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A Flipped Class to Support the Success of At-Risk Students

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Abstract

Early identification of at-risk students for timely intervention is critical to prevent non-completion of study programs. This article proposes a flipped class framework to support the academic success of at-risk students in an undergraduate Calculus course. It comprises three main components of setting, conduct, and monitoring. A flipped support class was implemented as periodic sessions throughout the learning semester over six consecutive semesters for the selected total of 560 at-risk students. At-risk students who attended the flipped support class reported a higher passing percentage than those who did not, in each of the six semesters. A strong mathematics foundation contributed to the likelihood of passing the course; however, it can be further increased by attending more hours of the flipped support class.

***Keywords**:* Dropout; tertiary education; remediation; intervention program; calculus.

Introduction

In higher education the term "at-risk" coined by National Commission on Excellence in Education (NCEE) (1983) is used to describe students who demonstrate academic underachievement and tend to leave before completing their programs and not re-enrol later (Grebennikov & Skaines, 2009). The attrition rate of at-risk students tends to be high (Pusey-Reid et al., 2021), and they are more likely to drop out within the first year of tertiary education (Willcoxson et al., 2011). According to the Organization for Economic Co-operation and Development (OECD), the average graduation rate of 25- to 34-year-olds in 2020 was 45.5% (OECD, 2021). One of the reasons for dropping out at the beginning stage of tertiary education is not being able to cope with a particular course of study (Perchinunno et al., 2021). Students who are required to repeat a course only have a 40-50% chance of completing a program (Harding et al., 2017).

There is a need to provide additional support to overcome barriers and promote success for the at-risk students (Lewis et al., 2018; Merritt, 2021), especially during the start of the studies (Heublein, 2014). It has been found that student support services enabled students who had considered dropping out to remain in the course (Chan et al., 2019). In some cases, student support strategies that are designed to identify the risk factors of the at-risk students and follow up by a series of workshops has successfully resulted in a retention rate of 90% (Merritt, 2021). It has also been found that individual student support such as individualized assistance for low performers provided by instructors after the class increased the chances of program completion (Lavy & Schlosser, 2005), and may lead to improvement (Woolcott et al., 2021). Intervention for at-risk students that employs self-directed learning using workbooks and supported by facilitators during extra-curricular activity may have a greater impact on students with lower baseline scores in catching up, as compared to those with higher baseline scores (Maruyama & Kurosaki, 2021). Other educational inputs affecting intervention for at-risk students are the quality of the instructor, class size, and the quality of peer engagement (Özek, 2021). In general, the academic environment and pedagogy employed are two critical factors in the success of intervention for at-risk students. This article aims to propose a flipped classroom framework to support the success of at-risk students with consideration of these factors.

The Flipped Classroom

A flipped classroom inverts the traditional classroom by delivering content at out-of-class time such as watching instructional videos and reading at a convenient time and place, while class time is utilised for problem solving, application, and review (Bergmann & Sams, 2012; Fidalgo-Blanco et al., 2017). It is an active learning strategy that has the potential to increase student engagement (Bond, 2020; Bashir & Hamid, 2022) and collaborative activities (Song & Kapur, 2017), thus enhance learning (Sullivan, 2022). Flipping the classroom generally has a positive effect on student performance regardless of discipline (Strelan et al., 2020). Senali et al. (2022) found that the main benefit of a flipped classroom in business and entrepreneurship education is that it improves academic performance. In the review by (Özbay & Çınar, 2021) 12 out of 16 studies showed that the exam results of students studying with a flipped classroom model are significantly higher than those with traditional classroom methods. Evidence also suggests that the flipped design has significantly led to improvement in academic performance with extra class time (Busebaia & John, 2020), high degree of attendance (Lewin & Barzilai, 2022), incorporation of cooperative learning (Foldnes, 2016; Shinaberger, 2017), homework and feedback monitoring, and quality online lecture contents (Shinaberger, 2017). In highly structured disciplines such as mathematics, the flipped classroom approach improves student performance across various content areas (Lo et al., 2017).

This article capitalizes on the advantages of the flipped classroom and proposes a framework to serve as the design principles of the flipped approach for supporting at-risk students (flipped support). Data are collected over six consecutive semesters to evaluate the effect of the flipped support on the scores of an undergraduate Calculus course for at-risk students enrolled in engineering, computer science, and applied sciences disciplines. Students' perceptions of the skills acquired through the flipped support class and their reflections are also analysed. It is hypothesised that the implementation of the flipped class framework for at-risk students could provide academic support to acquire and enrich the learning skills of the mathematics course. Specifically, this study hypothesises that the passing rate of the course is higher for the at-risk students attending flipped class (the treatment group) than the group that do not (the control group) for each grouping variables. It is also hypothesised that the course performance of at-risk students is significantly better with a higher attendance rate of flipped class. Next, the hypothesised factors contributing to at-risk students' course performance are tested in modelling prediction of pass in the course.

A Flipped Support Class

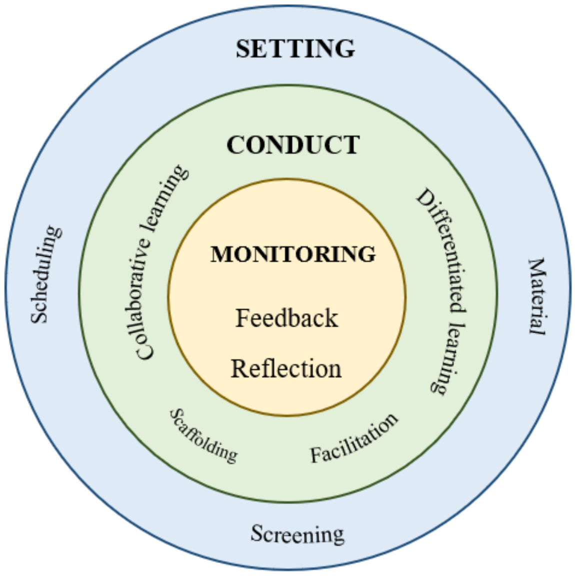
Flipped support class (FSC) introduces a new way of conducting remediation for improving learning achievement of at-risk students at tertiary education. It incorporates the concept of "flip" in such a way that the content delivery is conducted at out-of-class time of the support class, while class time is utilised for supporting activities. However, the content delivery at out-of-class time in FSC is different from a conventional flipped class defined by Bergmann and Sams (2012) and Fidalgo-Blanco et al. (2017) in terms of the content preparation and method of delivery. FSC considers regular lectures of an academic semester as the venue for out-of-class time activities where the content is prepared and delivered by the lecturer of the course in ways deemed suitable for the students. The operation during "out-of-class" time of FSC can be seen as separated from class time.

The class time of a FSC is designed according to a proposed framework developed by considering the key players in a successful flipped classroom. Evidence shows that it encompasses the environment setting of the flipped classroom which is concerned with the design of how it is conducted, the support which includes the instructors and pedagogy employed, and the instructional material used (Busebaia & John, 2020; Foldnes, 2016; Fredriksen, 2021; Shinaberger, 2017; Voigt et al., 2020). Conversely, studies reveal that the main elements that contribute to a meaningful intervention program in supporting at-risk students comprise participants of the program, a screening procedure to timely identify suitable participants for the program, instructional material prepared for the program, instruction during support sessions, an interventionist or instructor who delivers or facilitates the program, and on-going program monitoring for evaluation, reflection, and improvement (Björn et al., 2018; Büchele, 2020a; Fuchs et al., 2015; Heublein, 2014; Ketterlin-Geller et al., 2008; Lavy & Schlosser, 2005; Merritt, 2021; Özek, 2021; Woolcott et al., 2021).

This article proposes a framework of FSC, particularly the implementation during class time for at-risk students as depicted in Figure 1, with the inclusion and adaptation of the key players for a flipped classroom and the main elements of a typical intervention program. The players and elements are categorized into three main components which are the setting, conduct, and monitoring. These components are arranged in circular layers according to the procedure of FSC implementation.

Figure 1

Framework for Flipped Support Class



Setting

The outermost layer of the framework is the setting component. The setting of an FSC needs to be predominantly defined within the environment of a flipped classroom and intertwines with that of an intervention program. The frequency in conducting the class and the duration of each class are reported as important factors to the effectiveness of the support class and contribute to the students' performance (Büchele, 2020a, 2020b). An intervention program is typically conducted to support the low performers (Ketterlin-Geller et al., 2008) and thus the screening procedure is one of the main elements of an FSC. Moreover, material plays a vital role in the success of an FSC, as it appears as the key player for a flipped classroom and the main element of an intervention program (Bergmann & Sams, 2012; Fidalgo-Blanco et al., 2017). Hence, frequency, duration, screening, and material are adapted as the four aspects for the setting of an FSC. The setting component envelopes all other components, signifying its substantial impact to the success of the FSC.

Instructors or interventionists and students are not explicitly spelled out in the proposed FSC framework. The rationale is that students are already implicitly accounted for in the screening aspect of the setting component whilst instructors are inherently integrated in the conduct component, implying the importance of having good quality instructors (Özek, 2021). Furthermore, it is inherent to comprehend that a flipped support class is about the participation of students and involvement of instructors. Therefore, the setting of an FSC focuses on the scheduling, screening, and material preparation.

Scheduling

Scheduling of an FSC requires the setting of frequency in conducting it, and duration for each flipped class. The norm is three to four periodic sessions, set at three hours each, throughout the semester at a convenient time with students expected to attend all sessions.

Screening

A set of standardized screening procedures and criteria agreed collectively by the faculty members are needed to ensure that only the students who need the support class are selected. The criteria for identifying at-risk students considers the current academic performance and their academic track record, which includes their performance during secondary level or in the previous semesters, or both. The detailed criteria are described in sample under the methodology section. Apart from optimizing the resources of the faculty, the selection proportions for FSC varies between 23% and 55%.

Material

The at-risk students who portray academic underachievement are those who face challenges in comprehending the course content. They encounter barriers in attempting the questions in the course assessments, not knowing how to tackle them successfully. Thus, the materials are designed with the intention that the students could be guided step-by-step via scaffolding and facilitation during the flipped class. The materials of the FSC are mainly the handouts of exercises distributed during class time. They are prepared within the scope of the course syllabus (the course learning outcome incorporates Bloom's taxonomy of educational objectives), and with reference to the test specification table of the course. The exercises are sequenced according to the levels of difficulty starting with the knowledge and comprehension levels questions, then application and analysis level questions so that new knowledge can be built upon established knowledge.

A few exercises at knowledge and comprehension levels (the lowest levels of the taxonomy of learning) are also included considering the FSC participants are those at-risk students. It requires students to recall and grasp the meaning of the basic knowledge of a topic. The purpose is to strengthen the basic knowledge that they have learned and then use it seamlessly when solving the application and analysis level questions. For a Calculus course, these exercises include direct instruction in asking the students to practice using the rules of differentiation (the constant rule, power rule, sum and differences rules, product rule, quotient rule and chain rule, etc.) in finding the first derivative of functions.

Most of the exercises are at intermediate cognitive domain level of the taxonomy (application and analysis) as it contributes the highest percentage in the test specification table. These exercises require the students to apply the Polya's problem solving skills in extracting information from the questions, devising strategies in solving the questions, executing the strategies to solve the problems, and evaluating the solutions to confirm that it fulfils the aim of the questions. The application-level questions are relatively more straight-forward in extracting the important information and strategizing the way of solving it if compared to the analysis level questions. The latter requires additional analytical skills in solving the problems with indirect steps.

Conduct

The middle layer of the framework is the conduct component. It is essential for a fruitful learning process. There are several studies that substantiate both the intervention and the flipped design to promote self-learning, individualized assistance, critical thinking, active learning, student engagement, and collaborative learning (Bashir & Hamid, 2022; Bond, 2020; Lavy & Schlosser, 2005; Maruyama & Kurosaki, 2021; Song & Kapur, 2017). These characteristics imply the constructivist nature of an FSC, which is expected to benefit the at-risk students. Among the many approaches purported, collaborative learning, differentiated learning, scaffolding, and facilitation are the four main teaching and learning approaches this study has included in the framework. They collectively define a student-centered FSC, where timely help is provided to the students based on their needs, with peer learning being the integral emphasis. The conduct of an FSC also outlines the procedure and activities during class time. The teaching and learning approaches of collaborative learning, differentiated learning, scaffolding, and facilitation are incorporated in the four main activities, which are: identify gaps and misconceptions, relay for solution, rote learning, and solving problems independently.

Identify gaps and misconceptions

The class time includes identifying if there are gaps of knowledge compared with the syllabus and misconceptions from what the at-risk students acquired during the out-of-class time of FSC. Each student is given ten minutes to draw mind maps that link the concepts of the topics covered in FSC of the day. The mind maps are then put side by side to let the students compare their work with their peers and identify the missing part of their mind maps. The instructor facilitates the observations and comparison and provides feedback to each student about any gaps or misconceptions.

Relay for solution

When solving a problem in pairs, the students take turns to write the steps of each solution alternately. A student in the pair starts the first step and another student continues the next step, while the instructors provide timely assistance. The relay for solution repeats until both the students decide that they have completely solved the problem. This supports a collaborative learning approach where the relay involves scaffolding provided by the instructor, and from each student.

Rote learning

Once the at-risk students gain confidence to solve problems through relay, rote learning is carried out as an extension in the relay for solution activity. Although the drill-and-practice instructional feature of rote learning has been criticized (Nilimaa, 2023), it has the advantage of strengthening previous content knowledge and concepts by repeating certain exercises (Akın, 2022; Hillmayr et al., 2020). In FSC, the rote memorization is deemed temporary. When the strategy for discovering a solution to a problem is mastered without relying on rote memorization, long term memory is developed for the at-risk students. The principle of repetition used in this activity is based on differentiated learning approach. The at-risk students are required to repeat exercises of different difficulty levels subject to their prior levels of understanding. They can progress to high levels or the following subtopic once they are ready. The instructor provides appropriate and timely scaffolding and facilitation and prompts to aid the students when there is hesitation at a step or failure to proceed in solving a problem (Darling-Hammond et al., 2019; Rutherford, 2014).

Solving problems independently

The support class incorporates individual tasks where participants solve problems from past year examination questions. A 60-minute solve independently activity is placed at the end of the class. Participants choose the problems and subtopics that they want to answer, usually from low to high cognitive levels. When completed, instructors quickly check through the solutions steps and assess. If they are not satisfied with their performance, they can attempt similar questions repeatedly until they are ready to move on to the next subtopics.

Monitoring

The innermost layer of the framework is the monitoring component. Effective monitoring on the feedback and reflection of a program has been commonly accepted as the nuclei of flipped and intervention activities (Fuchs et al., 2015; Ketterlin-Geller et al., 2008; Shinaberger, 2017) to ensure the continual improvement and success of the programs. For that reason, this study includes the monitoring component to denote the on-going exercise of getting feedback and doing reflection for the FSC.

Feedback

The instructors provide feedback on the exercises prepared for a FSC to the students for correction and further improvement. The completion level of the exercises is recorded and shared with the students. The students who are unable to finish solving the exercises during the class time of FSC are required to complete within a stipulated time frame and submit to the instructor. Instructors also provide feedback on the students' learning achievement by showing the breakdown scores of the students' performance for every topic of the course and the overall course, according to the cognitive levels. These are presented in a spider web chart, which is then shared with the students. Instructors and faculty use this information to monitor the effectiveness of FSC.

Reflection

After the flipped session ends, reflection is carried out by both the students and instructors. Reflection by the students on the FSC is conducted at the end of each FSC session and at the end of the academic semester during the last FSC session. This reflection is done via discussion prompts focusing on what they have learned during the session. Reflection by the instructors is conducted through discussion during the faculty meetings and FSC concluding discussion. Feedback is then used to inform improvements in the coming semester.

Methodology

Sample

This study received ethics approval from the institution's Research Ethics Committee (ST/MR/72) and was undertaken in a public university in Malaysia. The sample includes first year students identified as at-risk when any of the following criteria applied: completed secondary level mathematics with marginal pass, earned a marginal pass grade in Preparatory Mathematics course, failed the Calculus course previously, or scored low marks in the first assessment of Calculus course during the current semester. The Preparatory Mathematics course is a pre-requisite for the Calculus course in certain academic disciplines with a lower entry requirement of mathematics.

Data was collected on a continual basis for six semesters which enabled a more diverse and representative sample of students. From 2016 to 2019, a total of 1574 students enrolled in the Calculus course. Specifically, the number of Calculus students were 262 (Semester 2 2016), 279 (Semester 1 2017), 248 (Semester 2 2017), 258 (Semester 1 2018), 227 (Semester 2 2018), and 300 (Semester 1 2019). The proportions of Calculus students identified as at-risk in the respective semesters were 37.0% (N=97), 23.3% (N=65), 41.5% (N=103), 26.4% (N=68), 54.2% (N=123), and 34.7% (N=104). Overall, 560 (35.6%) students were identified as at-risk and thus offered supplementary instructions via FSC on top of the regular lecture.

FSC prioritized at-risk students; however, some students withdrew due to commitment issues and personal decisions. The at-risk students who attended the FSC were considered as a treatment group while those who were selected but did not attend were taken as a control group. In other words, both treatment and control groups were attending the same out-of-class time activities at regular lectures, which follow the standard course learning structure outlined in the course syllabus accredited. It consisted of two periods of two-hour regular physical lectures weekly for 14 weeks of an academic semester. During the regular lectures, all students received intensive course content delivery, covering theories, examples, applications and disseminates exercises as homework by the course lecturer. The treatment group also attended the class time activities which are designed according to the framework of FSC. As the “flip” happened during the class time of the support class, only at-risk students who attended the FSC are considered in the treatment group. The background characteristics of the groups that attended (treatment) and did not attend (control) FSC are shown in Table 1.

Table 1

Background Characteristics of Sample

Background variable	**Attended (Treatment)**	**Did not attend (Control)**
Gender (*N* = 560)		
Male	266 (47.5%)	38 (6.8%)
Female	238 (42.5%)	18 (3.2%)
Discipline of study (*N* = 560)		
Applied Sciences	147 (26.3%)	19 (3.4%)
Computer Science	150 (26.8.%)	19 (3.4%)
Engineering	207 (37.0%)	18 (3.2%)
Attempt (*N* = 560)		
1	406 (72.5%)	27 (4.8%)
2	75 (13.4%)	21(3.8%)
3	20 (3.6%)	8 (1.4%)
4	3 (0.5%)	

Measure and Analysis

The variables considered for potential contributing factors to Calculus course performance in FSC were gender, number of attempts, number of hours attended FSC, and Preparatory Mathematics course exempt status. Performance of the Calculus course was measured by the score obtained from all the assessments of the course. The data was analysed quantitatively using Version 25 of SPSS. Chi-square test was used to examine associations between the contributing factors and the Calculus course performance. Independent *t*-test and one-way analysis of variance (ANOVA) were employed to ascertain whether performance in Calculus course differ across the groups of at-risk students. Subsequently, logistic regression analyses were performed to determine the factors contributing to the likelihood of passing the Calculus course, and thus a parsimonious model that predicts pass in the course was obtained.

In addition, the at-risk students’ perspectives were collected to gain insights about what benefits FSC offered to them. A questionnaire was adapted from the institution activity assessment instrument to elicit the participants’ opinion on the learning skills attained and reflections on FSC. Each measurement item was rated on a five-point Likert scale where 1=‘strongly disagree’ and 5=‘strongly agree’. Participants’ responses to the survey were voluntary. The Cronbach’s alpha value for overall scale was 0.918, indicating a high level of internal consistency or reliability.

Results

Effectiveness of Flipped Support Class

Exploratory analyses were conducted to give some preliminary understanding of the data. Table 2 depicts the passing rates in Calculus course of at-risk students who attended (treatment) and did not attend (control) flipped support class over the six semesters. The group that attended FSC reported a higher proportion of pass than fail in each of the six semesters under study with an average passing rate of 68.8%. Conversely, a lower passing rate of 41.1%, on average was observed for the group that did not attend FSC. Subsequent Chi-square test of independence revealed a significant association between students’ attendance of FSC and Calculus course pass-fail performance ($p < 0.001$). The group that attended was less likely to fail than expected, and more likely to pass than expected, while the group that did not attend was more likely to fail than expected, and less likely to pass than expected.

Table 2

Passing Rates in Calculus Course of At-Risk Students Who Attended and Did Not Attend Flipped Support Class Over the Six Semesters

	Attended (Treatment)		**Did not attend (Control)**	
	N	**Pass (%)**	***N***	**Pass (%)**
Semester 2 2016	84	70.2	13	30.8
Semester 1 2017	46	87.0	19	52.6
Semester 2 2017	92	60.9	11	54.5
Semester 1 2018	67	76.1	1	0.0
Semester 2 2018	120	62.5	3	0.0
Semester 1 2019	95	69.5	9	33.3
Overall	504*	68.8#	56*	41.1#

Table 3 shows the passing rates in Calculus course of at-risk students for both the treatment and control groups with regards to the grouping variables. Notably, this finding supports the hypothesis that each of the grouping variables of the treatment group reported higher passing rates as compared to the control group. Higher passing rates were observed for the female, first attempt, exempted from the Preparatory Mathematics course and attended 7 to 12 hours subgroups.

Table 3

Passing Rates in Calculus Course of At-Risk Students Based on the Groups

Variables	**Attended (Treatment)**		**Did not attend (Control)**	
	N	**Pass (%)**	**N**	**Pass (%)**
Gender (*N* = 560)				
Male	266	66.2	38	39.5
Female	238	71.8	18	44.4
Attempt (*N* = 560)				
1	406	70.0	27	48.1
2	75	65.3	21	42.9
3	20	60.0	8	12.5
4	3	66.7		
Preparatory Mathematics course (*N* = 560)				
Exempted	102	85.3	8	50
Not exempted	402	64.7	48	39.6
Number of hours attended (*N* = 560)				
0			56	41.1
1 to 3	89	51.7		
4 to 6	216	67.6		
7 to 12	199	77.9		

For the treatment group, there was no significant difference in the means scores between the female and male groups ($t_{502,\,0.025} = 1.206$, $p > 0.05$). Conversely, there was a significant difference in means scores between at least two groups of attempts ($F_{3,\,500,\,0.05} = 2.765$, $p < 0.05$). The mean score for the group that was exempted from Preparatory Mathematics course (56.57) was significantly higher than the non-exempted group (51.59) ($t_{502,\,0.025} = 3.057$, $p < 0.05$).

Further, there was a significant difference in means scores between groups of students attended FSC with different number of hours ($F_{2,\,501,\,0.05} = 22.043$, $p < 0.001$). The group that attended 7 to 12 hours had significantly higher mean score (57.2) than the groups that attended 4 to 6 hours (51.2) and 1 to 3 hours (45.7). Also, the mean score of the group that attended 4 to 6 hours was significantly higher than the group that attended 1 to 3 hours. Thus, more hours of FSC attended were associated to higher Calculus course mean scores. This finding supports the hypothesis that that the course performance of at-risk students is better with higher attendance rate of flipped support class.

Results of the exploratory analyses show that FSC was effective for at-risk students exempted from Preparatory Mathematics course and attempted the Calculus course for the first time regardless of gender. The benefits increased when students attended more hours.

Factors Contributing to Performance

Logistic regression was applied to ascertain the effects of number of attempts, number of hours attended and Preparatory Mathematics course exempt status on the likelihood that students pass the Calculus course. This showed that the number of hours attended and Preparatory Mathematics course exempt status were significant predictors to a student passing the course ($p < 0.001$). However, the number of attempts did not significantly affect students' pass-fail performance despite the finding of significance within the treatment group. Hence, the best-fitted two-predictor logistic regression model that included number of hours attended and Preparatory Mathematics course exempt status was obtained as depicted in Table 5.

Table 5

Best Fitted Logistic Regression Output for Flipped Support Class

Predictor	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for Exp(B) Lower	Upper
Number of hours attended	.160	.030	28.650	1	.000**	1.173	1.107	1.244
Preparatory Mathematics course exempt status (not exempted)	–1.114	.274	16.512	1	.000**	.328	.192	.562
Constant	.706	.297	5.635	1	.018*	2.026		
Test			χ^2	df	Sig.			
Overall model evaluation								
Likelihood ratio test (Omnibus Test)			48.996	2	.000			
Hosmer and Lemeshow			5.261	6	.511			

Note. Cox & Snell R Square = .084; Nagelkerke R Square = .116; $^*p < 0.05$, $^{**}p < 0.01$

The model for predicting the likelihood of passing the Calculus course with regards to the FSC is given as follows:

$$\ln[(\alpha/(1-\alpha)] = 0.706 + 0.160 \times \text{Number of hours attended} - 1.114 \times \text{Preparatory Mathematics course exempt status} \quad (1)$$

where α is the probability of a student passing Calculus course, and $\ln[(\alpha/(1-\alpha)]$ is the log of the odds of a student passing Calculus course.

The log of the odds of a student passing Calculus course was positively related to the number of hours attended and negatively related to Preparatory Mathematics course exempt status. Specifically, the greater number of hours attended, the more likely a student passes the courses. For every additional one hour of FSC attended, a student's odds of passing the course multiplicatively increased by a factor of 0.160. When the number of hours attended was controlled, those who were not exempted from Preparatory Mathematics course were less likely to pass the Calculus course than those who were exempted. The odds of a non-exempted Preparatory Mathematics student passing the Calculus course were 0.328 times less than the odds for a student who was exempted. This implies that a strong mathematics foundation before entering tertiary education contributes to the likelihood of passing the Calculus course. However, the likelihood of passing the course can be improved by increasing the number of hours attended the FSC.

Predicting Pass in Calculus Course

The model obtained from the previous section can be used to predict probability of pass in the Calculus course. The equation to predict the probability of student passing Calculus course is written as follows:

$$\text{Probability of passing Calculus course} = \frac{\exp(0.706 + 0.160 \times \text{Number of hours attended} - \text{Preparatory Mathematics course})}{1+\exp(0.706 + 0.160 \times \text{Number of hours attended} - \text{Preparatory Mathematics course})} \quad (2)$$

Figure 2 shows the graph of the predicted probabilities of passing Calculus course against the number of hours attended. For a certain hour of FSC attended, the probability of passing Calculus course for the group that was exempted from the Preparatory Mathematics course was higher than the group that was not exempted. For the group that was exempted from Preparatory Mathematics course, the probability of passing the Calculus course if they did not attend FSC was 0.67, and the probabilities increased to 0.77, 0.84 and 0.90 when attended 3, 6 and 9 hours, respectively. Similar trends with lower probabilities could be seen for the group that was not exempted from the Preparatory Mathematics course. Specifically, the probability of passing the Calculus course was 0.40 if did not attend FSC, and the probabilities increased to 0.52, 0.63 and 0.74 when they attended 3, 6 and 9 hours, respectively. Interestingly, if a student was not exempted from the Preparatory Mathematics course and attended the FSC up to 12 hours, the estimated probability to pass the Calculus course was 0.82. Although the number of hours attended the FSC increases the probability of passing the course, the margin of increase in the probability is reducing. Therefore, the number of hours conducted for the FSC should take into consideration of the optimization of faculty resources.

Figure 2

Probability of Passing Calculus Course Against Number of Hours Attended

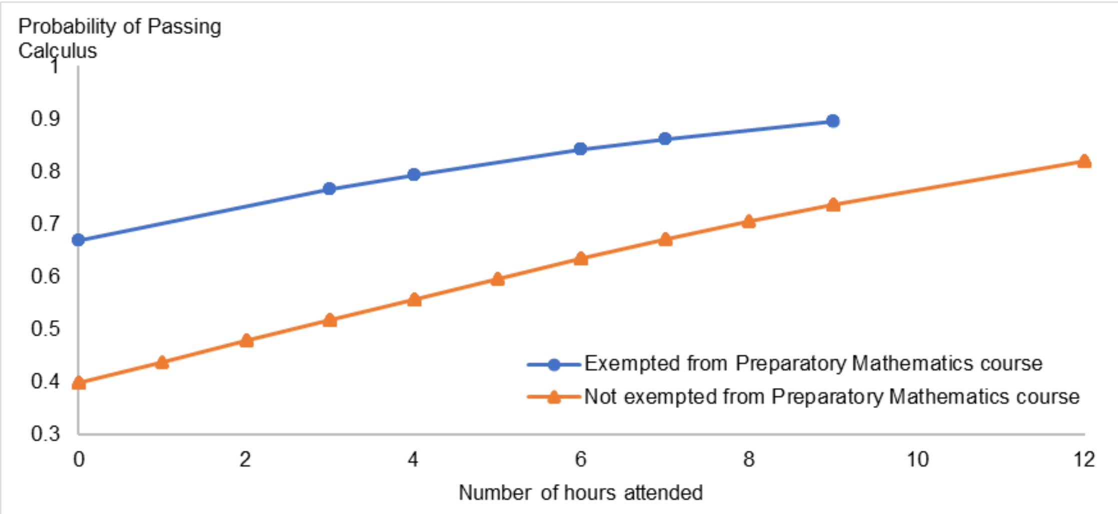


Table 6 depicts the validity evaluation of the predicted probabilities through confusion matrix of classification. The overall correct prediction of the above model was 68.9%. The prediction for students passing the Calculus course was more accurate than for those who failed. This was suggested by the sensitivity measure (93.2%) compared to that of specificity (21.6%). Thus, the hypothesised contributing factors to at-risk students' course performance could be modelled using logistic regression to predict pass in the course accurately holds.

Table 6

The Confusion Matrix of the Predictive Model

	Predicted		
Observed	**Pass**	**Fail**	**Percentage Correct**
Pass	345	25	93.2
Fail	149	41	21.6
Overall Percentage Correct			68.9

Perceptions of Flipped Support Class

Of the 504 participants of FSC, 429 (85.10%) responded in the questionnaire survey. The survey included four constructs of learning skills as perceived by the participants which were critical thinking and problem-solving skills; communication skills; team skills; and lifelong learning and information management. The respondents had positive perceptions on the acquisition of learning skills through FSC. In the order of most acquired learning skills were team skills (73.08%), critical thinking and problem-solving skills (72.61%), communication skills (68.53%) and lifelong learning skill (68.07%,). For the overall reflection on FSC, respondents rated the satisfaction, enrichment, and conduct levels at 87.65%, 86.71% and 84.62%, respectively.

Discussion and Conclusion

Many undergraduate students found quantitative courses such as the Calculus course difficult to learn due to insufficient preparation, knowledge, and skills. FSC provides additional support to alleviate the learning difficulties encountered by at-risk students in their academic courses outside the regular lecture on top of the regular curriculum. The data span of six semesters also examined the factors that contributed to at-risk students' success in Calculus learning which may inform future similar FSC practices, along with the development of the FSC framework that underpinned the study. The best-fit model of FSC for the Calculus course developed predicts pass in the course with high accuracy (93.2%) can be adapted as strategic planning to other courses by faculties who wish to embark into FSC.

The main element of FSC that contributed to students learning is the extra instruction. The flipped design allows more time for remediation. This is evidenced by the higher passing rates (61-87%) of the treatment group throughout the six semesters. In line with Busebaia & John (2020), Lo et al. (2017), and Strelan et al. (2020), improvement in academic performance was observed with flipped classroom.

The three components of the FSC framework, namely setting, conduct and monitoring are interrelated and considered equally important. Further investigation of the logistic regression model provides insight into the importance of the elements within the setting component of the FSC framework. It shows that the elements of scheduling and screening contributed significantly to the performance of students. Scheduling involves duration and frequency while screening identifies at-risk students. This is evidenced by the significant two predictors of the likelihood of passing the course, namely number of hours attended and Preparatory Mathematics course exemption status. Repeating status did not significantly contribute to students' passing the course. This is in line with the findings of Mitra and Goldstein (2018) and Lombardini et al. (2018) where the variable was not significant in their intervention program and flipped classroom. However, in the FSC framework, the repeating status continues to be one of the criteria in the screening process for identification of the at-risk students.

The activities within the conduct component of the FSC framework are well-accepted by the at-risk students. Findings indicated students have good (60-80%) perceptions of the learning skills acquired, especially in collaboration with peers, active listening skills, critical thinking, and problem-solving skills. A balanced combination of the four main activities (identify gaps and misconceptions, relay for solution, rote learning and solve problems independently) sought to support and enhance the learning skills of at-risk students. These are the key activities that enrich the conduct component of FSC. The learning skills comprising critical thinking and problem-solving, communication, team, and lifelong learning and information management were acquired through the teaching and learning approaches of collaborative learning, differentiated learning, scaffolding, and facilitation. During the conduct of FSC, at least two of these approaches were functional, thus their strengths are deemed relatively comparable.

Peer learning was utilised to provide students with active learning, social support and to build confidence. Active learning develops higher order thinking and team skills (Istiandaru et al., 2019; Tague & Czocher, 2016) as observed in the relay for solution which prepares participants for the individual learning tasks. By taking turns to write the solutions for each step in the relay for solution stage, they were engaged in lively discussion with their peers that created interest and curiosity. Instructors frequently asked closed questions at this stage to examine factual understanding of the participants.

When it came to solving problems independently, participants were already motivated to attempt problems associated with past year examination questions, starting with simpler questions to tougher questions. They were allowed to choose the type of questions to solve according to topic and level of difficulty. Each participant received constructive feedback from the instructors that helped them to explore their thinking skills and analyse problems. Instructors encouraged them to repeatedly solve similar problems until they had mastered the concerned topics. It is important that instructors facilitate the work of participants at this stage so that they progress from this knowledge level to analysis level to achieve the required learning outcomes. Facilitation through prompt feedback is the key to success at this stage, thus this activity may involve more than one instructor.

The effectiveness of the support class is not just a matter of setting and conducting. The effect of the monitoring component of the FSC framework is incorporated into the elements of setting and conduct, which cannot be measured directly. For example, feedback from student reflections suggests that it is necessary to conduct FSC close to the assessment date to promote a high attendance rate. This gives impact to the scheduling element of setting component. Further feedback improvements include the necessity to create exercises with different cognitive levels and difficulties; accordingly, the material element of setting is seen as supporting the differentiated learning approach in the conduct component.

There is evidence to suggest that access to FSC for all students should be considered. The framework is extendable to all students; however, it was considered critical at the inception of the support class to ensure that at-risk students have access to extra instruction and learning support to avoid failure and continue to progress through their studies. Interventions such as these can be considered more holistically depending on the resourcing available within the university.

The evidence in this study affirmed that catalysing at-risk students' Calculus learning and success using FSC is substantial and effective. Importantly, the framework of the flipped class can be strategically transferred and assimilated into other courses, academic levels or modes of teaching and learning, in the academic success context of at-risk students. Future research includes understanding how at-risk students are coping with the increased use of technology to support flipped class learning due to the recent impact of COVID-19 pandemic.

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