A Model of Approaches to Learning and Academic Achievement of Students from an Inquiry Based Bachelor of Health Sciences Program

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ABSTRACT

The Biggs' Study Process Questionnaire (SPQ) was used to test competing models of students' approaches to learning in a sample of undergraduate students (n = 125) from an inquiry based Bachelor of Health Sciences program. In addition to an internal consistency and test-retest reliability analysis of the SPQ, confirmatory factor analysis was used to evaluate the goodness-of-fit of two competing models of approaches to learning with students' GPA. The results provided support for a three-factor model of approaches to learning (CFI = 1.00, SRMR = .052, RMSEA = .000) and the connection between GPA and an achieving approach to learning (path coefficient = .99). A three-factor model of the SPQ that recognizes the strong relationship between students' GPA, achieving motives and strategies for learning warrants further investigation. Other factors such as faculty expectations, heavy workloads and time commitments may influence the adoption of less desirable approaches to learning.

RÉSUMÉ

Nous avons utilisé le Study Process Questionnaire (SPQ) de Bigg pour tester des modèles sur l'approche à l'apprentissage qui sont en concurrence, chez un échantillon d'étudiants sous-gradués (n=125) inscrits dans un Baccalauréat en Sciences de la Santé. Nous avons fait

une analyse d'uniformité interne et de fiabilité de test-retest du SPQ, ainsi qu'une analyse de facteur de confirmation, pour évaluer l'exactitude des modèles en concurrence. Le modèle le plus précis incluait trois facteurs dans l'approche à l'apprentissage (CFI = 1.00, SRMR = .052, RMSEA = .000) et nous avons également observé une relation entre la moyenne des notes et le désir de réussite (path coefficient = .99). Le modèle du SPQ qui inclut trois facteurs et qui reconnaît la forte relation entre la moyenne des notes des étudiants et leur motivation et stratégies pour réussir, mérite une investigation plus profonde.

INTRODUCTION

Since the early 1970s the study of students' approaches to learning in post-secondary education has been based on the idea that students have either intrinsic or extrinsic motives for learning. In particular, Marton and Säljö (1976) investigated student learning from a qualitative perspective. They established the surface (reproduction of content) and deep (intentional comprehension) level processing terminology associated with measurements of students' approaches to learning. Current research into the longitudinal study of approaches to learning indicates that students use both surface and deep motives and strategies. A third approach to learning, termed "achieving" or "strategic," was introduced with the development of Biggs' (1987) Study Process Questionnaire (SPQ) and Entwistle and Ramsden's (1983) Approaches to Studying Inventory. In particular, the SPQ utilizes three general approaches to learning: surface, deep, and achieving (Table 1).

Table 1. Biggs' approaches to learning motives and strategies.

Approach	Motive	Strategy
Surface (SA)	Surface motive (SM) - to meet requirements minimally; a balancing act between failing and working more than is necessary.	Surface strategy (SS) - to limit target to bare essentials and reproduce them through rote learning.
Achieving (AA)	Achieving motive (AM) - to enhance ego and self-esteem through competition; to obtain highest grades, whether or not material is interesting.	Achieving strategy (AS) - to organize one's time and working space; to follow up on all suggested readings, schedule time, behave as 'model student'.
Deep (DA)	Deep motive (DM) – an intrinsic interest in what is being learned; to develop competence in particular academic subjects.	Deep strategy (DS) - to discover meaning by reading widely, inter-relating with previous relevant knowledge, etc.

As described by Richardson (1994) in a review of students' approaches to learning, both qualitative and quantitative studies tend to support the two broad surface-deep approaches to learning orientations. In the context of learning, however, there are defined motives and corresponding strategies that reflect the students' cognitive and strategic approaches to completing the task (Evans et al., 2003; Newble & Clarke, 1986). The SPQ subscales are based on the process factors that determine the students' motives and corresponding strategies for institutional learning (Biggs, 1979, 1987). In particular, the SPQ subscales were developed to measure three general orientations that combine motives and strategies to reflect what is considered to be a relatively stable approach to learning (Burnett & Dart, 2000; Donnon & Violato, 2003). While surface and deep strategy subscales measure how students cognitively engage in the tasks of learning course material, the achieving subscale assesses how the tasks are to be completed within temporal and spatial contexts. Therefore, overlaps occur between the deep-achieving (i.e., meaning derived by reading widely in an organized and systematic manner), and surface-achieving (i.e., rote learning in an organized and systematic manner) approaches to learning (Biggs, 1987, 1993).

The achievement of students in post-secondary education has been found to be dependent largely on the approach taken to the task of learning within any particular course or program of study (Entwistle et al., 2001; Vermetten et al., 2001). As explained by Haggis (2003), the outcomes of learning are linked to students' conceptions of learning, their perceptions of the learning environment, and to their approaches towards learning. Subsequently, the general assumption about students' approaches to learning has been that a deep approach will be associated positively with learning performance outcomes, such as academic achievement. The relationship between students' approaches to learning as measured by the SPQ and grade point average (GPA), however, has been inconsistent. For example, Watkins and Hattie (1981) found that among four faculties of first year students and across all Student Approaches to Learning (SAL) motives and strategies subscales on the SPQ, only the science students showed a significant correlation between surface motives and their GPA ($r = -.39$, $p < .05$) and strategies ($r = -.40$, $p < .05$). In another study of first year students from Hong Kong, Jones and Jones (1996) also found no significant relationship between any of the SPQ subscales and students' academic performance measures. In a more recent three-year longitudinal study, Zeegers (2001) found a consistently positive correlation between students' deep and achieving approaches to learning, and a corresponding negative correlation between surface approach to learning and students' GPA. In particular, only the deep approach to learning showed significant correlations with GPA, as measured at the end of the students' first year ($r = .22$, $p < .05$; $n = 122$), the end of their second year ($r = .42$, $p < .01$; $n = 60$), and at the end of their third year ($r = .41$, $p < .01$; $n = 52$). Contextual factors such as characteristics of individual students, their fields of study and alternative teaching strategies have been shown to influence whether students adopt a surface, deep, or achieving approach to learning

(Biggs & Kirby, 1984; Newble & Entwistle, 1986; Ramsden & Entwistle, 1981; Zeegers, 2001).

The Bachelor of Health Sciences Program

The Bachelor of Health Sciences program in the Faculty of Medicine at the University of Calgary was created to emphasize the undergraduate students' research experience and inquiry based learning. It consists of three majors, namely, Biomedical Sciences, Bioinformatics, and Health and Society. Although initial enrolment expectations were 25 students per major, the Biomedical Sciences specialization attracted the interest of most students in the program. Candidates applying to the program are selected on the basis of their academic achievement (high school matriculation percentage) and performance indicators that include participation in student council, leadership in sports, community involvement, and written responses to three short essay questions (Hecker & Violato, 2006). The program strives to be multi-disciplinary, utilizing research faculty from across disciplines. The curricular structure consists of pre-existing introductory courses and newly created courses designed to introduce students to health science research. The foundations of the program include 1) a series of inquiry courses, one per semester for the first three years, in which students from each of the majors are brought together to learn about different aspects of health and how to conduct health science research; 2) a mentorship program where students interact with faculty to discuss and study health sciences research; and 3) the provision of summer research opportunities to all students. All of the components of the program aim to prepare students for their final year research project.

An underlying assumption of the inquiry based learning approach is that students become actively engaged in their learning process and thus take on a more deep approach to learning. As undergraduates, they are challenged to solve "authentic" research questions and develop comprehensive knowledge structures in an information-rich setting. The honours degree offered through the Bachelor of Health Sciences program is based on the philosophy of inquiry-based learning, with the mission of providing health sciences education that is based on research and scholastic inquiry through scheduled small group inquiry courses (Kenny, 1998). Based on the assumption that learners construct their own solutions, it is expected that exposure and guidance to research provided by mentoring practitioners in the field would promote a more effective and rewarding learning experience. In order to study this assumption, we implemented a longitudinal study to identify students' approaches to learning and investigate whether these particular motives and strategies change over the course of an academic year and whether they lead to a corresponding relationship in academic performance.

Since Biggs' three approaches to learning were introduced, recent research has focused on the inconsistencies associated with the constructs used to measure the learner's motives and strategies for learning using the SPQ. Kember and

Leung (1998) tested different models using confirmatory factor analysis and suggested that a two-factor model based on surface and deep approaches to learning provided the best fit for the SPQ. Although this theoretical shift emphasizes the predominance of the surface-deep dichotomy, it ignores the original intent of the 42-item questionnaire's attempts to delineate the influence that an achieving approach to learning has on students' motives and strategies for learning in a formal setting. In particular, Donnon and Violato (2003) found that an alternative model, based on the original three-factor model, reflects a representation that recognizes the connection between surface-achieving and deep-achieving overlaps in students' approaches to learning. The three prevailing model structures for the SPQ are the three-factor model proposed by Biggs (1987, 1993), the two latent variable surface-deep model purported by Kember and Leung (1998) and the alternative three-factor model reported by Donnon and Violato (2003). Of these three models, however, none have been tested with respect to corresponding academic achievement by students. The present study tests the fit of these competing hypothesized models of students' approaches to learning using SPQ data collected from junior (first and second year) students in an undergraduate health sciences program. In addition, we investigate the internal consistency and correlations of the SPQ subscales scores with GPA, conduct a test-retest of the SPQ over an academic year, and subsequently, re-examine two goodness-of-fit models at Time 2 that include students' end of year GPA to explore the relationship between approaches to learning and academic achievement.

METHOD

Participants

A total of 125 out of 132 first (61; 49% of total students) and second year (64; 51% of total students) undergraduate students from the Bachelor of Health Sciences program at the University of Calgary participated in the present study. The sample consisted of 79 females (63%) and 46 males (37%) enrolled in one of three areas of program specialization: 1) Biomedical Sciences (89; 71% of total students); 2) Bioinformatics (20; 16% of total students); and 3) Health and Society (16; 13% of total students). The mean age for the entire sample was 18.5 years (SD = 2.1, Median = 18.0; first year – M = 17.6, SD = 0.69; second year – M = 19.4, SD = 2.54). The 109 students who participated in the SPQ retest administration six months later reflected a similar percent of females (70; 64%) and males (39; 36%) and distribution by year of program (first year – 54; 50% and second year – 55; 50%).

Study Process Questionnaire

All participants completed the original 42-item version of the SPQ (see Biggs, 1987). The questionnaire consists of six subscales with seven positively worded items on a 5-point Likert scale, where a score of 5 means "always or almost always true of me" and 1 means "never or only rarely true of me." The

subscales are identified as surface strategies, surface motives, deep strategies, deep motives, achieving strategies, and achieving motives. They are summed to score a value for a corresponding surface, deep or achieving approach to learning orientation respectively.

Procedures

The SPQ was administered to participants at the beginning of the academic school year (Time 1; September, 2004) during an information session held for all of the first and second year students registered in the undergraduate Health Sciences program. Information about the purpose of the study and the test-retest collection of the data was completed by the first author who was unknown to the students. Students were also informed that although they needed to provide a signed consent form to participate in this study, their involvement was voluntary and would have no academic implications. Most students (125; 95%) provided a written consent to participate in the study. In total, 109 (87%) of the students completed the retest administration of the SPQ approximately six months later (Time 2; March, 2005). The retest took place during a regular class time period where attrition was believed to be primarily the result of student absence. The present study was approved by the Conjoint Health Research Ethics Board of the University of Calgary.

Confirmatory Factor Analysis

One of the major applications of confirmatory factor analysis is in the generation of a goodness-of-fit or fit indices assessment of a hypothesized model to quantitatively derived data. The application of confirmatory factor analysis begins with the specification of a theoretical model – in this case, the three models shown in Figure 1 – followed by the evaluation of the fit indices and interpretation of parameter estimations (Bentler, 1995). Although the sample sizes used for the analysis of the structural models are $n = 125$ at Time 1 and $n = 109$ at Time 2, they fall in the "medium" sample size range of 100 to 200 subjects based on the complexity associated with each of the three models tested (Klein, 2005). In an analysis of sample size and goodness-of-fit in models with latent variables, Tanaka (1987) found that model estimates, standard errors of the estimates, and the model fit statistics in samples of size 100 for confirmatory two-factor, six-variable models were appropriate for non-normal and normal data, if other fit indexes are reported. The two most common approaches of assessing model fit are those that involve the chi-square (χ^2) goodness-of-fit and fit indices analyses. In particular, when $N \leq 250$ the recommended combinational rules for fit indices in structural models include Bentler's Comparative Fit Index (CFI) in combination with the maximum likelihood (ML)-based standardized root mean squared residual (SRMR) and the root mean squared error of approximation (RMSEA) as they tend not to reject more simple and complex true-population models under nonrobust conditions (Hu & Bentler, 1999).

RESULTS

Students' Approaches to Learning (Time 1 vs. Time 2)

In a comparison of the three approaches to learning at the beginning of the academic year at Time 1 (n = 109), students self-reported a preference for both deep (M = 48.5, SD = 8.0) and achieving (M = 49.1, SD = 7.4) approaches to learning (Table 2). Correspondingly, students were less inclined to adopt a surface approach to learning (M = 46.2, SD = 7.1). In particular, at Time 1, the achieving (M = 25.5, SD = 4.2) and deep (M = 24.4, SD = 4.6) motives subscales scored the highest while the surface strategies subscale (M = 22.1, SD = 3.8) scored the lowest. In paired sample t tests at Time 1, the surface approach to learning scored significantly lower than either the deep, $t(124)$ = -2.73, $p < .01$ (d = .40), or achieving, $t(124)$ = -4.23, $p < .001$ (d = .44), approaches to learning. Therefore, both the achieving and deep approaches to learning were equally important in terms of the prevailing student motives and strategies measured at the start of the academic year. It should be noted that no significant differences were found between any of the motives, strategies, or approaches to learning scores obtained from the initial 125 students and those 109 students took part in the retest at Time 2.

At Time 2, statistically significant test-retest differences were reported in the students' approaches to learning preferences and in all motives and strategy subscales, except for students' achieving motives. As indicated in the paired sample t tests (Time 1 – Time 2; n = 109), students indicated an increased surface orientation, $t(108)$ = 3.10, $p < .01$, and less deep, $t(108)$ = -2.76, $p < .01$, and achieving , $t(108)$ = -6.85, $p < .001$, orientations in their approaches to learning. As shown in Table 2, the effect size differences from Time 1 to Time 2 are considered to be "small" for changes in students' deep (d = -.22), surface (d = .26), and achieving (d = -.46) approaches to learning (see Cohen, 1988). Correspondingly, with this shift towards a surface approach to learning, a small (d = -.26) and significant decrease was found in the students' academic performance based on their GPA from Time 1 to 2, $t(108)$ = -4.91, $p < .001$. At Time 2, the surface approach to learning scored higher by the students than the deep, but it was only significantly higher in comparison with the achieving approach to learning, $t(108)$ = 3.31, $p < .001$ (d = .33). In separate analyses, no significant gender (male vs. female) or year of study (1st vs. 2nd year students) differences were found in students' motives, strategies, or approaches to learning.

Internal and Test–Retest Reliability of SPQ

The internal reliability (Cronbach's alpha) of the total SPQ was .82 at Time 1 (n = 125) and .86 at Time 2 (n = 109). At Time 1, internal reliability coefficients for each of the six motives and strategies and three approaches to learning subscales ranged from α = .62 for surface motives to α = .86 for the deep approach to learning (Table 2). The test-retest correlation coefficients for the motives and

Table 2. Subscale internal reliability coefficients, means (standard deviations), test-retest correlations, *t*-tests scores and effect size differences for the SPQ motives, strategies, and approaches to learning scores for junior (1st and 2nd year) BHSc students

	Reliability Cronbach's alpha (α)	Time 1 (0 mth) M (SD) (n = 125)	Time 1 (0 mth) M (SD) (n = 109)	Time 2 (6 mths) M (SD) (n = 109)	Correlation r (T1,T2) (n = 109)	t-test† (T1,T2) (2-tailed)	Effect Size (T1,T2) (Cohen's d)
Surface							
Motives	.62	23.9 (4.3)	24.1 (4.3)	25.1 (4.3)	.62***	2.78**	.23
Strategies	.63	21.9 (3.8)	22.1 (3.8)	23.1 (3.9)	.50***	2.55*	.26
Approach	.76	45.6 (7.1)	46.2 (7.1)	48.1 (7.3)	.59***	3.10**	.26
Deep							
Motives	.75	24.4 (4.5)	24.4 (4.6)	23.3 (5.0)	.63***	-2.55*	-.23
Strategies	.81	24.1 (4.4)	24.1 (4.3)	23.4 (4.6)	.66***	-2.16*	-.16
Approach	.86	48.6 (8.0)	48.5 (8.0)	46.7 (8.7)	.68***	-2.76**	-.22
Achieving							
Motives	.72	25.2 (4.2)	25.5 (4.2)	24.9 (4.4)	.71***	-1.78	-.14
Strategies	.81	23.6 (5.0)	23.6 (5.1)	20.6 (5.8)	.70***	-7.50***	-.55
Approach	.80	48.8 (7.4)	49.1 (7.4)	45.5 (8.3)	.76***	-6.85***	-.46
GPA		3.56 (.33)	3.57 (.33)	3.48 (.34)	.83***	-4.91***	-.26

*p <.05, **p <.01, ***p <.001. †Note: The paired samples *t*-test compares Time 1 and Time 2 scores for (n = 109)

strategies subscales ranged between $r = .50$ to $.71$, $p < .001$, and were moderately low to high overall for the surface ($r = .59$), deep ($r = .68$) and achieving ($r = .76$) approaches to learning. In Table 3, a correlation matrix shows the relationships between students' approaches to learning and GPA at Time 1 and Time 2. The GPA for Time 1 was based either on the students' final high school grades or, in the case of second year students, on their overall first year undergraduate GPA, as measured two to four months earlier respectively. Time 2 GPA was derived from the students' final undergraduate year end performance, as measured a month later at the end of April, 2005. Although there is a large correlation between students' GPA scores at Time 1 and Time 2, $r = .83$, $p < .01$, students' approaches to learning were found to have little or no apparent relationship to students' academic performance. In particular, at Time 1 a small negative correlation was found between students' surface approach to learning and their GPA ($r = -.20$, $p < .05$). At Time 2, a small positive correlation was found between an achieving approach to learning and GPA ($r = .23$, $p < .05$).

Testing Model Fit

Table 3. Correlations between students' BHSc Program admission GPA, year end undergraduate GPA, and approaches to learning scores (i.e., surface, deep and achieving)

	T1 GPA	T1-SA	T1-DA	T1-AA	T2 GPA	T2-SA	T2-DA
Time 1 (Sept/04)							
T1 GPA							
Surface (T1-SA)	-.04						
Deep (T1-DA)	.09	-.12					
Achieving (T1-AA)	.06	.44**	.40**				
Time 2 (April/05)							
T2 GPA	.83**	.04	.12	.23*			
Surface (T2-SA)	-.20*	.59**	-.02	.40**	-.16		
Deep (T2-DA)	.05	-.13	.68**	.29**	.05	-.08	
Achieving (T2-AA)	.10	.31**	.33**	.76**	.23*	.45**	.39**

$n=109$. *$p <.05$, **$p <.01$ (2 tailed).

Time 1 (n = 125). The three hypothesized models were tested using the ML goodness-of-fit parameter estimates provided in the EQS software program (Bentler, 1995). Accordingly, the covariance matrix was derived from the sample data at Time 1 on the subscales of the SPQ (i.e., SM – surface motive, DM – deep motive, AM – achieving motive, SS – surface strategy, DS – deep strategy, AS – achieving strategy). The aim of this initial three model goodness-of-fit analysis is to determine whether the hypothesized models reflect the responses obtained from a cohort of undergraduate students in the evaluation of a small but unique inquiry focused undergraduate Health Sciences program.

In particular, these a priori theoretical models were tested at Time 1 to establish which of the models, if any, would allow for a re-examination of the results at the end of the academic year approximately six months later (Time 2). Due to potential inconsistencies related to students' GPA scores obtained from their respective high school transcripts at Time 1, the GPA variable was not used in this initial model fit analysis.

The two- and three-latent factor models tested are shown in Figure 1 with their respective parameter estimates and fit index values for CFI, SRMR, and RMSEA. In Model 1 the original three-factor theoretical structure of the SPQ is maintained with the acknowledgment of the covariance that exists between the achieving and deep (Biggs, 1987), and achieving and surface (Biggs, 1993) approaches to learning. In this model, the cut-off score values are achieved for the CFI at .96 and are close to the criteria set for SRMR at .093 and RMSEA at .089. As stipulated by Hu and Bentler (1999), a cut-off value for CFI of .96 in combination with SRMR < .09 and RMSEA < .06 results in the least sum of Type I and Type II error rates.

For Model 2, the fit indices summary results (CFI = .99, SRMR = .087 and RMSEA = .046) indicate a good fit of an alternative three-factor latent model to the data (Donnon & Violato, 2003). There is a modest improvement in the CFI with an increase of 2.8% over the preceding three-factor data analysis shown in Model 1. This result also supports Biggs' three-factor model structure for the SPQ. As shown in Figure 1, the factor loadings are small for the achieving approach to learning latent factor (AA) with observed variables achieving motives (AM) = .23 and achieving strategies (AS) = .20; $p < .05$. Notwithstanding, AM and AS are also observed variable indicators for both surface (path coefficients equal to .48 and .36, respectively) and deep (path coefficients equal to .26 and .53, respectively) approaches to learning latent factors.

In Model 3, a dichotomous deep-surface approach to learning model is presented in which the AM and AS variables align on both of the two latent factors. Although this model deviates from the intent of the original three factor model, the fit indices summary results for the CFI at .99, SRMR at .074 and RMSEA at .047 indicate a comparatively good fit with that of Model 2. As indicated by the small to moderate path coefficients in both Models 2 and 3, the AS variable is related more to a deep approach to learning (.53 and .55 respectively), accounting for about 29% of the variance, than to the AM variable (.26 and .29, respectively) which accounts for less than 8% of the variance. Models 2 and 3 also support an association of the AM variable with the surface approach to learning (both equal to .48) accounting for 23% of the variance than the AS variable (both equal to .36) which accounts for about 13% of the variance.

Time 2 (n = 109). The two competing hypothesized models, represented in Model 2 and Model 3, were re-tested using the SPQ at the end of the academic year with 109 of the original group of 125 students. The students' corresponding end of academic year GPA was included as an additional observed variable in each of the two models. The aim was to determine the potential influence SAL

Model 1 x^2 (7,125) = 13.84, CFI = 0.96, SRMR = .093, RMSEA = .089
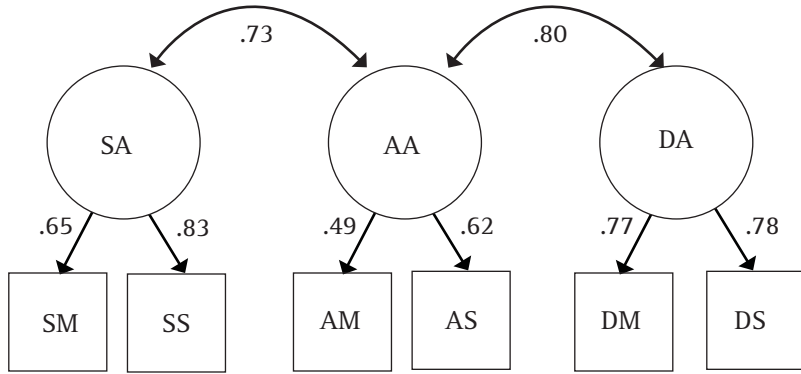
Model 2 x^2 (9,125) = 11.37, CFI = 0.99, SRMR = .087, RMSEA = .046
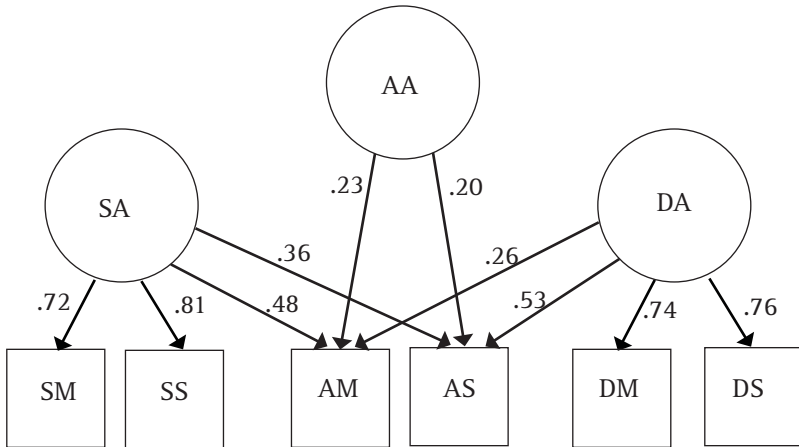
Model 3 x^2 (7,125) = 8.94, CFI = 0.99, SRMR = .074, RMSEA = .047
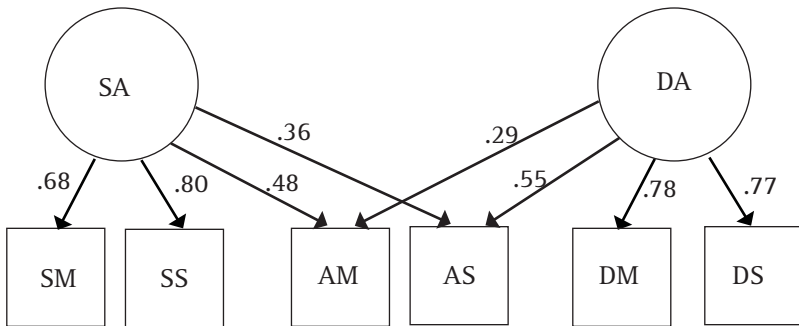
Figure 1. Three structural models of the Study Process Questionnaire (SPQ) at Time 1 (n = 125)

Note: SM = Surface Motive, DM = Deep Motive, AM = Achieving Motive, SS = Surface Strategy, DS = Deep Strategy, AS = Achieving Strategy, SA = Surface Approach, DA = Deep Approach, AA = Achieving Approach

latent variables had on academic achievement. As shown in Figure 2, both the two- and three-latent factor models achieved parameter estimates and fit index values for CFI = 1.00, RMSEA = .000 and SRMR = 0.052-0.58, respectively.

Comparatively, the factor loadings are small in relationship to students' surface (SA) and deep (DA) approaches to learning latent variables and their corresponding end of year GPA. In comparing the changes in Models 2 and 3 from Time 1 to 2, there appears to be little change in the coefficients derived for students' deep approach to learning (DA). Alternatively, there is a corresponding increase in students' emphasis on surface motives (SM) and achieving strategies (AS) in deriving their surface approach to learning (SA) at Time 2. In addition, the achieving motives (AM) and strategies (AS) coefficients are modestly reduced at Time 2 for the achieving approach to learning (AA) latent variable.

As indicated by the path coefficients in both Models 2 and 3, students' GPA is modestly related to a deep approach to learning (.15 and .18, respectively) accounting for about 3% of the variance while the surface approach to learning (.06 and .11, respectively) accounts for 1% or less of the variance. Model 2, however, supports a strong relationship between students' achieving (AA) approach to learning and their GPA variable with a path coefficient of 0.99 which accounts for 98% of the variance. Although both models are supported through confirmatory factor analysis, Model 2 assists in explaining the connection between students' approaches to learning and their corresponding GPA.

DISCUSSION

The main findings of the present study are that 1) the SPQ subscales have moderate to high internal reliability coefficients; 2) students' approaches to learning shifted from a deep-achieving to a surface approach to learning at the end of the academic year; 3) there was a strong relationship between students' achieving approach to learning and year end GPA; and 4) a three-factor model of students' approaches to learning with a surface-achieving and deep-achieving covariance offered the most coherent theoretical model.

The internal reliability coefficients for the SPQ subscales ranged from moderate to high, but were consistent with the findings of Hattie and Watkins (1981), O'Neil and Child (1984) and Biggs (1987). Although the SPQ as a self-report measure is based strictly upon student perceptions, the internal reliability coefficients obtained for the SPQ subscales would warrant further research into the overall efficacy of this instrument in the measure of students' approaches to learning. In particular, the reliability coefficients derived for both the surface motives ($\alpha = 0.62$) and strategies ($\alpha = 0.63$) were below the minimum 0.80 alpha value expected for norm referenced or standardized measures.

In the test-retest reliability analysis we found a moderate stability of students' approaches to learning over the six month period. Demonstrating the dynamic and malleable changes that can occur, however, the students in the Bachelor of Health Science program changed their predominantly deep ($d = -.22$) and achieving ($d = -.46$) approaches to learning orientation at the begin-

Model 2 x^2 (8,109) = 7.15, CFI = 1.00, SRMR = .052, RMSEA = .000
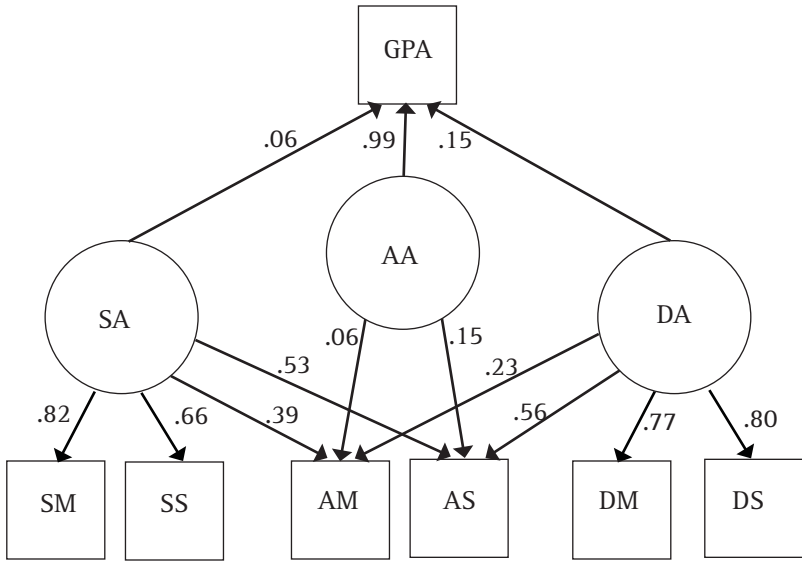
Model 3 x^2 (11,109) = 10.50, CFI = 1.00, SRMR = .058, RMSEA = .000
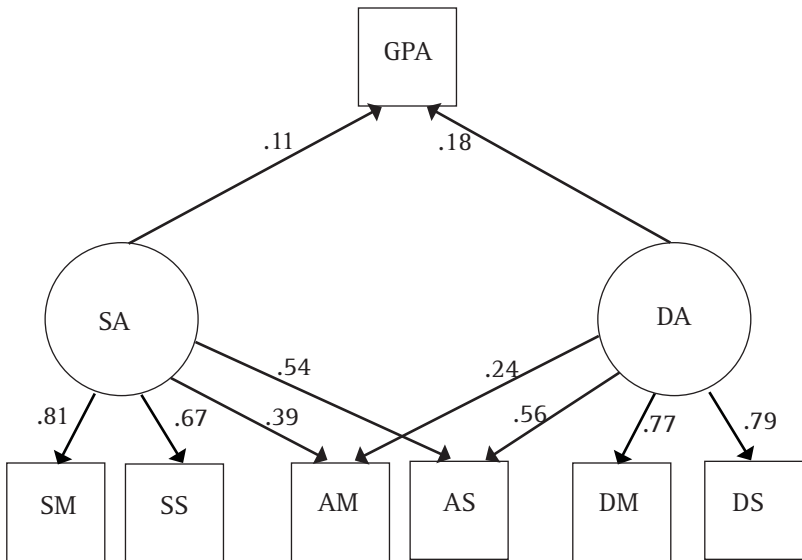

Figure 2. Model 2 and Model 3 SPQ comparison with students' end of year GPA at Time 2 (n = 109)

ning to a more surface ($d = .26$) approach to learning by the end of the academic year. Although these effect size differences are considered to be small to medium, the shift from a less deep and more surface approach to learning reflects concerns about whether the inquiry program does indeed provide opportunities that enhance students' motives and strategies, leading to presumably more meaningful and lasting learning experiences. This may represent a limitation of the present study as the sample was restricted to first and second year students in the Biomedical Sciences, Bioinformatics, and Health and Society specializations. In a table of norms established by Biggs (1987) for university undergraduate students, however, science majors were reported as being more surface and achieving oriented than those students studying in the arts (Donnon, 2002; Volet et al., 1994; Zeegers, 2001). Notwithstanding, over a longer period of time, there is an expectation that students' motives and strategies may change as they become academically more sophisticated (Biggs, 1987; Donnon & Violato, 2003; Zeegers, 2001).

Although the inquiry based BHSc program's mandate is to promote a learning environment that is student-centred and focused on a deep and integrated understanding of the content, the results of the present study indicate that the students moved towards a surface approach with a corresponding decrease in their deep and achieving approaches over the course of the academic year. This implies that existing course requirements are not necessarily supportive of a learning environment that is conducive of deep motives and strategies advocated by the inquiry based BHSc program. In particular, the may reflect an artefact of the program's reward system that ultimately relies on achievement measures that motivates students to become focused on obtaining the highest grades possible. Hence, there is a need to conduct future studies on the basis of representative samples longitudinally to further explore students' approaches to learning as influenced both by teaching, learning and assessment contexts.

In the present study, the confirmatory factor analysis cut-off criteria used to evaluate structural model fit indices for the three models and the subsequent two models re-tested showed support for a three-factor model of the SPQ. In particular, there is support for the original theoretical structure of the SPQ in Model 2 and the covariance that exists between deep-achieving and surface-achieving approaches to learning. There was, however, a strong relationship between students' achieving approach to learning and corresponding GPA at Time 2. As depicted in Model 2, the SPQ is represented by a three-factor students' approach to learning model with factor loadings connecting students' GPA to each of the surface, deep and achieving approaches to learning latent variables.

As shown by the path coefficients, the relationship between the students' GPA and approaches to learning can be delineated by an achieving approach to learning latent variable. With the exception of a small correlation between students' deep approach to learning and GPA, there is support for a model that explores the relationship between achieving motives and strategies in the pursuit of academic achievement. The usefulness of using GPA to quantify students'

academic performance is based largely on the premise that students in the BHSc program have had the identical course schedules and, hence, will have received equal exposure to the course material by the same set of instructors. The limitation of this approach, however, is that achievement criteria are not standardized (e.g., MCQ exams, laboratory assignments, written papers) across a number of different courses in any one particular academic year, hence preventing the derivation of a common measure or proxy of students' learning achievement.

As the original SPQ dimensions were based on the measure of six specific motives and strategies subscales that corresponded to three different approaches to learning, Model 2 is theoretically the most coherent model. The limited number of students enrolled within any one particular year of the BHSc program, however, has restricted our ability to study distinct cohorts of first and second year students. While connected by their mutual involvement in the program, the resulting paired-comparisons reflect a combined interrelated cohort of students in the junior years of an undergraduate program and are not necessarily an accurate depiction of either the first or second year students' approaches to learning in isolation. The small sample size and general characteristics of the students admitted to the BHSc program have potential implications for why motivations and strategies are skewed towards a model that emphasizes the predominant connection between GPA and the achieving approach to learning latent variable. Although the six variable models tested fell just within an acceptable sample size range for a confirmatory factor analysis, a limitation of this study is the size of the groups tested and the potential effect this has on parameter estimation.

Not unexpectedly, the motives and strategies for achieving have been found to be strongly connected to academic performance as measured by GPA. As indicated above, the Bachelor of Health Science students are known for both their academic performance and their achieving abilities in other extracurricular, social, and leadership interests. Notwithstanding, the process of learning appears to be context specific. It reflects many potential interactions between students' perceptions and the teaching and assessment demands placed on them. As explained by Biggs et al. (2001), the meaning of students' approaches to learning in a class provides an index of the quality of the teaching that is contextually based where a student who normally rote memorizes course content finds that this strategy does not work with assignments like the development of a portfolio. Subsequently, the student realises that a deep approach to learning is required to complete the task at hand.

The results of the present study have been shared with course coordinators and senior administration in the Faculty of Medicine. Faculty members teaching these courses have since been encouraged and assisted by the program administration to implement learning opportunities (small group work, guided inquiry of projects applicable to the area of study) and consistent assessment methods (written assignments and reports) in support of the inquiry based mandate of the BHSc program. This is being monitored through a program led

outcomes assessment plan that will provide information about student performance, engagement in research, and volunteer activities during and after the program and faculty teaching assessment, both formative and summative, for all courses.

Although the SPQ subscales were shown to have moderate to high internal reliability, there appears to be a significant shift from a deep and achieving to a surface approach to learning over the course of a single academic year. Nevertheless, there appears to be a strong relationship between students' achieving approach to learning and their academic achievement in their courses. Much of the teaching in the sciences in the first two years is didactic, focusing on the transmission of facts and symbolic content. Bachelor of Health Science students may be adapting their approaches to learning in response to the teaching and assessment expectations in the courses or the program as a whole. As such, there is a potential concern that the inquiry based approach to the curriculum may need to be re-evaluated to ensure that authentic opportunities for students to engage in deep learning are better articulated and outlined explicitly in the future. In particular, as the students progress through the third and final year of this inquiry based program, continued efforts need to be invested in clarifying how other factors, such as faculty expectations, heavy workloads and time commitments, may influence the adoption of less desirable approaches to learning.✤

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