RESEARCH

Predictors of Examination and Objective Structured Clinical Examination Performance in a Flipped Classroom Curriculum

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Objective. Students, educators, and administrators have a vested interest in understanding the factors that predict academic performance. To inform this, the authors examined the effects of student demographics, baseline factors (language assessment and situational judgement test scores), prior performance (high school admission rank), course engagement, and student time management of pre-class online activities on student performance in course examinations and objective structured clinical examination (OSCE) problem solving and communication scales.
Methods. Study participants were one cohort of pharmacy students enrolled in a five-year combined Bachelors and Masters of Pharmacy degree program at Monash University Faculty of Pharmacy and Pharmaceutical Sciences. Data were collected from course, learning management system, and institutional databases. Data were analyzed for univariate, bivariate, and multivariate associations (four linear regression models) between explanatory factors and outcome variables.
Results. The dataset included three years of data on 159 pharmacy students from one institution. Statistically significant positive predictors of OSCE communication performance included domestic (ie, Australian) student designation, higher baseline written English proficiency, and pre-class online activity completion. Positive predictors of OSCE problem solving included workshop attendance and low empathy as measured by a baseline situational judgment test (SJT). Positive predictors of year two end-of-course examinations included the Australian Tertiary Academic Rank, completing pre-class online activities prior to lectures, high integrity as measured by a SJT, and the pre-class online activity completion.
Conclusion. Several explanatory factors predicted student examination and OSCE performance in the regression models. Future research should continue to study additional contexts, explanatory factors, and outcome variables.
Keywords: OSCE, flipped classroom, blended learning

INTRODUCTION

Health professions education curricula are shifting focus from knowledge acquisition to knowledge application and skill development.[1] The methods by which we teach future pharmacists are also changing. As a part of this wider movement, educational leaders are studying both what we teach and how we teach it. Dialogue about what we teach is centered on 21st century skills development; those skills related to the emerging competencies contemporary healthcare workers worldwide need in order to contribute to better outcomes for people with chronic conditions.[2] Discourse about how we teach includes adaptations of what is known as flipped classrooms; a type of blended learning technique "which proposes that students engage with pre-class activities that prepare them for in-class active learning."[3]

There is a lack of education research that investigates which student factors predict success within flipped classrooms and skill development curricula.[4] In particular, much of the research on flipped classrooms focuses on the effectiveness of these models or elements of these models.[4] As instruction increasingly requires more self-direction and self-regulated learning,[4] student factors may become more important. Pharmacy students, educators, and workplace leaders have a vested interest in understanding the student factors that may improve academic performance.

The purpose of the study was to examine the extent to which student demographics, baseline factors (eg, English proficiency, situational judgment test scores),[5] course engagement, and time management of pre-class online activities predicted performance on Objective Structured Clinical Examination (OSCE) communication, OSCE problem solving, and year two examination grades. This study is an examination of the extent to which these student factors predicted academic success in one cohort enrolled in a pharmacy degree program. Since the degree program emphasized 21st century skills and every didactic course in the degree program followed the same flipped classroom model, this study was situated in a contemporary educational context.

The literature is replete with studies investigating potential predictors of standardized test scores; Pharmacy Curriculum Outcomes Assessment (PCOA) test scores,[6,7] pre-North American Pharmacist Licensure Examination (NAPLEX) test scores,[8] and NAPLEX test scores.[9] For predicting OSCE performance, there has been limited work in pharmacy education[10] and health professions education.[11,12] For OSCE and examination outcomes, researchers have investigated the predictive value of demographics, pre-admission prior performance, academic performance, and other types of factors. However, to our knowledge, no researchers have explored the relationship between pharmacy student academic outcomes and baseline English proficiency, situational judgment tests, course engagement, and time management of pre-class online activities. Therefore, we set out to comprehensively investigate what predicts pharmacy student OSCE and examination performance.

METHODS

In Australia, students must complete a bachelor of pharmacy degree, a year-long internship placement, and pass two registration examinations to become eligible for registration as pharmacists. Students in this study were enrolled in a five-year combined Bachelors and Masters degree program at the Monash Faculty of Pharmacy and Pharmaceutical Sciences.

A fundamental underpinning of the degree program was an evidence-based curriculum-wide flipped classroom approach.[13, 14] A topic cycle followed a Discover, Explore, Apply, and Reflect model, termed "DEAR." Every course followed the same flipped classroom DEAR model. For each content topic (lasting one week), students were provided with pre-class online activities (called "Discoveries"). Each week of the semester consisted of a day that had no on-campus instruction to give students time to complete the pre-class online activities (termed a Discovery Day). These days were termed Discovery Day. The day after each Discovery day, students had a day of interactive lectures where no new content was provided. Instead, educators clarified content from the "Discoveries" and engaged students in patient or medicine-focused problem-based learning activities. Lectures were followed by two days of "Apply" workshops. Each course had a two-hour workshop scheduled during these two days. In "Apply" workshops, students engaged in small-group learning to further their professional, clinical, and technical skills. Each workshop has 25-30 students to facilitator. The workshop activities depended on the course, but generally included patient cases, role plays, and group discussions. The day after workshops, students attended close-the-loop lectures to reflect on their grasp of the material for each topic, as well as on their skill development ("Reflect").

Another crucial aspect of the degree program was professional skill development through Skills Coaching. Students (typically groups of ten) met with a skills coach (an academic or practitioner) at least three times a semester. Prior to the meeting, students document in their e-portfolio a reflection and plan for developing a specific professional skill including communication, teamwork, empathy, integrity, inquiry, and problem-solving. They then received feedback from their skills coach via the same e-portfolio.

In this study, we utilized data from one pharmacy student cohort that commenced in 2017. For the majority of explanatory factors and outcome variables, cohort data from the first and second year (2017 and 2018) of their program was included. We also included third year (2019) results from one outcome variable; OSCE results. The cohort commencing in 2017 started with 200 students. Then, 39 students withdrew from the degree program and were not included in this analysis. In this Australian context, this withdrawl rate was a typical rate since students begin the degree after high school and may decide early to switch into alternative majors. Of the 161 students enrolled in this cohort in 2019, two students opted-out of the research study. Therefore, our final sample included 159 participants (99% of the cohort). The dataset for this study included the following categories of explanatory factors: 1) demographic and baseline factors; 2) course engagement factors; 3) student time management of the pre-class online activity factors, and the 4) outcome variables. In the following sections, we further elaborate on each category.

Demographic factors included student date of birth, gender, and domestic (ie, Australian) or international designation. Student date of birth was used to calculate a cohort average age and then distinguish those students who were at least two years older than the cohort average age. Baseline factors included student scores on the Australian Tertiary Admission Rank (ATAR), Diagnostic English Language Assessment (DELA) writing test, and situational judgment tests (SJT). The ATAR is a rank from 0 to 100 based on domestic students' year 12 high school grades. The DELA writing test is a 45-minute written assessment that asks students to write an argumentative piece in support or against a provided statement. Based on how the DELA raters deem the grammar, organization, logical reasoning, language use, and other factors, the students are either deemed proficient (score of 3), borderline (score of 2), or at risk (score of 1).[15] Lastly, the SJT was a 90 minute test developed specifically for pharmacy students involving scenarios and scoring guided by performance from practicing pharmacists.[5] The SJT development and testing for validity and reliability has been previously reported.[5] The students take the test within 90 minutes. The test had the following four scales: 1) teamwork, 2) integrity, 3) empathy, and 4) critical thinking and problem solving. The students received a score of either one (low), two (medium), or three (high) for each scale. Both the DELA and SJT were undertaken by students in the first few weeks of the program.

The students took five different courses in the first year of their program and another seven during their second year. Lecture attendance was quantified as percentage of sesssions students attended from a sample of 131 randomly selected lectures, representing approximately 73% of all lectures in two years. The data were collected both electronically and manually. For classes that used an audience response system, the data were collected from that system. For other classes, an administrative assistant would attend randomly selected lectures and record student attendance. At least three attendance data points were collected for each course.

Workshop attendance was measured as a percentage of attendance for all 176 workshops over two years. Attendance was recorded in Moodle®, our institutional learning management system (LMS). We measured Skills Coaching participation as a composite of the two following required course activities: in-person attendance at 16 small group Skills Coaching sessions and completion of 16 personal learning plans uploaded to an electronic portfolio system.

Pre-class online activity completion was measured by the percent completion of the activities over the two years. This factor was measured by log data from our LMS. Pre-class online activities consisted of readings, figures, videos, links to websites, and discussion forums and concluded with a multiple-choice quiz to assess learning. The completion of the online quizzes served as a proxy measure for whether students completed the pre-class online activities. Completion of pre-class online activities was measured across all 245 pre-class online quizzes over two years. The students were expected to complete the pre-class activities before each in-class lecture, but completion was not incentivized with course credit.

In addition to measuring whether students completed the pre-class online activities at any time, we created three factors based on the timing and frequency of when students completed the pre-class online activities. These factors were calculated from LMS trace data from five randomly selected pre-class online activities in their second year of the program. The first factor we labeled Prepared. A student was classified as Prepared if they completed the pre-class online activities for at least four out of the five randomly selected pre-class online activities before the time of the related lecture. The second factor, Catching-up included students who took an average of 10 days or more after the lecture time to complete the pre-class online activities.

The third factor, Revisiting, was created to capture students who used the study strategy of self-testing.[16] Students were classified as Revisiting if they completed the randomly selected five discoveries an average of 1.5 times or greater. Students classifed as Revisiting could also be classified as either Prepared or Catching-up.

Two of the outcome variables included students' performance on Objective Structured Clinical Examination (OSCE) including average grades for OSCE communication and OSCE problem solving. OSCE-related outcome variables were a composite of all OSCE grades across the three years. Students in the degree program completed an OSCE at the end of year one, the end of year two, and at mid-point in year three. OSCE-related outcome variables were a composite of all OSCE grades across the three years. The OSCEs included two stations in year one, four stations in year two, and four stations in year three. Over the three years of OSCEs, the breadth of topics was extensive. Year one OSCE included community pharmacy topics (eg, tinea, headache, gastro-esophageal reflux disease). Year two OSCE included hospital pharmacy topics (eg, medication history taking, blood pressure, evidence-based practice). Year three OSCE included several therapeutics topics (eg, anemia, infectious diseases, pain).

OSCE communication grades were determined by an examiner that followed a rubric with criteria for oral communication. OSCE problem solving was determined by an examiner using case specific criteria (eg, did they recommend an appropriate treatment). The Monash pharmacy program has included OSCEs for about a decade, investing substantial time in developing and sharing our overarching framework and robust training materials for assessors.[17] OSCE assessors complete an online training program that involves reviewing and assessing video examples. They complete oral communication checklists and then compare their answers to a standard. All assessors re-train in face-to-face sessions by reviewing video cases together prior to each OSCE session. OSCE sessions are video recorded. Videos of all failed stations and any irregularities are reviewed by at least two additional academics, the simulation lead and the course coordinator.

The third outcome variable was the average end-of-course examination grades for year two. This was calculated by averaging student end-of-course examination grades in the seven year two courses. The end-of-course examinations included mutiple-choice and open-ended questions that comprised approximately 40-50% of their class grade.

We examined the effects of the explanatory factors on three outcome variables. Prior to building the linear regression models, univariate and bivariate aspects of the data were examined. There were no missing data points. We evaluated all variables for violations of normality, linearity, collinearity, and homoscedasticity. Univariate analyses included means, standard deviations, proportions, and ranges.

For the bivariate analyses between the explanatory factors and the outcome variables, t-tests, analysis of variance with contrasts, and Pearson correlation coefficients were calculated. Correlations between the explanatory factors were tested using Phi correlation coefficients, Spearman's rho, and Pearson's correlations coefficient and reported on a scale of -1 to 1.[18] If the correlation coefficient was above .50, the interaction was considered large, and if it was above .70, the interaction was considered collinear.[19] Multicollinearity was further investigated during regression diagnostics using the variance inflation factor. For continuous variable explanatory factors, a linear regression was also calculated between the explanatory factor and each outcome variable.

For the multivariate analyses, we computed three multiple linear regression models with the following outcome variables: OSCE communication performance, OSCE problem solving performance, and year two examination performance. Since 45 students did not have an available metric for prior performance from high school (ie, ATAR score), separate regressions were run with and without the explanatory factor of prior high school performance. The regression models only included explanatory factors that were statistically significant with the outcome variable in bivariate analyses at the $\alpha<0.2$ level. All variables were entered into the models as fixed effects. Statistical significance was established at $\alpha=0.05$.

All analyses were conducted in STATA version 16 (StataCorp, College Station, TX). The study was approved by the Monash University Human Research Ethics Committee.

RESULTS

The overall sample included 159 pharmacy students. Continuous data are presented as mean ± standard deviation (SD). Most commonly, students were female (71.1%), Australian (68.5%), and were 18.5 years old (SD 1.4, range 16-27 years old) at commencement of the program. Tables 1 and 2 summarize averages and variation for each outcome variable and explanatory factor.

We calculated additional descriptive statistics for factors related to student management of pre-class online activity factors. For this data set, 51.6% of the students were classified as Prepared, 21.4% were Catching-up, and 27% were in between Prepared and Catching-up. In other words, 27% of students often completed their pre-class online activities after lectures but within 10 days. Students classified as Prepared completed their pre-class online activities an average of 3.1 days before the lecture start times (SD=2.9), whereas Catching-up students completed them an average of 16.1 days after lecture (SD=6.5). Of the students classified as Prepared, 34% also used Revisiting, whereas 44.2% of the Catching-up students used Revisiting.

The majority of correlations between independent variables was small with the exception of three different relationships. As expected by definition of these variables, Catching-up and Prepared had a large negative association (Cramer's V = -0.54). Workshop attendance rate and skills coaching attendance rate had a large positive association (Pearson's correlation coefficient = 0.533). Estimated average lecture attendance rate and workshop attendance rate had a collinear positive association (Pearson's correlation coefficient = 0.736). To account for these large associations, we did not exclude any variables from the regression, but calculated the variance inflation factor for each model as a check for multi-collinearity. No multi-collinearity existed for any regression model. The remaining correlations between independent variables were less than 0.5.

We calculated bivariate associations between explanatory factors and outcome variables. All explanatory factors that had a bivariate association with the outcome variables (*p* value of 0.2 or less) were included in the multivariate models. Tables 1 and 2 summarize the associations between the explanatory factors and the three outcome variables.

Model one was the result of a multiple linear regression for OSCE communication. Model one accounted for 16.5% of three years of OSCE communication grade variation (Table 3, $p<.001$). In this model, international student designation (β=-0.03, p=.006) and an incoming DELA score of one (ie, "at risk") (β=-0.05, p=.004) were significant negative predictors of OSCE communication grades. Therefore, controlling other variables, international student designation explained 3% less on OSCE communication scores. A DELA of one, controlling other variables, explained 5% less on OSCE communication scores compared to a DELA of two or three. Pre-class online activity completion was a positive predictor of OSCE communication grades (β=0.10, p=.04). Thus, the model predicts a 10% difference in OSCE communication scores between students who completed 0% of pre-class online activities compared to those students who completed 100% of pre-class online activities. Other included explanatory factors were not statistically significant.

Model two was the result of a multiple linear regression for OSCE problem solving. Model two accounted for 12.2% of three years of grade variation OSCE problem solving (Table 3, $p<.001$). In this model, OSCE problem solving grade variation, controlling for other variables, was positively predicted by an incoming SJT empathy scale score of one (ie, low empathy) (β=0.07, p=.02) and workshop attendance (β=0.62, p=.004). Thus, controlling other variables, a SJT empathy score of one explained 7% of OSCE problem solving scores compared to a SJT empathy score of two or three. The workshop attendance, in particular, had a large beta coefficient of 0.62 (p=.004). The model predicts a 62% difference in OSCE problem solving scores between theoretical students with a workshop attendance of 0% versus 100%. In Model 2, all other included explanatory factors were not statistically significant.

Model three was the result of a multiple linear regression for year two examination grades, but excluding ATAR scores as they were not available for every student. Model three accounted for 37.9% of year two course examination grade variation (Table 3, $p<.001$). Because ATAR scores were not available for most of the international students (28.9%), a separate model with run without (ie, Model 3) and with ATAR scores (ie, Model 4). In Model 3, year two examination grade variations were positively predicted by Prepared (β=0.03, *p*=.01) and the pre-class online activity completion (β=0.11, *p*=.007). Thus, Prepared students, controlling for other variables, explained 3% of year two examination scores compared to students who were not Prepared. The model predicts a 11% difference in year two examination scores between students who completed 0% of pre-class online activities compared to those students who completed 100% of pre-class online activities. An incoming SJT integrity scale score of one (ie, low integrity) (β=-0.03, *p*=.04) negatively predicted year two examination grades. A SJT integrity score of one, controlling other variables, explained 3% less on year two examination scores compared to a SJT integrity score of 2 or 3. In Model 3, all other included explanatory factors were not statistically significant.

Model four was the result of a multiple linear regression for year two examination grades including ATAR scores. Model 4 included all the explanatory factors in Model 3 and the addition of incoming ATAR scores, omitting the students without an ATAR score. Model 4 accounted for 31.5% of year two course grade variation (Table 4, *p* <.001). In Model 4, incoming ATAR score was the only explanatory factor with a statistically significant association with year two examination grades (β=0.003, *p*=.004). Thus, the model predicts a 0.3% difference in year two examination scores between theoretical students with an ATAR of 0 versus 100.

DISCUSSION

Alternative sets of factors predicted qualitatively different outcomes**.** The factors that predicted OSCE performance were not the same as the factors that predicted performance on course examinations. The ATAR was predictive of examination scores but not OSCE scores. Course engagement factors were positively associated with higher performance, but attendance at applied workshops, in particular, predicted OSCE problem solving. Also, we would have predicted that students' high participation in activities requiring communication (eg, workshops, Skills Coaching) would have predicted their OSCE communication, but, instead, completion of pre-class online activities was a predictor for OSCE communication. One hypothesis for this effect includes the possibility that acquisition of knowledge led to greater confidence in communication performance. Alternatively, completion of pre-work may have been highly correlated with factors unavailable for the analyses (eg, motivation, study strategies). Lastly, international student designation and baseline low English proficiency were negative predictors for OSCE communication scores, but not for other outcome variables.

Students completing flipped classroom pre-work prior to lecture predicted performance. In a flipped classroom, engagement with the key curricular elements of pre-class learning material and in-class active learning, aided by self-regulation strategies may be an important moderator of success.[4,20,21] Distributed practice and cognitive load theory support the flipped classroom approach of initial exposure to content and self-testing prior to class.[22,23] The study results contribute to a growing body of research highlighting the importance of completing pre-class activities and timing the completion of pre-class activities before lectures.[24,25]

There is a need for further investigations on empathy. One surprising finding was that low empathy, as measured on the SJT, predicted higher OSCE problem solving scores. Potentially, the result may be a chance occurrence of the seven students with low SJT empathy scores performing consistently well on OSCE problem solving. However, since empathy is essential to the patient-provider relationship,[26] researchers should continue to explore whether low empathy benefits students on assessments and therapeutic problem solving. We plan to investigate whether this effect persists in future cohorts.

Pharmacy schools need to support international students as they have the added challenge to adjust to a new culture and, at times, a new language. As globalization grows, more pharmacy schools will recruit and admit international students.[27] Currently, more than 30% of our students are international students. From this study, we learned our international students are succeeding academically.

Further research and support is required to improve students' communication performance. The DELA, in particular, was predictive of students' future communication performance. As a school, we will continue to provide additional English language supports (eg, small group conversation classes) to students who score a one on their DELA. This study contributes to previously reported mixed results on international students and communication performance. Another study found similar results to this study[28] (ie, international students faring worse on OSCE communication performance), whereas a multi-institutional study did not find a significant relationship between student ethnicity and communication performance.[29] Future researchers should seek to understand whether this is due to the actual communication performance of international students or rater bias in communication performance scores.[28] This study is one of the most comprehensive to date investigating health professions student predictors of OSCE and grade performance. Well-established and novel factors including SJT scales and student time management of pre-class online activities were compared across three distinct outcome variables. However, researchers can always include a greater number and quality of factors to these types of models. The variables that were measured in the study are also subject to measurement errors for outcome and explanatory factors. Ceiling effects, in particular, limited the exploration of course engagement factors. Although it would require substantial time resource, greater sampling of the pre-class online activity factors would improve the reliability of those measures. As we have found the time management of pre-class online activities to be a predictive factor, we plan to invest in a solution that would automate this measure. The results of this study should be considered in context as they are from a single cohort in one institution in one region of the world. Further, despite some suggestion that the early didactic curricula of bachelors, masters, and professional doctorate pharmacy programs are similar, type of degree could influence generalizability of the results.[30]

CONCLUSION

Our explanatory model revealed the importance of completing pre-work before lectures, engaging with workshops, and measuring communications skills in our students. These findings may be used to build targeted interventions to support students in developing optimal learning behaviors. For example, researchers could study approaches to promote timely completion of pre-work. Also, international students and incoming students with lower English proficiency could be triaged early to support services that would better prepare them for OSCE communication (and future experiential placements).

In addition to the areas already noted, future researchers should consider longitudinal studies, other outcome variables and explanatory factors, and further contexts. For example, although OSCE performance has mixed evidence for predicting experiential placement and postgraduate performance,[31,32] these performance metrics could also be measured and modeled directly. Other outcome variables could include other types of skill-based measurements, work-place outcomes, and patient outcomes. The resulting model accounted for 16.5% of OSCE communication performance, an improvement from previous models (4.2 – 7.2% OSCE communication).[10] However, as much of the variability between the examined outcome variables remains unaccounted for, future researchers could seek to explain more of the variance between students' outcomes. For example, they could include motivational beliefs, learning strategies, and self-regulated learning processes in their models, especially since these are hypothesized to be important moderators of success in a flipped classroom.[4] Researchers should explore further contexts including different institutions, curriculums, degree programs, and student populations.

Our institution and others should continue to model how different student factors explain and predict outcomes, especially in the context of flipped classrooms and professional skill development. Students, educators, and workplace leaders have a vested interest in understanding how student factors may explain academic performance. In the end, modelling these types of factors serves as one means to greater develop students' learning, skill development, and future performance.

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Table 1. Univariate and Bivariate Associations for All Outcome Variables and Demographic, Baseline, and Student Time Management of Pre-Class Online Activity Factors (n=159)

	Descriptive Statistics	OSCE Communication[a,b]		OSCE Problem Solving[a,b]		Year Two Examination Grades[a]	
Study Variables	**No. (%)**	**Mean (SD)**	***P* value[c]**	**Mean (SD)**	***P* value[c]**	**Mean (SD)**	***P* value[c]**
Demographic and baseline factors							
Gender							
Female	113 (71.07)	0.81 (0.07)	.12	0.73 (0.07)	.36	0.72 (0.05)	.02
*Male**	46 (28.93)	0.79 (0.07)		0.71 (0.07)		0.69 (0.05)	
International designation							
*International student**	50 (31.45)	0.78 (0.06)	<.001	0.72 (0.07)	.89	0.71 (0.07)	.98
Domestic student	109 (68.55)	0.82 (0.07)		0.72 (0.07)		0.71 (0.06)	
Older age							
*>2 years above average cohort age**	27 (16.98)	0.78 (0.07)	.01	0.70 (0.08)	.15	0.70 (0.05)	.17
<2 years above average cohort age	132 (83.02)	0.81 (0.07)		0.73 (0.07)		0.72 (0.06)	
Incoming DELA (1-3)							
1 – At risk	16 (10.06)	0.75 (0.08)	.002	0.69 (0.09)	.20	0.70 (0.07)	.32
2 – Borderline	63 (39.62)	0.81 (0.06)		0.73 (0.07)		0.71 (0.06)	
3 - Proficient*	80 (50.31)	0.81 (0.07)		0.72 (0.07)		0.72 (0.06)	
SJT Team scale							
1 – Low	21 (13.21)	0.79 (0.09)	.62	0.72 (0.09)	.45	0.70 (0.08)	.78
*2 – Medium**	124 (78.00)	0.81 (0.07)		0.73 (0.07)		0.72 (0.06)	
3 - High	14 (8.81)	0.81 (0.07)		0.70 (0.06)		0.71 (0.06)	
SJT Integrity scale							
1 – Low	19 (11.95)	0.79 (0.08)	.58	0.70 (0.08)	.20	0.68 (0.07)	.03
*2 – Medium**	131 (82.39)	0.81 (0.07)		0.73 (0.07)		0.72 (0.06)	
3 – High	9 (5.66)	0.82 (0.08)		0.72 (0.08)		0.69 (0.09)	
SJT Empathy scale							
1 – Low	7 (4.40)	0.85 (0.05)	.08	0.79 (0.06)	.03	0.72 (0.04)	.42
*2 – Medium**	118 (74.21%)	0.80 (0.07)		0.72 (0.07)		0.71 (0.07)	
3 - High	34 (21.38%)	0.82 (0.07)		0.73 (0.07)		0.73 (0.06)	
SJT Critical thinking and problem solving scale							
1 – Low	21 (13.21)	0.79 (0.09)	.32	0.71 (0.08)	.53	0.71 (0.06)	.88
*2 – Medium**	109 (68.55)	0.81 (0.06)		0.73 (0.07)		0.71 (0.07)	
3 – High	29 (18.24%)	0.81 (0.07)		0.71 (0.07)		0.72 (0.06)	
Student time management of pre-class online activity factors							
Catching-up							
*Yes**	34 (21.38%)	0.80 (0.08)	.80	0.72 (0.09)	.89	0.69 (0.06)	.03
No	125 (78.62%)	0.81 (0.07)		0.72 (0.07)		0.72 (0.06)	
Prepared							

*Yes**	82 (51.57%)	0.82 (0.07)	.04	0.73 (0.06)	.09	0.74 (0.05)	<.001
No	77 (48.43%)	0.79 (0.07)		0.71 (0.08)		0.68 (0.06)	
Revisiting							
*Yes**	63 (39.62%)	0.80 (0.07)	.90	0.73 (0.07)	.11	0.72 (0.05)	.38
No	96 (60.38%)	0.81 (0.07)		0.71 (0.08)		0.71 (0.04)	

Abbreviations: SD indicates standard deviation; OSCE, objective standardized clinical examination; ATAR, Australian Tertiary Admission Rank; DELA, Diagnostic English Language Assessment; SJT, situational judgment test

* Indicates the comparison group for the regression models

[a]The mean for OSCE communication was 80.6% (SD 6.9%), mean for OSCE problem solving was 72.2% (SD 7.3%), and year two grades mean was 71.3% (SD 6.4%)

[b]This represents a composite of three years of data

[c]*P* value represents independent samples t test (two groups) or analysis of variance (three groups). P value is not corrected for multiple comparisons. Variables were included in the multivariate analysis if the *P* value <0.2

Table 2. Bivariate Associations: OSCE Communication, OSCE Problem Solving, and Year Two Exam Grades by Engagement (n=159) and Prior Performance (n=113), Monash University, 2017-2019

	Descriptive Statistics	**OSCE Communication[a,b]**		**OSCE Problem Solving[a,b]**		**Year Two Examination Grades[a]**	
Study Variables	**Mean (SD)**	**Pearson r (*P* value[c])**	**Linear regression beta coefficient (*P* value)**	**Pearson r (*P* value[c])**	**Linear regression beta coefficient (*P* value)**	**Pearson r (*P* value[c])**	**Linear regression beta coefficient (*P* value)**
Course engagement factors (n=159)							
Lecture attendance[d]	0.71 (0.22)	0.06 (.45)	0.02 (.45)	0.12 (.12)	0.04 (.12)	0.26 (.001)	0.07 (.001)
Workshop attendance[d]	0.97 (0.04)	0.17 (.04)	0.28 (.04)	0.28 (<.001)	0.50 (<.001)	0.29 (<.001)	0.46 (<.001)
Skills Coaching participation[d]	0.92 (0.11)	0.10 (.21)	0.06 (.21)	0.16 (.04)	0.10 (.04)	0.30 (<.001)	0.16 (<.001)
Pre-class online activity completion[d]	0.87 (0.13)	0.16 (0.04)	0.09 (.04)	0.21 (.007)	0.12 (.007)	0.37 (<.001)	0.18 (<.001)
Prior performance (n=113)							
Incoming ATAR score	92.11 (4.84)	0.12 (.21)	0.002 (.21)	0.13 (.18)	0.002 (.18)	0.34 (<.001)	0.004 (<.001)

Abbreviations: SD indicates standard deviation; OSCE, objective standardized clinical examination; ATAR, Australian Tertiary Admission Rank

[a]The mean for OSCE communication was 80.6% (SD 6.9%), mean for OSCE problem solving was 72.2% (SD 7.3%), and year two grades mean was 71.3% (SD 6.4%)

[b]This represents a composite of three years of data

[c]P value represents coefficient significance. *P* value is not corrected for multiple comparisons. Variables were included in the multivariate analysis if the *P* value <0.2

[d]This represents a composite of two years of data

Table 3. Model 1, 2, 3 results (n=159) and Model 4 results (n=133)

	Model 1[e] OSCE Communication		**Model 2[f] OSCE Problem Solving**		**Model 3[g] Year 2 Exam Grades**		**Model 4[h] Year 2 Exam Grades with incoming ATAR scores**	
Study Variables	**Coefficient (95% CI)**	***P* value**	**Coefficient (95% CI)**	***P* value**	**Coefficient (95% CI)**	***P* value**	**Coefficient (95% CI)**	***P* value**
Constant	0.59		0.07		0.35		0.03	
Demographic and baseline factors								
Gender (Male)	-0.01 (-0.03, 0.01)	.37			-0.02 (-0.04, 0.001)	.07	-0.009 (-0.03, 0.02)	.47
International student (Yes)	-0.03 (-0.06, -0.01)	.006						
Older age (Yes)	-0.02 (-0.04, 0.01)	.30	-0.02 (-0.05, 0.01)	.23	-0.02 (-0.04, 0.01)	.21	-0.006 (-0.05, 0.04)	.79
Incoming ATAR score							0.003 (0.001, 0.006)	.004
Incoming DELA (reference = 3)								
1 – At risk	-0.05 (-0.09, -0.02)	.004						
2 - Borderline	0.004 (-0.02, 0.03)	.70						
SJT Team scale (reference = 2)								
1 – Low								
3 - High								
SJT Integrity scale (reference = 2)								
1 – Low					-0.03 (-0.06, -0.002)	.04	-0.03 (-0.06, 0.004)	.09
3 – High					-0.03 (-0.07, 0.006)	.10	-0.01 (-0.05, 0.03)	.61
SJT Empathy scale (reference = 2)								
1 – Low	0.04 (-0.01, 0.09)	.12	0.07 (0.01, 0.12)	.02				
3 - High	0.01 (-0.01, 0.04)	.12	0.009 (-0.02, 0.04)	.53				
SJT Critical thinking and problem solving scale (reference = 2)								
1 – Low								
3 – High								
Student time management of pre-class online activity factors								
Catching-up (Yes)					0.01 (-0.02, 0.04)	.43	-0.001 (-0.03, 0.03)	.96
Prepared (Yes)	0.003 (-0.02, 0.03)	.78	0.006 (-0.02, 0.03)	.65	0.03 (0.007, 0.05)	.01	0.03 (-0.001, 0.06)	.05
Revisiting (Yes)			0.02 (-0.01, 0.04)	.20				
Course engagement factors								
Lecture attendance[d]			-0.06 (-0.14, 0.01)	.09	-0.003 (-0.06, 0.06)	.91	-0.03 (-0.10, 0.05)	.45
Workshop attendance[d]	0.14 (-0.11, 0.41)	.27	0.62 (0.20, 1.04)	.004	0.23 (-0.11, 0.56)	.19	0.29 (-0.20, 0.78)	.24
Skills Coaching participation[d]			0.01 (-0.09, 0.13)	.77	0.05 (-0.04, 0.14)	.31	0.03 (-0.08, 0.13)	.64
Pre-class online activity completion[d]	0.10 (0.01, 0.19)	.04	0.08 (-0.03, 0.18)	.15	0.11 (0.03, 0.18)	.007	0.07 (-0.02, 0.16)	.11

Abbreviations: SD indicates standard deviation; OSCE, objective standardized clinical examination; ATAR, Australian Tertiary Admission Rank

[a]The mean for OSCE communication was 80.6% (SD 6.9%), mean for OSCE problem solving was 72.2% (SD 7.3%), and year two grades mean was 71.3% (SD 6.4%)
[b]This represents a composite of three years of data
[c]P value represents coefficient significance. P value is not corrected for multiple comparisons. Variables were included in the multivariate analysis if the P value <0.2
[d]This represents a composite of two years of data
[e]In Model 1, $R = 0.22$, adjusted $R2 = 0.17$, and $P < .001$
[f]In Model 2, $R = 0.17$, adjusted $R2 = 0.12$, and $P < .001$
[g]In Model 3, $R = 0.30$, adjusted $R2 = 0.25$, and $P < .001$
[h]In Model 4, $R = 0.30$, adjusted $R2 = 0.22$, and $P < .001$