, and study pressure or the ability to succeed and prosper even after hardship.

1.1 The development of the Motivated Behavior Inventory in Chemistry (MBIC)

The initial inventory was created and intended to represent the four construct on Pintrinch (1994) model for student motivation namely choice behavior, persistent behavior, study approaches and strategies and resilient behavior. Items for each scale were developed by obtaining opinions from some college students of how they can show their motivation in chemistry class and by using some relevant motivation questionnaires — such as the MSLQ (Pintrich et al. 1991), the Patterns of Adaptive Learning Survey (Midgley et al. 1993) and the Multidimensional Motivational Instrument (Uguroglu, Schiller and Walberg, 1981).

A single judgment format using single unit interval range from 1 to 4 was employed with a scale 1- strongly disagree, 2- disagree, 3-agree and 4-strongly disagree. These were equivalent to very large, large, small and very small motivation in chemistry.

The initial inventory was reviewed by five experts to validate its' content, grammatical correctness, organization, readability and clarity. Experts were also asked to suggest modifications for the individual items (e.g., reword, revise, grammatical corrections and asked to share any additional items and to rate each proposed item's relevance on the four constructs using a content validity index (CVI). The CVI is a three point ordinal scale: 1=not relevant, 2= relevant, but needing minor alteration and 3 = very relevant. The item weighted content validity index, mean rating and written comments from the experts were used to make decisions about whether to eliminate, revise, or retain items. For content validity index, agreement was established by the application of the standard error of the proportion; for example, on a ten-item rater, if the total number of 2 or 3 ratings is equal to 8, then the CVI = 8/10; therefore, I-CVI = 0.80. Items with a weighted CVI score of greater than 0.70 were considered valid items. Items that attained CVI below 0.70 were deleted. In addition, repeating items that were identical or differed in only a word or two were eliminated from the list. Mean rating were used to determine which valid items need revision. Items with a mean rating of less than 1.50 were revised. Items were revised if suggestions appeared to be congruent with the purpose of the instrument, did not change the meaning, or did not weaken the item when placed in the Likert scale format (DeVellis, 2003).

After expert validation, it was pilot tested to eighty three students taking up Bachelor of Applied Science in Laboratory Technology (BASLT) and Bachelor of Science in Environmental Science (BSES) at Technological University of the Philippines. Their answers were became the basis of establishing the construct validity and internal consistency of the items. In analyzing, principal component analysis, with varimax raw rotation as the method of extraction was selected. Sample adequacy was assessed by examining the Kaiser-Meyer- Olkin (KMO) and Barlett's Test of Sphericity. Also, Cronbach's alpha of each factor was determined to determine the internal consistency or average correlation of items in each factor.

KMO correlations of 0.60-0.70 and Barlett's Test of Sphericity with level of significance of less than 0.05 are considered adequate to move forward with principal component analysis which is a technique for data reduction used to uncover the underlying factor structure of a relatively large set of variables. This explores the data and provides researchers with information about how many factors are needed to best represent the data. The items that were retained have a factor loading of 0.40. Items that failed to load on at least one factor at greater than 0.39 and with multiple high factor loadings with the factor were deleted. For cronbach's alpha, values with marked substantial internal consistency of 0.60 and above were retained.

For establishing other validity, the final inventory were administered again to 45 students of BASLT, 38 students of BSES and 44 students taking up Technology- Graphic Arts and Printing Technology (GAPT) and Apparel and Fashion Technology (AFT). It was hypothesized that if the inventory was concurrent valid, differences would be found among group means. In addition, these students were asked to answer Science Motivation Questionnaire II, English Motivation Questionnaire and Cheating Behavior Questionnaire. Pearson r correlations between students' motivation measured using MBIC and SMQ II were used to establish convergent validity, Pearson r correlations between students' motivation measured using MBIC and students achievement and cheating behavior were computed to establish predictive validity. Pearson r correlations between students' motivation in chemistry measured using MBIC and students' motivation in English were used to establish discriminative validity.

Results
Messick (1989) identified six types of validity that need to be addressed in developing an inventory. These were content validity, construct validity, predictive validity, concurrent validity, convergent validity and discriminative validity. For content validity, five experienced chemistry teachers, reviewed the items. From sixty items only fifty items were accepted, thirty items were considered relevant and twenty items were relevant but needs minor alterations. Intraclass Correlation revealed that the average scores of the five experts are highly reliable with interval of .778-.991 at 95% confidence.

Before PCA analysis, the factorability of the correlation matrix was evaluated. Kaiser–Meyer–Olkin Measure of Sampling Adequacy was 0.60, indicating that the factor structure was appropriate for the data. The Bartlett Test of Sphericity was 2295.560 ($P < 0.001$), allowing rejection of the hypothesis that the correlation matrix is an identity matrix and indicating an appropriate factor structure. The analysis, performed for the answers to the 50 items of the pilot questionnaire, produced a nine-factor solution, but some factors contain few items and some items did not have enough substantial factor loadings on any of the factors, thus were deleted. These resulted to inclusion of only four factors with totality of 28 items. The factor loadings for the 28 remaining items are presented in table 1.

Table 1. Factor loading of items in the MBIC (n = 83)

Item #	Statements	Factor 1	Factor 2	Factor 3	Factor 4
Factor 1: Choice Behavior					
8	It makes me nervous to think about chemistry problem solving and experiments.	.426			
10	I am afraid to enter on my chemistry class.	.462			
12	I appreciate all chemistry tasks given to me.	.486			
17	I am thrilled to take more chemistry subjects.	.493			
24	I don't want to attend on my chemistry class.	.674			
25	I am always interested and curious to the lesson discussed by my teacher.	.456			
26	I am always late on my chemistry class.	.570			
32	I always think of ending my chemistry activity.	.718			
Factor 2: Persistent Behavior					
27	I prefer to listen to the answer of my classmates than to express my own ideas.		.513		
28	I do not collaborate with my group mates if we have a chemistry tasks.		.618		
30	I become not persistent when encountering new tasks in chemistry.		.650		
31	I give up easily in face of difficult topics in chemistry.		.820		
35	When chemistry activities are too difficult, I give up or only do the easy parts.		.766		
36	I skip chemistry lesson when it is difficult.		.749		
38	To perform laboratory experiments with real samples is too time consuming and complicated to be worth the effort.		.531		
Factor 3: Study Approaches and Strategies					
14	I answer questions in our chemistry book even if my teacher does not require it to do so.			.457	
37	When learning new chemistry concepts, I attempt to understand them.			.479	
40	I am willing to participate in this chemistry class because I know it can satisfy my curiosity.			.513	
41	I always give my own conclusions, inferences or speculations after we make analysis in chemistry class.			.718	
42	I do own chemistry activities to experience or gain knowledge through active involvement.			.685	
44	When studying chemistry, I try to determine which concepts I don't understand well.			.666	
45	I do all that I can to make my chemistry assignments turn out perfectly.			.604	
46	I passed paperwork such as seatwork and homework in chemistry on time.			.612	
Factor 4: Resilient Behavior					
6	I always try to improve my previous work in chemistry even though it is not graded.				.444
7	I am willing to understand difficult topics chemistry.				.441
15	When I do not understand a chemistry concept, I discuss it my teacher or other students to clarify my understanding.				.621
33	When new chemistry concepts that I have learned conflict with my previous understanding, I try to understand why.				.559
34	When I meet chemistry concepts that I do not understand, I still try to learn them.				.625

The results presented in table 1 indicate that four factors constitute the construct of the motivated behavior inventory in chemistry, and these factors confirmed the four construct designed. Factor 1, 2, 3, and 4 obtained factor loadings ranging from 0.426 to 0.718, 0.513 to 0.820, 0.457 to 0.718, and 0.441 to 0.621, respectively.

Before testing the predictive, concurrent, convergent and discriminative validity of the motivated behavior inventory in chemistry, reliability analyses were carried out. The reliability of four constructs was assessed using cronbach's alpha, which represents the degree of replicability of a construct based on its measured indicator variables. Results are shown in table 2.

Table 2. Internal consistency (Cronbach alpha coefficient) of MBIC

Factor	Item number	Mean	Variance	Cronbach's Alpha
Choice Behavior	8	3.20	0.16	0.74
Persistent Behavior	7	3.20	0.03	0.84
Study Approaches and Strategies	8	3.22	0.09	0.84
Resilient Behavior	5	3.39	0.02	0.71
Overall (MBIC)	28	3.25	0.07	0.90

When each factor were analyzed using Cronbach's alpha where the exact coefficients were calculated with the correlations between each item and the remaining items, reliability coefficient for each scale, using an individual student as the unit of analysis, ranged between 0.74 and 0.90. The values are indicative of good internal consistency.

After having tested the construct validity and reliability of the MBIC, other validity including convergent validity or the degree to which the operationalization is similar to (converges on) other operationalizations that it theoretically should be similar to was assessed. Based on the data, students' motivation measured using the Motivated Behavior Inventory in Chemistry has significant correlation ($r=0.82$, $p>0.01$) with the students motivation in chemistry using Chemistry Motivation Questionnaire (SMQ) developed by Glynn (2011). The ability of the inventory to correlate this was measured using Pearson Correlation.

Similarly, the ability of the inventory to differentiate between classes is important. Students within a class usually have different motivation from students in other classes. The ability of the inventory to differentiate this aspect was measured using analysis of variance with class membership as the main effect. (Tuan, 2005) The results in table 3 show that each factor in the MBIC differentiated significantly between classes ($p < 0.01$).

Table 3. One-way analysis of variance of high-motivation (BASLT), moderate-motivation (BSES) and low motivation (BT) students' responses on the MBC inventory.

	Choice Behavior	Persistent Behavior	Study Approaches and Strategies	Resilient Behavior	MBIC
High Motivation (BASLT) n=45	3.28/0.40	3.21/0.52	3.26/0.41	3.42/0.42	3.28/0.36
Moderate Motivation (BSES) n=38	3.02/0.27	3.05/0.33	2.99/0.32	3.13/0.34	3.04/0.25
Low Motivation (BT)	2.96/0.34	3.01/0.41	2.93/0.32	3.09/0.50	2.98/0.31
F	10.28	23.62	10.64	7.56	10.81
LSD	AB,AC	AB,AC	AB,AC	AB,AC	AB, AC

Notes. Data presented as mean/standard deviation. (A-BASLT) high motivation; (B- BSES) moderate motivation; (C-BT), low motivation.

Students with high motivation showed a significant difference to moderate and low motivation students in the choice behavior value, persistent behavior, study approaches and strategies and resilient behavior ($p < 0.01$).

Similarly, instruments' predictive validity and discriminative validity was assessed by computing Pearson's correlation coefficient for each construct and students' achievement in chemistry, cheating behavior and students' motivation in English. The results of the correlation analyses are displayed in Table 4.

Table 4. Pearson correlation analyses of Students' Motivation measured using MBIC with chemistry achievement, English motivation and cheating behavior

	Choice Behavior	Persistent Behavior	Study Approaches and Strategies	Resilient Behavior	MBIC
Science Achievement	0.43**	0.27**	0.40**	0.40**	0.45**
English Motivation	0.082**	0.10**	0.27**	0.063**	0.16**
Cheating Behavior	-0.30**	-0.35**	-0.35**	-0.34**	-0.40**

The results revealed that although correlations between the MBIC constructs and students' achievement in chemistry, cheating behavior and students' motivation in English are moderate to weak they are all statistically significant. For science achievement and cheating behavior, choice behavior has the highest correlation (r = 0.43, r= -0.30) while persistent behavior has the least correlation (r = 0.27, r= -0.35).
Discussion, Conclusion and Implication

Investigating the validity and the reliability of the Motivated Behavior Inventory in Chemistry revealed that choice of behavior, persistent behavior, study approaches and strategies and resilient behavior serve as indicator of motivation. It has four good factors contributing to better construct validity; it also exhibits predictive validity because it can determine students' achievement and cheating behavior, concurrent validity because it has an ability to distinguish between groups, convergent validity because it functions similar with Science Motivation Questionnaire (SMQ) and discriminative validity because results diverge with students' motivation in English.

Students' motivation had moderate and significant correlation (r = 0.45) with their chemistry achievement. Studies in science education (Zusho, Pintrinch& Coppalo 2003; Granville& Dika, 2002) revealed that motivation to learn positively affects students' performance in science, as motivation to learn has an effect on student achievement. Geban and Dindar (2010), showed that students' chemistry grade was significantly correlated with some factors that affect motivation, and as a whole there is a small-medium, positive correlation between the chemistry grade and degree of motivation. Tuan (2005) during his validation of students' motivation towards science learning, scales like self efficacy, active learning strategies, science learning value, performance goal, achievement goal, learning environment stimulation have significant correlation with science achievement (r = 0.46 , p < 0.01). Napier and Riley (1985) also reported that motivation has correlation (r = 0.26) with science achievement. In this study, the questionnaire has almost equal correlation (r=0.43) with science achievement with Tuan (2005). Among motivation factors, choice behavior has the highest correlation with students' chemistry achievement (r=0.43) while persistent behavior has the lowest correlation with the students' chemistry achievement (r=0.27). With the result, it is not questionable why chemistry achievement is often used as indirect evidence of students' motivation (Pintrich and Schunk 1996). Students with active learning strategies, good choice, persistent and resilient behavior are likely to learn more effectively and gain better score on the tests than those who do not have these characteristics.

Cheating behavior had negative correlations (r= -0.30 to -0.40) with the student mean score in motivated behavior inventory in chemistry and to its four constructs. The results were similar with the study of Olenrewaju (2010); findings revealed that academic cheating behavior index has significant negative relationships with achievement motivation, Pearson correlations ranges from -0.09 to -0.39. Thus, this suggests that students who are high on motivation are less likely to cheat in their academic work, have an urge to accomplish goals and act towards attaining goals with the hope of succeeding (Kumar and Stoody, 1995) and with good choice, persistent and resilient behavior, and with active learning strategies as what the motivated behavior inventory measured.

Students' motivation in English measured using established English Motivation Questionnaire had weak but significant correlation (r=0.063 to 0.27) with students' motivation in chemistry measured using MBIC. The results were similar to the study of Rotgans and Schmidt (2012), which showed that effort regulation, elaboration, organization/study strategies, self-efficacy/ persistence had low and significant correlation at 0.01 level of significance to English motivation (r=.13, r=.11,r= .08), respectively. It was also similar with the study of Ngamkhan (1986) and Tolentino (2000). Using the descriptive correlation method with documentary technique, the study revealed that students had satisfactory motivation in English and fairly satisfactory in Science. There were existed significant, low, positive relationships between the students' motivation in English and Science. Thus, this result suggests that MBIC exhibits discriminative validity since it's' construct is different from the construct of English Motivation Questionnaire. The degree to which its' operationalization is not similar to the operationalizations of English Motivation Questionnaire that is why the results is not highly correlated.

As expected, there is significant difference among the scores of BASLT (High Motivation), BSES (Moderate Motivation) and GAPT and AFT (Low Motivation), this can be attributed to the nature of the students. Students taking up BASLT have specialty focused in chemistry. They are trained to be chemists, quality control specialists, laboratory technicians and thus, have highly intrinsic motivation to learn chemistry. BSES students are with specialty in environmental impacts; even though chemistry is needed in the course but not as much as with BASLT. GAPT and AFT are vocational courses, and for students taking up these courses, chemistry is not a major subject. This result suggests that MBIC exhibits concurrent validity as it has an ability to distinguish between groups.

Considering the practical implications of the findings, the MBIC can be considered as an alternative inventory to existing motivation questionnaires — such as the MSLQ and the Multidimensional Motivational Instrument in measuring student motivation. The advantage of using MBIC maybe is its four construct that focused only to choice behavior, persistent behavior, resilient behavior and study approaches and strategies. This is only few compared to other motivational questionnaires that have large number of construct. This difference may provide detailed information about students' motivation.

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