Are There Differences Between Online and In-Person Team-Based Learning Classes? Through the Lens of Self-Determination Theory and Learners' Characteristics

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Abstract

Background: The rapid transition to online delivery of medical curriculum has facilitated the continuation of medical education during COVID-19 pandemic. Whilst active learning approaches, including Team-Based Learning (TBL), are generally more supportive of the learner's needs during such transition, it remains elusive how the different learning environments can affect a learner's motivation, engagement and perceived learning over a prolonged period. We leveraged on Self-Determination Theory (SDT) and key learners' characteristics to explore student's engagement and perceived learning in two TBL learning environments, online and in-person, over an extended period.

Methods: This is a mixed method study with 53 preclinical medical students completed the same questionnaire twice for each learning environment, online TBL and in-person TBL, over an eight-month period. Quantitative data were collected on learners' characteristics (such as resilience, curiosity, growth mindset, use of cognitive strategies and self-regulation), basic psychological needs satisfaction (autonomy, competence and relatedness), motivation (intrinsic, identified, external and amotivation), student's engagement and perceived learning. The final questionnaire also explored participants' perception on which learning environment better supported their learning.

Results: We found that autonomy support, perceived competence and needs satisfaction, and perceived learning were higher in-person than online. We also showed that increases in autonomy support and intrinsic motivation positively predicted engagement, which in turn predicted enhanced perceived learning. Additionally, a majority of learners felt that in-person TBL was better for learning, as the concepts of learning space and the community of practice were mediated by being in-person.

Conclusions: TBL, being an active instructional method, can maintain students' engagement because it supports many aspects of SDT constructs perceived learning. However, online TBL is unable to fully support the students' needs and perceived learning. Hence, we strongly advocate for any in-person opportunities to be included in a course and for instructors to adopt strategies that support learners' ability to stay regulated and intrinsically motivated, as they are crucial predictors of engagement in any learning environment.

Background

Enhanced social distancing measures due to the COVID-19 pandemic has transformed the delivery of education, from onsite physical lessons to online setting (1–3). With the looming threat of infectious variants and evolving pandemic situation, either fully online learning or a hybrid arrangement of blended in-person and online learning are likely to continue for a while. In some cases, these teaching arrangements may become a permanent mode of instruction (4). The increasing number of reports on the lessons learned and efforts in the online transition (1, 5), particularly in terms of learners' perception of the online learning environment (3), has enabled the swift implementation of online learning. However, it remains unclear whether being in an online learning environment over an extended period changes a

learner's motivation and in turn, the level of engagement and the perception of learning. Hence, gaining a better understanding of the effects of learning environments on students would help to identify key elements needed to support learners in a prolonged online learning environment, and inform future integration of online learning into the existing medical curriculum.

At Duke-NUS Medical School, we adopt Team-Based Learning (TBL) as our main instructional method in the preclinical curriculum. Whilst we have previously shown that a week-long, online learning experience did not affect students' perception of their classes (2). However, the online learning classes in that study did not encompass all aspects of a typical TBL session, as no video-conferencing was used, therefore was no active discussion between students and faculty. Furthermore, there is limited research on the effect of online versus in-person TBL on students' engagement and perceived learning. Hence, in this study, we used the self-determination motivational theory framework, together with key learner's characteristics, to identify changes to the factors underlying learners' engagement and perceived learning when taking classes in two different learning environments, over an extended length of time.

Theoretical Framework

According to Self-Determination Theory (SDT) motivational theory, motivation is a continuum, ranging from amotivation, a lack of motivation state, to extrinsic motivation which is propelled by an external factor or reward, and then to intrinsic motivation, a self-generated state (6). Intrinsic motivation, which is the pursuit of an activity for one's personal interest, is shown to associate with better learning outcomes and well-being (7–10). Such motivation fosters engagement on any task. SDT further differentiates the types of extrinsic motivation based on the level of autonomy (6, 11). External regulation, the least autonomous one, is outside of personal control and driven by external reward or avoidance of punishment, whereas identified regulation, the most autonomous one, is associated with valuing an activity. Both intrinsic motivation and identified regulation are the autonomous types of self-determination for a learner.

Importantly, SDT hypothesizes that learner's motivation on any given task can change from extrinsic to intrinsic, depending on the satisfaction of the learner's three basic psychological needs: autonomy, competence, and relatedness. Autonomy refers to acting with a sense of volition; competence is self-perceived efficacious in a learning environment; relatedness is the feeling of being connected and belonging to other or one's community. It was further demonstrated that students are more able to stay motivated and engaged in a learning task when instructional method fulfills these psychological needs (12). Furthermore, when in-person, the TBL instructional method was better, than didactic instructional method, at fostering intrinsic motivation, perceived competence, autonomy and overall needs satisfaction (13). Using the SDT framework, helps us to understand why learners stay engaged and develop greater sense of perceived learning in a TBL environment. However, it is unknown whether the extended immersion in an online learning environment will affect, through the lens of SDT, learners' engagement and perceived learning.

While SDT is important in shaping the fundamental aspects of engagement and learning, research has shown there other factors, such as learners' characteristics, that interact with the SDT framework and motivation via their correlations with the basic psychological needs satisfaction. These key characteristics include curiosity, resilience, and growth mindset (14–20). The self-regulated learning ability of a learner is yet another important aspect that explains the correlation with motivation in learning (21). Pintrich (1990) further conceptualized this by including the use of self-regulated learning strategies, such as cognitive strategy, to show their importance in being able to stay motivated and engaged. Students who were motivated to learn were more cognitively engaged and were more likely to apply meta-cognitive learning strategies in learning, thus becoming more self-regulated learners.

Given the dynamic relationship between various learners' characteristics, the learning environment, and the satisfaction of the basic psychological needs for motivation, we seek to elucidate how these factors interact, and how they influence learners' engagement and perceived learning (Figure 1). We posit that the reduced or lack of social interactions of the students, with their team members and faculty, in an online TBL learning environment might lead to reduced satisfaction of basic psychological needs compared to an in-person TBL learning environment. Hence, students' engagement and perceived learning in online TBL will be adversely affected.

Specifically, we primarily aim to characterise the differences in learners' characteristics (such as resilience, curiosity, growth mindset, use of cognitive strategies and self-regulation), basic psychological needs satisfaction (autonomy, competence and relatedness), motivation (intrinsic, identified, external and amotivation), student's engagement and perceived learning between the two TBL learning environments, online and in-person, over an extended period of time. Our secondary aim is to explore the relationship of these constructs in shaping student's engagement and perceived learning with the change of TBL learning environment. Understanding such differences in learning environment will inform the academic support system on how best to engage learners in their learning environment. Besides, key elements identified in this relationship will also facilitate integration of online TBL learning into existing medical curriculum post COVID era.

Methods

Participants

Participants were recruited from Year 1 medical students of Class of 2024 at Duke-NUS Medical School. These students underwent both online and in-person pre-clinical classes due to the heightened, then relaxed, social distancing measures during the COVID-19 pandemic. Due to the COVID-19 safe management measures and the venue capacity limit, students experienced a hybrid arrangement of synchronous TBL lessons where half the class being physically present and the other participating online (Figure 2).

Procedure

This study, primarily using survey methodology, was exempted by the National University of Singapore Institutional Review Board (NUS-IRB-2020-346) in view of the study design meeting criteria for Social Behavioral and Educational Research. Informed consent was obtained however from all participating Year 1 students. All Year 1 students were sent with an email by a staff member, with no grading responsibilities, to request for their participation in the research study. Link to the questionnaire, consisting of demographic questions with scales measuring the various constructs (below), was embedded in the email invitation. Students indicated their consent electronically before attempting the questionnaire.

Participants completed two questionnaires for each learning environment, online and in-person (Figure 2). Participants started their Year 1 in the online TBL environment, due to the heightened social distancing measures during the COVID-19 pandemic. In semester 2, as the local clusters came under control, social distancing measures were relaxed sufficiently for half the class to attend lessons in-person. Due to this hybrid class arrangements, participants were reminded to only take into consideration their experiences for the in-person sessions when completing the survey.

For each learning environment, the participants received the first questionnaire after undergoing 75 days of classes, and the second questionnaire after undergoing 125 days of classes in the same learning environment. During the final, we also explored students' perception of their overall learning experiences in both online and in-person TBL, indicating which learning environment they thought they learnt better in, and why.

Scales used

At each sampling timepoint, the questionnaire measures all SDT related constructs (autonomy, perceived competence, motivation, basic needs satisfaction), learner's characteristics (resilience, curiosity, growth mindset, use of cognitive strategy and self-regulation), engagement and perceived learning.

SDT related constructs: Students' perception of the instructor's autonomy support was measured using six-item Learning Climate Questionnaire (13, 22, 23). Students' perceived competence was measured using four-item Perceived Competence Scale (23). Students' needs satisfaction in general was measured using Basic Psychological Needs Scale (24, 25) which is made up of three subscales: autonomy; competence; relatedness. The three subscales were combined to measure a general needs satisfaction scale. To measure students' situation motivation during the learning environment, we used Situational Motivation Scale which determines the level of intrinsic motivation, identified regulation, external regulation and amotivation (26).

Learner's characteristics

Students' resilience was measured using six-item Brief Resilience Scale (27). Mindset of students was determined using three-item Growth Mindset Scale (28, 29). Curiosity of students was measured using 5D Curiosity Scale that focuses on joyous exploration and deprivation sensitivity of students (19). Self-

regulated learning of students was measured using Motivated Strategies for Learning Questionnaire on the subscale of twelve-item cognitive use strategy and nine-item self-regulation (21).

Perception of Engagement and Learning

22-item Multidimensional Engagement scale was used to measure four aspects of students' engagement including agentic engagement, behavioural engagement, emotional engagement and cognitive engagement (30). Nine-item CAP Perceived Learning Scale was used to measure perceived cognitive, affective and psychomotor learning gain (31).

Quantitative Data Analysis

The R statistical program (R Foundation for Statistical Computing, Vienna, Austria) was used for data analyses. Data were expressed as means $\pm$ SEM and $p < 0.05$ was considered statistically significant. For all measured constructs, learning environment and sampling timepoint were within subject factors. The normality of the residuals was assessed using the tools for building OLS regression model package. The homogeneity of variance was assessed using the Levene's test from the car statistical package. The regression models were fit using Linear Mixed Effect Regression Model, lmer() in the lmerTest statistical package (32, 33). They were then assessed using the anova() function from the stats package. Cronbach's Alpha for each scale was calculated using the Cronbach.alpha() function from the ltm package.

The residuals for the path analysis were obtained from regressing the scores of online to in-person for every construct using the resid function from the (13) package. We assessed the data for multicollinearity using the ols_coll_diag() function from the olsrr package (34). Following which, the path analysis was carried out using the confirmatory factor analysis in the lavaan package (35). We used the conventional cutoff (36) criteria for goodness of fit to assess the model fit, where χ^2/df ratio is below 2 and p-value > 0.05 , CFI > 0.9 , RMSEA < 0.08 , and SRMR < 0.08 (37). The path analysis model was then visualized using the semPaths() function from the {semPlot} package (38). We then conducted the Sobel tests (39) on the significant paths by using the sobel() from the multilevel package and mediate() from the mediation package (40) for bootstrapping (36).

Thematic Analysis

We used thematic analysis to explore the reasons why students perceived a particular environment better for learning. We used an inductive, reflexive thematic analysis through the 6 phases for thematic analysis (41). The author familiarized with the data, taking casual observational notes about the content. This was followed by inductive question informed coding, at both semantic and latent levels. Themes were then constructed from these codes and their associated data, first, by establishing candidate themes, which were tested for their utility in telling the story of the data, then reviewing and finalizing themes. Two authors discussed the content of codes and candidate themes using thematic maps to make sense of

them. We generated two themes from the data describing the reasons underlying the better learning in a particular environment.

Results

Demographics

A total of 49 participants participated in the study, of which there were 30 female and 19 males. Their age distributions are as follows: 49.0% were between 21-25, 44.9% were between 26-30 and 3% were >30. There were 3 participants who were married.

Reliability statistics

Internal reliability of survey instruments was compared to previous values reported in the literature. The obtained Cronbach's alpha values for all the survey instruments were indicated in Supplementary Table 1, together with Cronbach's alpha values that have been reported in the literature. In short, the obtained reliability statistics values in our study were comparable to previously reported values.

Effect Of Learning Environment on Variables of the Learner Characteristics and Self-Determination Theory Framework

All variables showed homogeneity of variance. The residuals of cognitive strategy, self-regulation, identified regulation, external regulation and perceived learning did not follow normal distribution due to the presence of outliers. The removal of these outliers, as identified by Cook's Distance (42), showed that these observations did not have any influence on the regression model. As such, these observations remained in the analyses. The linear mixed effect regression model (LMER) analysis within each learning environment, in-person and online, showed no significant main effect of time in all measured variables (Supplementary Table 2). Since there were no significant differences between the early and late survey timepoints for each variable within each learning environment, they were averaged for subsequent analysis.

We assessed the effect of learning environment on the five variables from the learner characteristics framework: resilience, growth mindset, curiosity, cognitive strategy, and self-regulation (Table 1). The LMER analysis of averaged responses showed no differences between in-person and online TBL classes (Figure 3A).

Table 1
Means, standard error of means and Cronbach's α for learner characteristics averaged across the two timepoints.

Learner's Characteristics	In-Person		Online	
	Mean	SEM	Mean	SEM
Resilience	3.72	0.09	3.80	0.08
Growth Mindset	4.33	0.19	4.46	0.19
Curiosity	5.48	0.12	5.44	0.11
Cognitive Strategy	5.05	0.08	5.05	0.08
Self-Regulation	5.15	0.09	4.99	0.09

We also assessed the effect of learning environment the variables from the self-determination theory framework (Table 2). Autonomy support, perceived competence and needs satisfaction showed significant main effects of learning environment (Figure 3B; $p = 0.073$, $p = 0.028$ and $p = 0.003$ respectively), with in-person being higher than online. There were no significant changes detected in the motivation variables: intrinsic motivation, identified regulation, external regulation and amotivation.

Table 2
Means, standard error of means and Cronbach's α for Self Determination Theory constructs and study outcomes averaged across the two timepoints. *These measured variables showed significant differences between in-person and online learning environments ($ps < 0.075$).

SDT	In-Person		Online	
	Mean	SEM	Mean	SEM
Autonomy*	5.30	0.10	5.04	0.10
Needs Satisfaction*	3.77	0.06	3.48	0.07
Perceived Competence*	4.64	0.09	4.34	0.10
Intrinsic Motivation	5.34	0.12	5.32	0.12
Identified Regulation	5.97	0.08	5.91	0.08
External Regulation	4.99	0.13	5.14	0.12
Amotivation	2.45	0.16	2.39	0.15
Engagement	5.27	0.08	5.20	0.07
Perceived Learning*	3.58	0.07	3.30	0.07

Of our outcome measures, engagement and perceived learning, only perceived learning showed significant main effect of learning environment (Figure 2B; $p=0.00584$), with in-person being higher than online.

Assessing the data for multicollinearity

Before carrying out the path analysis, we assessed the data for multicollinearity. The tolerance factors of the variables were all greater than 0.1, ranging between 0.18 and 0.79. The variance expansion factors of the variables were all less than 10, ranging between 1.27 and 5.67. These findings showed that there were no multicollinearity problems amongst the variables.

Fitting Learner Characteristics and Self-Determination Theory Constructs Together

To assess how well the learner characteristics and self-determination theory constructs fit together, we carried out a path analysis using the residuals from regressing scores from online to in-person. The model fit well ($\chi^2(5) = 4.762$, $p = 0.446$, CFI = 1.0, RMSEA = 0.000 [CI: 0.00 – 0.194], SRMR = 0.023; Figure 4). We found that increases in engagement positively predicted increases in perceived learning ($p=0.009$) and the model overall accounted for 72% of the variance in engagement and 16% of the variance in perceived learning. Increases in resilience, self-regulation, autonomy support and intrinsic motivation positively predicted increases in engagement, while increases in curiosity predicted decreases in engagement ($ps < 0.04$).

Within the learner characteristics constructs, the covariation between self-regulation and cognitive strategy was significant ($p < 0.001$), and the covariation between curiosity and resilience was close to significance ($p = 0.052$).

Within the self-determination theory constructs, perceived competence, needs satisfaction and autonomy support positively covaried with one another ($p < 0.005$). Identified regulation also significantly covaried with intrinsic motivation ($p = 0.001$).

We also found significant covarying factors between the learner characteristics and self-determination theory constructs. Curiosity positively covaried with intrinsic motivation ($p = 0.052$). Self-regulation positively covaried with identified regulation ($p = 0.001$) and external regulation ($p = 0.065$), and negatively covaried with autonomy support ($p = 0.064$). Cognitive strategy positively covaried with identified regulation ($p = 0.042$) and perceived competence ($p = 0.016$). Growth mindset, external regulation and amotivation did not seem to covary with any other constructs.

Indirect Effects of Intrinsic Motivation, Autonomy, Self-Regulation, Resilience and Curiosity on Perceived Learning

We conducted Sobel tests on our significant paths (39) by carrying out linear regressions of the independent variable and mediator, and of the mediator and dependent variable (43, 44), and computing

the unstandardized indirect effects for 5000 bootstrapped samples (36).

We found that intrinsic motivation had significant indirect effects on perceived learning through engagement ($0.289 \times 0.495 = 0.143$, $p=0.0036$), whilst autonomy ($0.147 \times 0.393 = 0.0574$, $p=0.087$) and self-regulation ($0.424 \times 0.350 = 0.148$, $p=0.07$) had close to significant indirect effects. Resilience and curiosity did not have any statistically significant indirect effect on perceived learning through engagement.

Which Learning Environment Did Students Feel that They Learnt Better in?

At the last survey timepoint, we asked students to reflect upon their class learning experience and choose which environment they thought they learnt better in. From the 49 responses, 29 picked in-person TBL, 14 did not have a preference, and 6 picked online TBL (Figure 3C).

The comments reflected two themes that shaped a student's perception of a particular learning environment for being more superior. Each theme cohered around a central organising concept that underpins the thematic explanation of the data: (1) Being in the community of practice, supported by the interpersonal interaction opportunity and its associated value, influences students preference of a learning environment in learning (2) How learning space directly impacts students' ability to learn and focus.

The *main theme* is the community of practice, supported by the interpersonal interaction opportunity and its associated value that is offered in that learning environment.

Majority of students valued such community of practice as evident by the interpersonal interaction amongst peers which was facilitated during in-person TBL. Students perceived ease of communication, reflected by the authenticity of non-verbal cues and real-time feedback, to support team building and bonding during in-person TBL. For example, these are the comments by participants favouring in-person TBL:

Face-to-face TBL is more convenient and conducive way to work together with our team members and our classmates. It is easier to forge friendships and learn from one another

Discussion during GRA is more conducive in person where it is easier to express our thought process and interject each other.

The ability to clarify concepts either with peers or faculty during in-person also shapes such perception of community of practice. Students favoured in-person TBL given the flexibility to clarify concepts with peers face-to-face. For instance,

...can ask for help from friends whenever we have questions or didn't catch what the lecturer said.

"Discussion during GRA is more conducive in person where it is easier to express our thought process and interject each other".

However, such interaction with faculty remains limited as the faculty did not co-share the same physical learning environment with the students, given the prevailing social distancing measures on teaching venue. Thus, this was highlighted in students who found no difference between the two learning environments. Such sentiments were reflected by students who commented the following:

"Both modalities feel rather the same to me with the main bulk of the teaching done by the professors and doctors over zoom and the location where I am receiving and learning such information does not really matter much to me".

I miss the moments when after class we can go up to the lecturer to ask questions freely + listening to the lecturer interacting with us answering our questions.

Additionally, another critical sub-theme was sense of belonging as students perceived having common goals of working and learning together being possible only with in-person TBL.

It is easier to concentrate when physically surrounded by classmates focusing on doing the same thing. ..because I like the atmosphere of doing the same thing achieving the same goal with a crowd of people.

While most students who supported in-person TBL due to the abundance of interpersonal interaction with peers, a handful of students preferred online TBL as a result of dysfunctional team dynamics presented over the initial phase of prolonged online learning environment. For examples, these two students perceived being disconnected from team members and not being engaged in an in-person TBL, suggestive of inherent challenges with team cohesion and dynamics.

Don't really feel connected to teammates... Better to focus at home instead

"While discussing things over zoom, everyone is on the same page whereas in school, discussions will leave some members out".

The second theme, learning space, also plays crucial role in shaping students' preference of a learning environment better for learning.

Students perceived the importance of spatial and physical space for learning, by which campus provides that unique identity for students to stay focused as shared by the following comments:

"...less distracted in person because the environment is encouraging you to pay attention to the most salient thing around you which is the lecture (on the projector)".

"The school's environment is more conducive for learning, and I get into a state where I know "it's time to study".

On this note, such spatial identity for learning, in part, supports the main theme via providing the opportunity for community of practice.

Easier to keep engaged/pay attention during physical lessons, being in a physical study space surrounded by peers and faculty is much more conducive for learning and retention.

Similarly, some students experienced more distractions at home, negatively impacting their learning and preference as shown below:

At home unengaged, mixed environment cues from bedroom, distractions of home and family, My home environment is not optimized for online TBL, and there are too many distractions (construction outside my house, parents also working on call, internet instability, etc) for online TBL to be effective

On the other hand, students, who favoured online TBL, enjoyed the direct benefits of home learning environment including convenience and comfort. Students valued more time studying at home as it saved from travelling to campus.

Less time travelling = more time studying

...home-based learning is less distracting, allows you to study more efficiently during breaks, and allows me to use my own work desk with laptop stand, external keyboard, mouse and footstool etc. in comfort so I can study more effectively.

While these two themes shape and influence how students favoured a particular learning environment, it also emphasized the critical element of satisfying the needs of being part of community of practice supported via interpersonal interaction.

Discussion

Previous studies have shown that instructional methods and environment influence self-determination theory constructs, which in turn affect engagement and perceived learning (13, 45). Ours is the first longitudinal study we know of that looked at how the learner's characteristics are impacted by the type of TBL learning environment over time, and whether the characteristics interact with the self-determination theory constructs to result in changes in engagement and perceived learning.

Although Self-Determination Theory Constructs Were Stable Across Time in an Online Learning Environment, They Were Lower Than In-person

In this study, we show that the learner's characteristics and self-determination theory constructs did not show changes across time in the in-person learning environment (Table 1). More importantly, these constructs remained stable across time within the online learning environment as well. This is irrespective of the subject matter being learnt, as the participants were undergoing different courses at each survey timepoint. Our observation of the stable behaviours in the online learning environment contrasts with previous studies which showed that online courses often experienced high attrition rates due to reduced learner's motivation and engagement over time (46–49). As such, we posit that, in an online environment where there is a lack of physical interactions, the TBL instructional method is better than a didactic

instructional method, such as lectures, in being able to satisfy the student's basic needs for learning in a classroom.

When comparing across different learning environments for TBL, we found that self-determination theory constructs, such as autonomy support, perceived competence and needs satisfaction, and perceived learning were significantly higher when students had TBL classes in-person than online (Figure 3B). These three self-determination theory constructs, together with identified regulation and intrinsic motivation, also covaried with one another (Figure 4). In addition, autonomy support and intrinsic motivation positively predicts engagement and hence perceived learning when changing from an online to in-person TBL class (Figure 4). Our observations support the basic tenets of SDT, which are in line with previous research that showed how TBL supports learner's engagement and perceived learning via SDT (13). Similarly, a recent paper applied SDT framework to demonstrate the importance of autonomy support in enhancing K12 students' engagement in an online learning environment during pandemic (50).

Notably, our study also showed no significant difference in the levels of engagement between online or in-person TBL classes, whereas engagement in lecture classes is lower than that of in-person TBL classes (13). As such, our findings suggest, whilst online TBL classes cannot support student's needs satisfaction to the same extent as that of in-person TBL classes, it is still able to maintain student engagement over time. Consistent with this notion, whilst medical schools have adopted different online instructional methods during the pandemic, learner-centered and active instructional method, such as Team-Based Learning (TBL) and Case-Based Learning, has appeared to be more engaging as opposed to didactic remote lectures (5). We now provide further evidence to support the sustained engagement seen in both TBL learning environments, and this is likely to be associated with the overall satisfaction of basic needs mediated by TBL, irrespective of learning environment.

Finally, although learner's characteristics showed no differences in averages across in-person versus online TBL classes, we found that self-regulation and cognitive strategy co-varied with self-determination constructs. Additionally, resilience and self-regulation positively predicted engagement when changing from an online to in-person class. This suggests that a change in the learning environment of a TBL class can affect the relationships between some learner's characteristics and engagement. Previous studies have shown that relationships with instructors and peers in the classroom affects students' resilience and in turn engagement, because these social relationships form the support network for the student that provides a sense of competence, relatedness and autonomy (51–53). Hence, if online TBL classes are to be implemented, instructors should explore ways to support these learner's characteristics.

Taken together, our findings suggest that using an active instructional method, such as TBL, in an online learning environment, will help instructors to avoid the pitfalls that long-term online courses often face, because an active instructional method is better able to sustain the students' autonomous motivation across time. The TBL class structure provides opportunities for feedback, collaboration, and greater learning accountability and responsibility during class (54), which respectively increases support for competence, relatedness, and autonomy (13, 55), aligning well with the best practice in creating

autonomy-supportive classroom (10). These opportunities are important for creating a sense of belonging to the learning community and is especially important in an online learning environment, where learners may experience social isolation for a long period of time (56, 57). In contrast, didactic instructional methods reduce learner's responsibility and interpersonal relations and offers fewer opportunities for optimal challenges (58). However, online TBL classes are still unable to replace in-person TBL classes, suggesting that the 'live' factor cannot be fully replicated in an online setting. Our findings are supported by other studies which showed that students felt that online lectures should not replace live lectures (59). Hence, we suggest that if classes must be held online, instructors should consider implementing the TBL instructional method. In addition, where possible, a blend of in-person and online TBL classes should be adopted (4).

What do these findings mean for online classes?

Whilst there was no change in the levels of engagement, perceived learning was higher for in-person TBL classes than online (Figure 3B). Consistent with these findings, majority of the students indicated that in-person TBL was a better environment for learning than online TBL (Figure 3C). While there were indirect effects of SDT constructs and learner's characteristics, such as resilience and self-regulation, on perceived learning via engagement as shown by path analysis, our qualitative analysis also illuminated two main themes that influenced student's perception of learning (Figure 3D). The first theme was the community of practice. Students supported the in-person opportunities as they valued how it contributed to be part of the community of practice. Being in person allowed them to socialize and interact with their peers, and start to build their teams' relationships. Importantly, the sense of belonging was promoted when students were physically present to experience common goals during TBL lessons. Similarly, recent studies showed a greater preference for in-person TBL than online TBL, with poorer ratings for teamwork interdependence in online TBL environment compared to in-person TBL (60, 61). Given that the sense of belonging to the community of practice is critical for professional identity formation (62, 63), having a solely online TBL environment might affect this crucial process for physicians' development.

The second theme, which also interacts with community of practice, is the learning space. The spatial identity of a learning environment influenced the learner's perceived learning. Previous studies have shown that the design of a learning space was shown to influence engagement, motivation, professional preparation, and knowledge transfer of learners (64–66). Thus, it is conceivable that when a TBL class is conducted in-person, instead of remotely, there is a significant, symbolic meaning on learning. Just as how the results from the survey administered for employees in 29 countries that found two-thirds of people prefer working flexibly, unconfined to just office space (67), our students also welcomed having a hybrid arrangement, as they could benefit from both environments. Therefore, a hybrid type of TBL lesson arrangement, where one half of the class would be attending lessons in-person on a rotation basis, could be a middle ground to address the reduced perceived learning, autonomy support, basic psychological needs that are otherwise observed in an online TBL environment.

Caveats

There are several limitations to our study. First, our institute's safe management measures implemented in response to the pandemic precluded an in-person TBL class for the full cohort of students. Hence, the participants would attend in-person TBL on a rotational basis, with some of their classmates being online, in a synchronous hybrid TBL format. We have tried to mitigate the impact of such the hybrid TBL arrangement by ensuring that every participant will have experienced a similar number of in-person TBL classes before responding to the survey. Additionally, we gave explicit instructions in the survey for participants to respond based on their experience from the in-person classes. However, we cannot rule out the possibility of unknown intermediate effects that may have an impact on our findings. Second, our study data is obtained from self-reported surveys administered during the COVID-19 pandemic, when the stress due to the general uncertainty of the situation and social isolation could have an impact on students' psychological states (68). Hence, our data may not be representative of the perception of online and in-person TBL classes during normal times. Third, although subjective data on perceived learning sheds light on students' overall state of mind during learning, we cannot draw any inference on actual learning gain (69).

Conclusions

In summary, our findings join a growing body of findings showing how TBL supports many aspects of SDT constructs. Hence, TBL, or other active instructional methods that satisfies these SDT constructs, should be the preferred instructional method in an online environment. In addition, we strongly advocate for any in-person opportunities to be included where possible, as online TBL still is unable to fully support the students' needs. Educators should try to implement strategies that support learners' ability to stay regulated and intrinsically motivated, as they are crucial significant predictors for engagement in any learning environment. Through the lens of SDT, we have also identified that autonomous support shape students' engagement and perceived learning in both learning environments. In congruence, strategies that created an autonomy-supportive learning environment have been shown to enhance students' self-regulation and performance (70). Considering limitations in our study implementation and design, as highlighted earlier, we recommend that future studies include objective measures of the SDT constructs, learner's characteristics and learning gain, with a cleaner online and in-person intervention in a cross-over experimental design, to strengthen the validity of our results.

Abbreviations

SDT

Self-Determination Theory

TBL

Team-Based Learning

LMER

Linear Mixed Effect Regression

CFI

Comparative Fit Index
RMSEA
Root Mean Square Error of Approximation
SRMR
Standardized Root Mean Square Residual

Declarations

Ethics approval and consent to participate: All methods were performed in accordance with the relevant guidelines and regulations approved by the NUS institutional Review Board. The current study was exempted by NUS IRB (NUS-IRB-2020-346) in view of the study design meeting exemption criteria for Social, Behavioural and Educational Research. Informed consent was obtained from all individual participants.

Consent for publication: Not applicable

Availability of data and materials: The datasets generated and analysed during the current study are not publicly available due university policy, but are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: Both ICJ Lee and P Wong conceptualized and designed the study. Both authors collected the data. ICJ Lee carried out the thematic analysis and P Wong analysed the quantitative data. Both authors wrote the paper.

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Figures

Figure 1

Theoretical framework to elucidate student’s engagement and perceived learning (measured outcomes) via the measured SDT and learner’s characteristics constructs in the in-person and online TBL learning environments.

Figure 2

Timeline of the experiment. The cohort started TBL classes online in August of 2020 due to the high number of cases in Singapore. The first survey for online TBL classes was administered 75 days after their first online TBL class, and the second survey followed 50 days later. In December 2020, synchronous hybrid TBL classes started, as case numbers were lower. For each TBL class, half the cohort will be attending class in-person, with the other half online, on a rotational basis. The first survey for in-person TBL classes was administered 75 days after their first hybrid TBL class, and the second survey followed 50 days later. Infographic of daily number of COVID-19 positive cases obtained from the Ministry of Health, Singapore, COVID-19 interactive situation report website (<https://covidstrep.moh.gov.sg/>)

Figure 3

Changes in scores between in-person (white bar) and online (blue bar) TBL learning environment for learner's characteristics constructs (Panel A), and self-determination constructs and measured outcomes (Panel B). Effect sizes (Cohen's d) for differences between in-person and online: autonomy support, $d = 0.367$; needs satisfaction, $d = 0.620$; perceived competence, $d = 0.446$; perceived learning, $d = 0.569$. Data is represented as means and standard error of mean. Most of the participants perceived in-person classes

to be better for learning (Panel C). A thematic analysis showed two main themes of why students perceived a particular environment better for learning (Panel D). The community of practice supported by interpersonal interaction opportunities and the learning space played crucial roles in shaping the students' perception of which learning environment was better for learning.

Figure 4

The path analysis model showing the relationships between the study variables and the variables that predicted engagement and perceived learning. We found that intrinsic motivation indirectly predicted perceived learning through engagement, whereas autonomy support and self-regulation had close to

significant indirect effects. Whilst resilience and curiosity directly predicted engagement, they did not have any indirect effects on perceived learning. For clarity, only significant paths are shown.

Supplementary Files

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