Academic discipline as a moderating variable between seating location and academic performance: Implications for teaching

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The literature on university students' academic performance indicates that students' seating locations can be an indicator of their academic performance. However, the literature's findings of the relationship between university students' seating locations and their academic performance are mixed, and there is a lack of research about whether students' academic discipline has a moderating influence on this relationship. This study addresses this gap in the literature through a study of 182 university students in Hong Kong. The results revealed that students from soft fields who sat at the front of a class performed better than their counterparts who sat at the back, and the performance of students from hard fields was not significantly influenced by their seating location. This paper's findings suggest that classroom seating arrangements should be tailored to academic disciplines to maximize their efficacy and that universities should redesign classroom layouts to extend the experience of sitting in the front of a class to all students.

Keywords: iBeacon/BLE technology; seating location; academic performance; academic disciplines; university students

Introduction

It is important for scholars and educators to develop a robust understanding of the factors that contribute to students' academic performance in higher education; not least because students' academic performance has been found to be highly related to their life satisfaction (Samaha & Hawi, 2016). Studies have indicated that students' self-efficacy and attributional style (McKenzie & Schweitzer, 2001) and goal orientation (Fenollar et al., 2007) can predict their academic performance. However, most of the research to-date has not studied the relationship between the physical parameters of university classrooms and university students' academic performance. We consider this to be a significant gap in the literature because some scholars have suggested that

the physical parameters of classrooms contribute to the overall learning environment and facilitate the learning process, and therefore partially predict learning outcomes (Philips et al., 2012). This paper aims to fill this gap in the literature by assessing whether students' seating location affects their academic performance and whether students' academic discipline has a moderating effect on the relationship between their seating location and academic performance.

University students spend almost all of their in-class time in their seats. Most students sit in the same seat during the entire semester. Montello (1988) found that students' seating location is indicative of their learning engagement. Recent studies' evidence regarding seating location's benefits for university students' academic performance is controversial and has yet to be verified (Meeks et al., 2013; Navarro Jover & Martínez Ramírez, 2018). One view is that seating location's influence on academic performance may vary across disciplines. As such, this study attempts to provide a better understanding of the influence of seating location based on academic disciplines, which would provide insights into facilitating teachers to develop more effective teaching methods (Devlin & Samarawickrema, 2010).

Literature Review

Seating location as an indicator of university students' academic engagement

Students choose their seats for many reasons. Losonczy-Marshall and Marshall (2013) suggest that there are five factors that decide how students choose their seats: their performance, whether they are social, whether they are asocial, a seat's noticeability, and the overall classroom environment. They noted that students sitting in the front of a classroom were more noticeable and suggested that this implies that students sitting in the front of the classroom have a greater intent to participate and engage during class. However, in reality, students are sometimes unable to sit in their preferred seat. Therefore, the actual extent to which students choose to sit at the

back of a classroom reflects their intent and engagement has yet to be determined. Parker et al. (2011) examined the relationship between students' actual seating location and their engagement. They randomly assigned their study participants into seats and found that although the participants could not choose their seats, their actual seating location changed their classroom behavior in the class.

Several observational studies support the notion, that students sitting in the front of a classroom are more engaged during class. Parker et al. (2011) found that students sitting in the front of a classroom participate significantly more than their counterparts who sit at the back. Levine et al. (1980) reached the same conclusion when seating location was randomly assigned. Koneya (1976) studied students' participation in the form of comments or questions and their interactions with other students, and noticed that high-interaction students tend to sit in the first two rows and students sitting at the back tended not to interact or communicate with their classmates. To sum up, the literature suggests that seating location is an indicator of student engagement, and that students sitting in the front of a classroom engage more than those sitting at the back.

The relationship between seating location and academic performance

Several studies have found student engagement to be an indicator of students' higher academic achievement. Carini et al. (2006) found that improvements in students' engagement improve their learning outcomes. Studies also show that students with low learning ability benefit more from improved engagement than their more able counterparts. Kahu and Nelson (2017) assessed students emotional and cognitive engagement and found that students are emotionally engaged when they are interested in the teaching content and cognitively engaged when they believe in their ability to understand and complete a learning task. They found that emotional and cognitive engagement can also predict academic success. This study hopes to extend their findings by

assessing whether students' seating location, which has been found to predict their engagement, can predict academic performance.

Benedict and Hoag (2004) attempted to determine the separate influences of students' seating preference and their actual seating location, and found that students who preferred to sit at the back of a classroom but were forced to sit in the front performed better than those students sitting at the back. In a similar fashion, Perkins and Wieman (2005) randomly assigned students seats and flipped the organization of the classroom in the middle of the semester so that students who were at the back were now at the front and vice versa. They found that those students who sat in the front of the classroom during the first half of the semester performed better than their counterparts. This finding is corroborated by other, older findings in the literature. For example, Levine et al. (1980) also found that students who choose to seat in the front of examinations perform better than those sitting in the back, and Becker et al. (1973) had similar findings in the context of large lectures. In summary, the literature indicates that students' actual seating location influences their academic performance.

Armstrong and Chang (2007) asserted that the link between students' actual seating location and their academic performance is relatively weak. Only six of the 20 classes exhibited a significant relationship between seating location and academic performance, and the seating location accounted for less than 7% of the variation in students' academic performance. Furthermore, some scholars have asserted that there is no significant relationship between students' seating location and their academic performance (Meeks et al., 2013; Navarro Jover & Martínez Ramírez, 2018). These studies suggest that the relationship between students' seating location and their academic performance may be subject to several moderating factors. Pichierri and Guido (2016) examined the moderating effects of shyness and non-conformity and found that students' seating location and academic performance are moderated by shyness, but not by non-

conformity. Other studies have proposed that classroom size is a driving factor (LaCroix & LaCroix, 2017) and suggested that seating location is only influential in large classrooms or lecture hall settings (Shernoff et al., 2017). This suggests that the inconsistencies in the literature might be caused by the fact that previous studies have not sufficiently explored the possibility that the relationship between students' seating location and their academic performance may be moderated by several variables.

While other scholars have considered the moderating influence of various psychological and physical variables on the relationship between students' seating location and their academic performance, few studies have assessed whether students' academic disciplines might moderate this relationship. The literature is inconsistent in this regard: for example, Zomorodian et al. (2012) found that seating location benefits medical students, but Meeks et al. (2013) found that it does not benefit business students. The literature indicates that lecturers from different academic disciplines employ different teaching practices and hold different pedagogical beliefs (Jones, 2011; Umbach, 2006), and their learning and teaching processes vary. (Smart & Umbach, 2007). These differences have been found to impact the relationship between students' engagement and their academic achievement (Pike et al., 2011).

Laird et al. (2008) used Biglan categorization (Biglan, 1973) to categorize academic disciplines based on the degree of consensus about knowledge within them. Their categorization classifies disciplines into soft (a low degree of consensus) and hard fields (a high degree of consensus). They found that deep learning—which facilitates students' retention, integration, and transferring of learned content—occurs more in the former than the latter, and that deep learning is facilitated by student engagement. Student engagement varies by academic discipline; hard fields require less engagement (Leach, 2016) and see less active and integrated learning than their soft counterparts. As seating location has been found to be an indicator of student engagement,

we suggest that its influence academic performance may be different in hard fields than it is in soft fields.

Gaps in the literature and the present study

There are several gaps in the literature on the relationship between university students' seating location and their academic performance. First, the literature's findings are inconsistent, which suggests the potential existence of a moderating variable. Second, previous studies have operationalized rows and columns as variables that define classroom seating, but that approach has several limitations—for example, the space between rows and columns vary between classrooms, which impacts the generalizability of some of the findings in the literature. Third, previous studies have relied on classroom observations and self-reported questionnaires, but these methods are not appropriate for the study of larger lecture halls and similar settings.

This study seeks to address these gaps. Its theoretical framework is outlined in Figure 1, below. Sharma et al. (1981) defined a moderating variable as a variable that influences the strength and/or direction of the relationship between predictors and outcome measures. As such, a moderating variable is different from a mediating variable—the latter accounts for the relationship between predictors and outcome measures (Baron & Kenny, 1986). We used regression in our moderation analysis to include the interaction term for both predictors and moderators in our model (as per Sharma et al., 1981).

This study is not the first to apply moderating variables to studies of teaching and learning. Gu et al. (2018) found that supervisor–student relationships moderate students' motivation and sense of how challenging a course is. However, Honicke et al. (2020) found that students' academic self-efficacy does not significantly moderate the relationship between students' goal orientation and their academic performance. This study hypothesizes that the

negative relationship between students' seating location and their academic performance is stronger in soft fields than in hard fields.

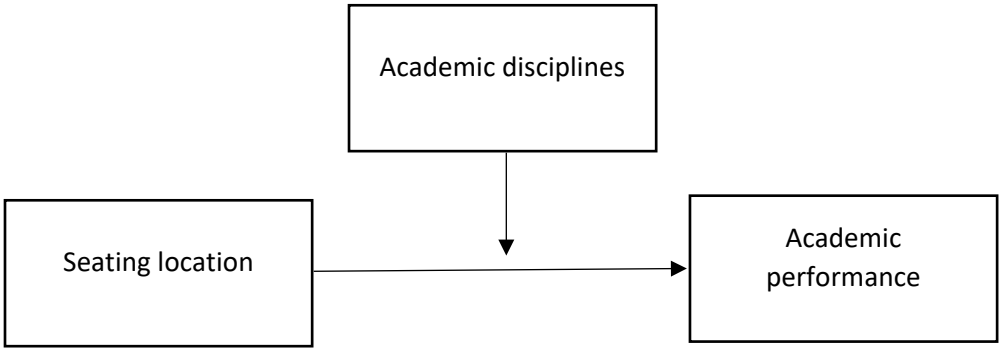

Figure 1. The study's theoretical framework

Method and procedure

Study population

We recruited study participants from Hong Kong Polytechnic University, the University of Hong Kong, the Chinese University of Hong Kong, and Hong Kong Baptist University between January 2019 and December 2019. A total of 182 students from 7 courses participated in this study. Overall, 68.7% of study participants study in hard fields and 31.3% of them study in soft fields.

Location- based service: our use of ATLAS software

The project team developed a mobile app—called the Augmented Teaching and Learning Advancement System (ATLAS)—to record student attendance, check-in times, and seating location in a precise manner. Students were required to install a mobile app and provide written consent before participating in the study. Students also used the ATLAS app to do quizzes and tests, and the time they spent doing tests and the locations they did the tests in were registered in the app as well. More details can be found on the ATLAS website: https://www.atlas-learn.com/.

In addition to the functions described above, ATLAS empowers teachers with the ability to open new streams of engagement, facilitate active participation and communication with students, and enhance the learning experience in general, by providing a holistic platform for sharing content, hosting discussions, and assessing and engaging students. It has four main components: (1) a web-based administration portal; (2) a student/visitor mobile app (compatible with both iOS and Android devices); (3) a web-based content management system; and (4) server-side services for the central storage of educational information and location-based data collected through the app. The mobile app was developed to allow for the utilization of iBeacon-based system to facilitate its question and answer, attendance monitoring, and seating location measurement functions.

Location-based service: Our use of iBeacon hardware

Bluetooth beacon is a small, portable transmitter that employs Bluetooth Low Energy (BLE) protocols to transmit information to nearby Bluetooth-enabled smart devices. This study's use of this technology makes its data collection more accurate. For example, if a student were outside the classroom and trying to register their attendance, the Bluetooth beacon could detect their location and reject their registration.

There are three ways to determine the location of mobile devices—proximity, trilateration, and fingerprinting. ATLAS chooses one of these three methods depending on the functionality of certain actions, time constraints, and the number of beacons available. The efficacy and accuracy of these methods are based on environmental factors (Paek et al., 2016) and the devices themselves (Mori et al., 2015). Although several studies have attempted to improve the efficacy and accuracy of this method, none have totally optimized its performance (e.g. Paek et al., 2016; Yang et al., 2016). Before conducting our study, we conducted several experiments to optimize the performance of our tools.

Measurement

Outcome

Students' in-class test scores were used as the outcome variable in this study. We administrated the quiz via ATLAS and measured participants' test scores as a percentage.

Predictor

We used seating location as the predictor variable in this study. The actual distance (in meters) between the students and the front of the class was calculated by the ATLAS software in the following way. First, we created a floor map of each classroom and set the front of the class as 0. The x and y positions of each student were mapped on this floor map. Subsequently, we calculated the distance (in meters) between students and the front of the class using the Pythagorean theorem. We validated and optimized these methods through several pre-experiments.

Moderator

We used academic discipline as a moderating variable in this study, using Biglan's (1973) classification of academic disciplines into hard or soft fields.

Covariate

The classroom sizes (in m2) were provided by facility management departments. When this information was not available, we measured classroom size ourselves using a laser.

Data Analysis

We performed a linear regression to examine students' seating location's effects on their academic performance. Apart from the predictor, moderator, and outcome variables, we also

included classroom size as a covariate variable. Moderation analysis were run in R studio using the jtools package, version 2.0.1 (Long, 2018), and the interactions package version 1.1.1 was used for moderation probing (Long, 2019). Model 1 includes seating location, academic disciplines, and covariates; Model 2 includes seating location x academic disciplines. Following Sharma et al. (1981), we suggest that if the difference between the models is significant, then the moderator is significant. We used a simple slope analysis to visualize the interaction between variables (Hayes & Rockwood, 2017). This method enabled us to notice the different effects of students' seating location on their academic performance across academic disciplines.

Results

Among the test scores, there is no significant relationship between seating location and classroom size. As Table 1 shows, participants' average test score was 62.0%, and they sat an average of seven meters from the stage.

Table 1. Descriptive information

	Description		Correlation	
	Mean	SD	1	2
1. Test score [%]	62.00	32.24		
2. Seating location [meters]	5.96	3.39	-0.041	
3. Classroom size [m^2]	162.30	100.30	0.339*	0.435*
Academic discipline				
Hard field	125	68.70%		
Soft field	57	31.30%		

* p-value < 0.05

Table 2 shows the results of our linear regression model. In Model 1, seating location has a significant and simple effect (β = -0.26, t(178) = -3.32, p = .001, 95% CI [-0.42, -0.11]) and academic discipline (β = 0.40, t(178) = 2.11, p = .036, 95% CI [0.03, 0.77]) on test scores.

Table 2. Linear regression

	Model 1			Model 2		
	β	t	p	β	t	p
Seating location[1]	-0.262	-3.318	0.001	-1.798	3.922	0.074
Classroom size	0.555	5.977	0.000	0.530	5.753	0.000
Academic discipline[2]	0.397	2.109	0.036	0.295	3.331	0.001
Seating location X academic discipline				-0.442	-2.566	0.011
R^2	0.179	12.946 [3]	0.000	0.209	11.660 [3]	0.000
ΔR^2				0.030	6.584 [2]	0.011

[1] Lower indicate closer to front of the classroom

[2] Coding: hard = 1, soft = 0

[3] F test was performed

Results of our moderation analysis indicate academic discipline significantly moderates the relationship between students' seating location and their test scores. As shown in Table 2, the significant interaction between students' seating location and their academic discipline can predict their test scores (β = -0.44, t = -2.57, p = .011, 95% CI [0.10, 0.78]). In Model 2, the interaction term accounted for a significant amount of the variance (ΔR2 = .03, F[4, 177] = 6.58, p = .011). Thus, we performed a simple slope analysis to probe the moderation effect. The simple slope analysis revealed no significant relationship between students' seating location and their test scores in hard fields (Table 3) but a significant relationship between these two variables in soft fields (β = 0.60, t[178] = 3.92, p = .018, 95% CI [0.30, 0.90]) (see Figure 2). In summary,

students from soft fields had higher test scores when they sat in the front of the classroom than when they sat in the back, and students from hard fields' test scores did not vary significantly by seating location.

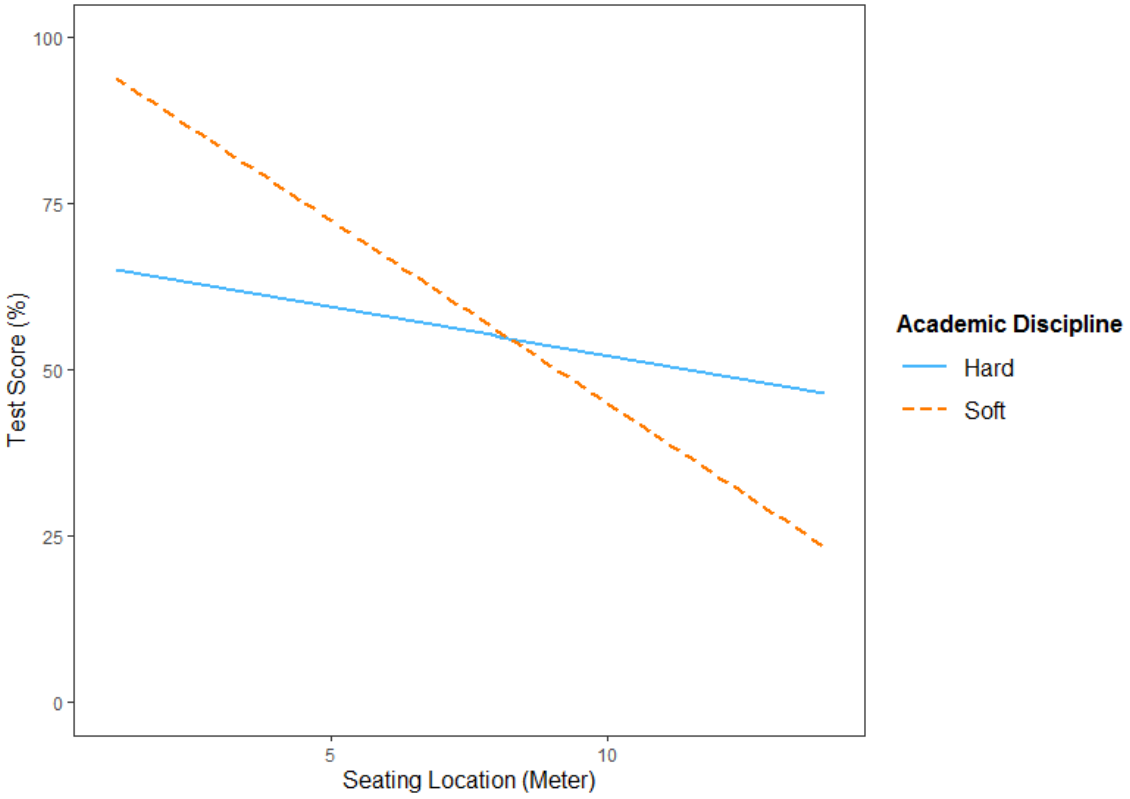

Figure 2. Simple Slope Analysis

Table 3. Simple slope analysis

	B	SE(B)	β	t	p
Academic discipline					
Hard	-1.446	0.804	-0.158	-1.798	0.074
Soft	-5.501	1.403	-0.600	-3.922	0.000

Discussion

This study's findings suggest that there is a significant relationship between university students' seating location and their academic performance. This finding is consistent with recent research (e.g. Bergtold et al., 2019). We might explain this finding by asserting that students sitting in the front of a classroom are more engaged than their counterparts at the back of the room (Montello, 1988), and that this improves their academic performance. We might also explain this by asserting that the relationship between students' seating location and their academic performance is mediated by their engagement, attention, and intrinsic motivation (Shernoff et al., 2017).

In addition, this study's findings suggest that academic discipline does indeed moderate the relationship between students' seating location and their academic performance. Furthermore, the findings suggest that students studying in soft fields receive the greatest benefits from sitting at the front of a classroom. This finding is consistent with previous research (e.g. Kim & Sax, 2011; Leach, 2016) and suggests that teachers might be able to design their courses differently based on the academic discipline (Smart & Umbach, 2007). The effect of academic discipline may culminate in a multisystem of teaching that amplifies the impact of seating position on academic performance, particularly in test score. The results also indicate that academic discipline may influence academic performance, in the sense that student engagement, positive teacher-student interactions, and encouraging learning atmospheres are more common in soft fields than in hard fields.

The findings beg the question of what the underlying mechanisms are which drive this moderating effect. Recent studies suggest that teachers' different beliefs and practices produce differences in student socialization (Jones, 2011). They also suggest that teachers emphasize different learning outcomes through the provision of discipline-specific learning environments (Smart & Umbach, 2007; Smart et al., 2009). For example, teachers from soft fields tend to focus

on facilitating and developing students' ability to discuss alternative and critical perspectives (Gaff & Wilson, 1971), and those in hard fields tend to focus on having students to memorize and apply key concepts (Smart & Ethington, 1995). Other studies have shown that teachers employ different practices to attain different, discipline-specific learning outcomes. Braxton et al. (1998) found that teachers from soft fields tend to encourage teacher-student interaction and value communication, active learning, and students' personal development. Conversely, Michel et al. (2018) found that teachers from hard fields tend to emphasize tests and exercises and focus less on students' personal development or interactions. In short, the literature indicates that soft and hard fields have different pedagogies and aim at different learning outcomes. Although it is generally unknown whether a discipline's intended learning outcome or the teaching pedagogy promotes the moderation effect (Brophy, 1983), this study partially specifies how these differences play out in practice.

This study's findings can provide university administrators and teachers with several important insights and recommendations regarding how to improve student engagement and performance. First, given our finding that the relationship between students' seating location and their academic performance is moderated by other contextual factors, teachers should abandon the thought that sitting in the front guarantees students' high level of academic performance. Their negative bias toward students sitting at the back of a classroom could turn out to be a self-fulfilling prophecy (Brophy, 1983). We suggest that this vicious cycle can be ended through teachers' continued education and professional development.

Second, classroom seating arrangements should be tailored to the various pedagogical and learning outcome demands of individual academic disciplines. By creating specific classroom and pedagogy designs for different academic disciplines, we think that universities can maximize students' learning opportunities and outcomes. We think that a more flexible classroom set-up

would be most beneficial for students in soft fields—allowing teachers to rearrange classrooms will help engage students (Henshaw et al., 2011) and improve their learning outcomes.

Various universities have redesigned the layout of their classrooms to apply these and similar findings to maximum effect. For example, Iowa State University uses swivel seats in a large lecture hall to encourage student interactions (Ogilvie, 2008), as does the University of North Carolina (Henshaw et al., 2011). These changes allow students to interact more and, in the latter case (where aisle space is left between each seat), facilitates teachers' physical proximity to students. However, the use of swivel seats still retains the row and column seating arrangement; other universities have dramatically reorganized seating arrangements into groups or clusters to great effect (Kaya & Burgess, 2007).

Researchers at the City University of Hong Kong have also examined active learning classrooms' (ALCs) impact on teaching and learning (Chiu & Cheng, 2016). ALCs feature movable, round tables and allow students to form small groups and have been shown to encourage interaction among students and teachers alike. Some universities have designed technology-infused ALCs. For example, at the University of Hong Kong, classroom walls are equipped with LCD TVs and moveable teacher stations, both of which facilitate small group discussions (Salter et al., 2013). This design has also been successfully implemented at the University of Iowa (Van Horn et al., 2012). Our study and the studies mentioned here suggest that round tables and moveable furniture can improve students' engagement and learning outcomes, and that the more teachers can move around the room and interact with students, the better.

Conclusion

This study highlighted how the relationship between university students' seating location and their academic performance is moderated by academic discipline. It contributes to the literature by validating previous studies' finding that students' seating location does not universally predict

their academic performance. However, it has several limitations that might be overcome by future researchers.

First, this study's cross-sectional design can only capture the relationship between seating location, academic performance, and academic disciplines at a given point in time (Sedgwick, 2014). Future researchers might use a longitudinal study design to better understand the underlying mechanisms that drive our theoretical model.

Second, this study focuses only the influence of a classroom's physical parameters; it does not address potential psychological parameters, such as students' seating preferences (Benedict & Hoag, 2004), motivation and engagement (Shernof et al., 2017), and personality (Totusek & Staton-Spicer, 1982). These psychological factors may partially explain academic disciplines' modifying effect, and could be covered in future studies simultaneously under the framework of moderated mediation analysis.

Third, the respondent sample in this study only included students from four academic disciplines. Future studies could do similar research on respondents from more academic disciplines to increase the representativeness and generalizability of the findings.

Finally, this study did not consider cultural factors that affect students' behavior and academic performance. Given that cultural factors have a strong influence on students' performance and their perception of and preferences for seating location (Haghighi & Jusan, 2012), this should also be considered in future work.

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Compliance with ethical standards

This study was approved by the Human Research Ethics Committee of the Hong Kong Polytechnic University (Reference: HSEARS20180205002). All study participants provided informed consent.

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Disclosure statement

The authors have no conflicts of interest to declare.

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