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The Impact of Student Engagement and Motivation in the Statistics Learning Process

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Abstract

The aim of the present exploratory study was to examine students' situational engagement and motivation in the statistics classroom at Zayed University, in Dubai, United Arab Emirates (UAE). Two instruments were used for this purpose: a) experience sampling method (ESM), and b) the validated Mathematics Motivation Questionnaire (MMQ). This study employed two samples, at undergraduate level (2nd and 4th Semesters). Participants consisted of 100 students enrolled in Statistics I and Statistics II (Probability and Structure of Randomness). The results indicate that, apart from challenge and effort, emotional engagement is not significantly different across different activities. The results also indicate increases in intrinsic value and utility value and decreases in test anxiety. Finally, results indicate higher engagement and effort when social interaction is purposely planned and fostered, such as in small groups. On the contrary, individual class activities seem to generate slightly lower levels of engagement and effort. These findings have significant implications for educators and researchers who seek to enhance students' engagement and motivation in their statistics courses.

Keywords

Situational engagement; motivation; statistics; Higher Education

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El impacto del Compromiso y la Motivación de los Estudiantes en el Proceso de Aprendizaje de la Estadística

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Resumen

El objetivo del presente estudio exploratorio fue examinar el compromiso situacional y la motivación de los estudiantes en el aula de estadística de la Universidad Zayed, en Dubai, Emiratos Árabes Unidos (EAU). Para ello se utilizaron dos instrumentos: a) método de muestreo de experiencia (ESM), y b) el Cuestionario de Motivación Matemática (MMQ) validado. Este estudio empleó dos muestras, a nivel de pregrado (2º y 4º Semestres). Los participantes consistieron en 100 estudiantes matriculados en Estadística I y Estadística II (Probabilidad y Estructura de la Aleatoriedad). Los resultados indican que, además Del desafío y el esfuerzo, el compromiso emocional no es significativamente diferente entre las diferentes actividades. Los resultados también indican aumentos en el valor intrínseco y el valor de utilidad y disminuciones en la ansiedad ante los exámenes. Finalmente, los resultados indican un mayor compromiso y esfuerzo cuando la interacción social se planifica y fomenta deliberadamente, como en grupos pequeños. Por el contrario, las actividades individuales de clase parecen generar niveles ligeramente más bajos de compromiso y esfuerzo. Estos hallazgos tienen implicaciones significativas para los educadores e investigadores que buscan mejorar el compromiso y la motivación de los estudiantes en sus cursos de estadística.

Palabras clave

Compromiso situacional; motivación; estadísticas; Educación Superior

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The study of student situational engagement and motivation is gaining increased traction in the research literature. Situational engagement is contextual and is often described as moments in time when students are entirely focused on a teaching and learning activity (Inkinen et al., 2020) and experience important levels of challenge, skill, and interest (Pietsch et al., 2020). A considerable amount of literature has been published on engagement. These studies have however mainly focused on *overall* engagement, cognitive, behavioral, or emotional engagement in regular classrooms at undergraduate level (McKellar et al., 2020; Bond et al., 2020). More recently, several studies have begun to examine *momentary engagement* in science classes and *optimal learning moments* (Salmela-Aro et al., 2021; Tang et al., 2020; Rosenberg et al., 2020; Bocquet et al., 2019) posited that students experienced elevated levels of situational engagement during approximately 15% of the time spent in the classroom. What is less clear is what happens during the remaining 85% of the time. Although there is emerging qualitative and quantitative research on situational engagement and motivation in various disciplines and published research in which motivation and/or engagement in the mathematics classroom at university level were investigated, assessed, or measured, (Minhaj et al., 2022; Lim & Rasul, 2022; Moustafa et al., 2022; Park et al., 2021) a search of the literature revealed a paucity of studies which (a) seek to answer the research questions and (b) use the methodology set for this study 1. At tertiary level, 2. In the statistics classroom, and 3. In the context of the UAE. The present study seeks to address this gap, as it contributes to literature by combining situational measures of engagement in the mathematics/statistics classroom using the Experience Sampling Method (ESM) and the Mathematics Motivation Questionnaire (MMQ). This article has been divided into five sections. The first section deals with the literature review and gives a brief overview of situational engagement and motivation. The second section is concerned with methodology. Section three presents and analyses the results. The fourth section discusses the results and presents its limitations. Section five concludes the study.

Research on situational engagement originates in the concept of *flow,* “the experience of complete absorption in the present moment”(Kotler et al., 2022). According to flow theory, a *flow moment* emerges when there is an activity with clear goals and immediate feedback. It requires a dynamic fragile equilibrium of intense focused concentration, driven by interest (in the subject area, topic, and domain, teaching and learning activity), perceived skill/capabilities, and challenge (tasks that provide opportunities for action) (van den Hout et al., 2018). The flow moment can be sustained (often referred as *directed motivational currents*) or repeated only if students continue to progressively engage with more complex activities, tasks, challenges. That is, to be actively engaged and motivated in a teaching and learning activity face-to-face (F2F) and/or online, students should experience (1) situational interest, which sets the foundation for continuing motivation and subsequent learning (Shaltoni et al., 2017), (2) challenge in the activity or task, and Should perceive that they have the (acquired) skill or competence (s) to tackle the task (Hoogkamer et al., 2018) have shown for instance that discussing and/or solving a math problem individually, with a classmate or within a group can trigger situational interest and engagement. Results of a study by Tzafilkou et al., (2021) showed that a flow experience had direct and indirect positive consequences on the achievement of the learning outcomes. Additionally Kundu,

(2020) argued that intrinsic motivation, self-efficacy, flow experience, and learning progress, were positively correlated. As student engagement in learning is often intricate, the concept of flow has been investigated in several modalities (online, blended) and in various contexts (Mamun et al., 2020; Hilliard et al., 2020) to identify similarities. Degnan et al., (2020) uncovered for instance a series of flow-paths and patterns related to the online interactions that occurred in the classroom. Several patterns of situational engagement were also identified by Salmela-Aro et al., (2021) in F2F classes, which indicates that levels of engagement (and experience) within and between students in one classroom and with similar tasks can vary significantly (Vijenthira et al., 2020)

Expectancy value theory is a psychological model that describes how individuals make decisions. The theory posits that people evaluate different options by considering the expected outcome (the average outcome if the option were chosen many times) and the value (or desirability) of that outcome. The overall evaluation of an option is the product of these two factors: the expectancy value. Expectancy-value theory (Eccles et al., 1983) is also a key theory on student motivation and achievement. Expectancy value theory can therefore be used to understand and predict a wide range of behaviors, including educational choices, career decisions, and health behaviors. Additionally, it can help to explain why people may choose to engage in certain activities despite the potential costs or challenges involved. According to EVT, the expected value of an action is determined by two factors: the probability that a particular outcome will occur, and the value that the person places on that outcome. EVT posits that (1) expectancies students have about their success in a specific task ("Can I actually do this task?"), a positive answer would predict better performance and increased motivation to select more challenging tasks (Schunk & DiBenedetto, 2020), and (2) *reasons* or task-related value beliefs ("Why should I do this task?") are critical to student engagement and motivation in the classroom. Recent research indicated however that (a) engagement is malleable (Bocquet et al., 2019) and (b) motivation also often fluctuates during class periods. To reflect these latest findings, relabeled EVT as Situated Expectancy-Value Theory (SEVT) to give higher prominence to the fact that expectancy-value beliefs are "situationally sensitive and interact over short periods of time" (Wigfield & Eccles, 2020).

Purpose of the Study and Research Questions. The overall aim of the current study was to build on previous research by investigating situational engagement and motivation in the statistics classroom at university level in the UAE. For the purposes of this study, the authors adopted (Rychlowska et al., 2017)' definition of motivation "as the inclination, energy, emotion, and drive relevant to learning, working effectively, and achieving. The present study sought answers to the following three research question: RQ1. To what degree are students in the statistics classroom situationally engaged and motivated? RQ2. Does the type of activity students were engaged in influence their level of engagement, effort, persistence, experience of flow, and anxiety? RQ3. Is there a correlation between the levels of engagement across different dimensions of the situational engagement?

Methodology

Participants and Procedure. This study used two convenience and purposeful samples, at undergraduate level (2nd and 4th Semesters), at Zayed University (ZU) in Dubai, UAE. The first sample comprised of 17 students in a 4th semester Statistics Course (Statistics II), with a Mean age *M*= 19, SD ± 0.87; range: 17-21 years. Demographics (17.6% male / 82.4% female). Overall, the first sample data comprised 38 Survey responses (MMQ) and 108 ESM responses. The second sample consisted of 61 students in a 2nd semester Statistics Course (Statistics I), with a Mean age *M* = 17.9, SD ±0.78; range: 17-21 years. Demographics (9.8%, 90.2 % female). Overall, the second sample data consisted of 146 Survey responses (MMQ) and 391 ESM responses. The class length was 90 minutes for both samples. Ethical clearance was sought and obtained on 27 November 2022. [Ethics Approval Number: ZU22_089_F]. A consent form was sent to all participating students for signature, before starting the experiment. McColskey, (2012) argued that "most current methods" did "not adequately capture the dynamic and interactive nature of engagement". Dekker et al., (2020) stated that situational engagement was "often studied using single time-point surveys—which may not account for the dynamic nature of learners' situational engagement".

Others such as Pieske et al., (2019) indicated that retrospective surveys were not as accurate as Experience Sampling Method (ESM). As they often under-reported negative experiences and over-reported positive experiences. This study therefore used (1) the Mathematics Motivation Questionnaire or MMQ (Golden et al., 2021). (2) Experience Sampling Method (ESM) to collect, by means of self-report, actual, real-time data for three weeks. MMQ: Originally designed to gauge secondary students' motivation in mathematics classes, the 19-item validated MMQ was adapted by Breland et al., (2023) from the 25-item validated SMQ (Science Motivation Questionnaire) designed (Komperda et al., 2020). The nonlinear SEM reliability coefficients of the five MMQ constructs indicate well to excellent values and range from .76 to .91. Cronbach's α for the five constructs are: Intrinsic value (3 items, .85); Self-regulation (4 items, .72); Self-efficacy (4 items, .86); Utility value (4 items, .89); Test anxiety (4 items, .78). Considering that results above 0.7 are deemed acceptable, a value close to .9 suggests that the consistency of the results obtained by the MMQ questionnaire was relatively high.

ESM was used to capture graduate students' situational engagement and motivation in math classrooms, *in situ/online* and in the moment (s) they were occurring Adler & Pansky, (2020) to minimize memory biases. Students were asked to specify whether they were [in the classroom] or [online]. Measures. MMQ: The 19 items of the MMQ are divided into 5 categories: (a) intrinsic value, described by Wigfield & Eccles, (2020) as "anticipated enjoyment one expects to gain from doing the task or purposes of making choices and as the enjoyment one gets when doing the task" (p. 11); (b) self-regulation; (c) self-efficacy; (d) utility value, or "how well a particular task fits into an individual's present or future plans" and (e) test anxiety. Example items were "I like math that challenges me" (intrinsic value), "I put enough effort into learning the math" (self-regulation), "I believe I can master the knowledge and skills in the math course" (self-efficacy), "I think about how learning math can help my career" (unity value), and "I am nervous about how I will do on the math tests" (test anxiety). A demographics section was added to the MMQ and collected information about participants' gender, nationality (Emirati/non-Emirati), year of study, GPA, major, number and titles of mathematics courses currently taken and most recent score at a math exam.

The MMQ was administered online on 30 January 2023 (= start of the experiment, *pre*) and a second time on 19 February 2023 (= three weeks later, *post*). ESM: Interval contingent notification triggers (Van Berkel et al., 2017) - *experience* questions (one-to-five Likert scales) were simultaneously sent to all students (online and face-to-face) by email (Google forms) at 45 minutes (into the class, break time) for all samples and one question and 4 statement items were sent to all samples at the end of each class with a notification expiry time set at 5 minutes, to reduce participants' burden and avoid interrupting students' situational engagement. Research by Natarajan et al., (2020) on 200 million notifications from more than 40,000 users, indicated that the probability of a participant not clicking on a notification five minutes after receiving it was 17%. Students were asked (1) to give thought to and reflect on the lecture and the activities of the past minutes and (2) to rate the items within 5 minutes. Then they were asked similar questions at the end of the class. See Tables A and B in the Appendix.

Analytic Plan. Statistical analysis. The collected data were coded, entered, and analyzed using the Statistical package SPSS version 28. Statistical tests with p–values < 0.05 were considered statistically significant. Descriptive statistics were employed to describe all items of the questionnaire. T-tests, paired t-test, or ANOVA were also used by examining the correlations between the different constructs measured by the Likert scale items. For the MMQ, we computed mean and standard deviation for each statement that were all positively worded, then we constructed the below subscales:

Intrinsic Value (Items 1-3), Self-Regulation (Items 4-7), Self-Efficacy (Items 8-11), Utility-Value (Items 12-15), and Test Anxiety (Items 16-19). To score each subscale, the mean score (and standard deviation) of the statements that belong to each subscale was calculated, without the need to reverse-score any statement. For the ESM scale, the average scores for the dimensions for both the ESM at 45 minutes and the ESM were computed at the end of class.

Results

Demographic Characteristics

100 students enrolled in two classes were selected for the experiment. Out of the 100 students, 78 answered the demographic survey, leading a sample size of 78, with 88.5% being female and 11.5% male. Table 1 shows that most participants are in their first year of study (78.2%), while the rest are in their second year. Most participants are Emirati (96.2%), while only a small percentage are non-Emirati. In terms of high school type, most participants attended private schools (59%), followed by public schools (34.6%), and a small percentage attended both. Regarding majors, the most popular one is Computational Systems (56.4%), followed by Business Transformation (28.2%), Social Innovation (11.5%), and Sustainability (3.8%). Lastly, in terms of courses, most participants were enrolled in Statistics I (78.2%),

while 21.8% were enrolled in the Probability and Structure of Randomness course (Statistics II).

Table 1

Demographic Characteristics of Participants

Variable	Labels	Total Participants	
		No.	%
Gender	Female	69	88.5
	Male	9	11.5
Study year	1st year	61	78.2
	2nd year	17	21.8
Nationality	Emirati	75	96.2
	Non-Emirati	3	3.8
Type of High School	Public	27	34.6
	Private	46	59.0
	Both Public and Private	5	6.4
	Public	27	34.6
Major	Computational Systems	44	56.4
	Business Transformation	22	28.2
	Social Innovation	9	11.5
	Sustainability	3	3.8
Course	Statistics I	61	78.2
	Statistics II	17	21.8

Table 2 provides additional information about the participants (age, *experience* with Math, GPA).

Table 2

Participants' Characteristics

Variable	No.	Minimum	Maximum	Mean	Std. Deviation
Age	78	17	21	18.15	.913
How many mathematics courses did you take in high School?	78	1	12	3.47	2.771
What was your score on the mathematics section of the EmSAT (The Emirates Standardized Test)?	69	580	2000	991.68	254.210
How many mathematics Courses have you taken at ZU?	78	1	7	1.62	1.108
Current (semester) GPA	74	1	4	3.45	.610

MMQ

First, the descriptive statistics for the MMQ statements were calculated: Out of the 100 students enrolled in the study, 84 were present during the start of the experiment, while all of them were present during the last day of the experiment. This explains the difference in the total number of answers between MMQ-Start and MMQ-End, as shown in Table 3.

Table 3

Comparison of MMQ Scores between Start and End of Experiment: Student Attitudes towards Learning Math

MMQ Items	MMQ-Start (N=84) Mean	MMQ-Start (N=84) Std. Deviation	MMQ-End (N=100) Mean	MMQ-End (N=100) Std. Deviation
1. I enjoy learning math	3.56	1.29	3.58	1.30
2. I find learning math interesting	3.56	1.27	3.68	1.24
3. I like math that challenges me	3.15	1.40	3.30	1.31
4. I put enough effort into learning the math	4.00	1.02	4.03	1.11
5. If I am having trouble learning the math, I try to figure out why	3.64	1.22	3.69	1.16
6. I use strategies that ensure I learn math well	3.76	1.05	3.81	1.05
7. I prepare well for math tests and quizzes	3.99	1.18	3.9	1.03
8. I am confident I will do well on math assignments and projects	3.63	1.04	3.71	1.10
9. I am confident I will do well on math tests	3.62	1.16	3.49	1.15
10. I believe I can master the knowledge and skills in the math course	3.76	1.13	3.76	1.14
11. I believe I can earn a grade of “A” in the math course	4.01	1.04	3.84	1.23
12. I think about how the math I learn will be helpful to me	3.59	1.20	3.58	1.27
13. I think about how I will use math I learn	3.42	1.22	3.51	1.27
14. I think about how learning math can help me	3.50	1.24	3.61	1.27
15. I think about how learning math can career help my career	3.69	1.15	3.64	1.22
16. I become anxious when it is time to take a math test	3.63	1.26	3.33	1.30
17. I am nervous about how I will do on the math tests	3.58	1.25	3.29	1.27
18. I worry about failing math tests	3.29	1.52	2.83	1.41
19. I am concerned that the other students are better in math	2.94	1.43	2.67	1.30

Analysis of the MMQ-Start data revealed that the students had moderately high levels of motivation for learning math. The mean scores for each item ranged from 2.94 to 4.01, with a standard deviation ranging from 1.02 to 1.52. Notably, the students reported the highest levels of motivation for "putting enough effort into learning math" (mean = 4.00) and the lowest levels of motivation for "being concerned that other students are better in math" (mean = 2.94). Items 13, 14, and 15, which relate to how learners perceive the usefulness of math in their lives and career, have high mean scores, suggesting that respondents are motivated to learn math because they see its relevance to their future. On the other hand, items 17 and 18, which reflect anxiety and worry towards math tests and performance, have lower mean scores compared to other items, indicating that respondents are less anxious about math tests at MMQ-End than MMQ-Start.

Analysis of the MMQ-End data revealed a slight decrease in the students' motivation levels for learning math. The mean scores for each item ranged from 2.67 to 3.84, with a standard deviation ranging from 1.03 to 1.41. Notably, the students reported the highest levels of motivation for "preparing well for math tests and quizzes" (mean = 3.90) and the lowest levels of motivation for "being concerned about failing math tests" (mean = 2.83). Overall, the results suggest that the students had moderately high levels of motivation for learning math at the beginning of the course, but that their motivation levels decreased slightly by the end of the three weeks. These findings may have implications for math educators and suggest the need for interventions to sustain students' motivation levels throughout the course.

Next, we calculated the descriptive statistics for the constructs, i.e., MMQ Dimensions, as shown in

Table 4

Comparison of MMQ Dimension Scores at Start and End of Experiment

	MMQ-Start		**MMQ-End**		
		(N=84)		(N=100)	
MMQ Dimensions	Mean	SD	Mean	SD	P-Value (Paired t-test)
Intrinsic Value	3.42	1.22	3.52	1.21	0.439
Self-Regulation	3.85	0.86	3.86	0.89	0.864
Self-Efficacy	3.76	0.96	3.69	1.06	0.783
Utility Value	3.55	1.03	3.58	1.13	0.815
Test Anxiety	3.36	1.13	3.03	1.12	0.033

Table 4 shows that the mean scores for all five subscales slightly increased or remained stable from MMQ-Start to MMQ-End. The standard deviations for each subscale were relatively consistent across MMQ-Start and MMQ-End, indicating that the variability in responses did not change significantly over time. However, the Test Anxiety subscale showed a notable decrease in mean score from MMQ-Start to MMQ-End. These results suggest that the study had a positive impact on students' attitudes towards math learning and reduced their test anxiety levels. In terms of intrinsic value, there was a slight increase in mean scores from 3.42 to 3.52, indicating that students may have found math more enjoyable and interesting as they progressed through the study. This is a positive result as intrinsic motivation is a key factor in learning and academic achievement. The self-regulation subscale showed no significant change, with mean scores remaining consistent at 3.85 and 3.86. This indicates that students maintained their level of effort and use of learning strategies throughout the study. The self-efficacy subscale showed a slight decrease in mean scores from 3.76 to 3.69. This could indicate that students may have become less confident in their ability to learn math as they progressed through the study. However, the difference in mean scores is not large enough to draw any definitive conclusions. The utility value subscale showed a small increase in mean scores from 3.55 to 3.58. This suggests that students may have become more aware of the usefulness of math in their lives and future careers as they progressed through the study.

Finally, the test anxiety subscale showed a significant decrease in mean scores from 3.36 to 3.03. This is a positive result as it indicates that students may have become less anxious about math tests as they progressed through the study. As it can be seen from Table 4, there is a significant difference between the means of MMQ-Start and MMQ-End for the Test Anxiety subscale (p=0.033). The mean score for Test Anxiety decreased from 3.36 (SD=1.13) at MMQ-Start to 3.03 (SD=1.12) at MMQ-End, indicating that students reported less anxiety towards math tests after completing the study. For the other subscales (Intrinsic

Value, Self-Regulation, Self-Efficacy, and Utility-Value), there is no significant difference between the means of MMQ-Start and MMQ-End. The mean scores for these subscales remained relatively stable over time, indicating that the intervention did not significantly affect students' motivation towards math in these areas.

The results suggest that the intervention was effective in reducing students' anxiety towards math tests but did not significantly impact their motivation towards other aspects of learning math. To answer RQ1, MMQ scores were computed, which is the average of all items in the MMQ scale (MMQ-End). The mean score of 3.54 on the MMQ suggests that, on average, students have a moderate level of motivation and engagement in mathematics. The standard deviation of 0.71 indicates that there is some variability in the scores, with some students having higher levels of motivation and engagement than others. A t-test to compare the mean scores on the MMQ across different groups of students was run, such as by semester of study and course enrollment. The t-test was 2.153 (p-value= 0.031) indicating a statistically significant difference in the mean MMQ scores between students in their second or fourth semester of study. Therefore, based on these results, it can be concluded that students in their fourth semester of study, enrolled in Statistics II (mean of 3.80), have a significantly different level of situational engagement and motivation than students in their second semester of study enrolled in Statistics I (mean of 3.45). T-tests were then used to compare the mean scores on the MMQ's five subscales across different groups of students, the two groups are by semester of study and by course level. The results are summarized in Table 5.

Table 5

Comparison of MMQ Subscale Mean Scores Across Different Groups of Students

	P-value	**t**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
					Lower	Upper
Intrinsic Value	0.07	1.66	0.46	0.28	-0.09	1.01
Self-Regulation	0.05	0.97	0.20	0.21	-0.21	0.61
Self-Efficacy	<0.001	2.98	0.70	0.24	0.24	1.17
Utility-Value	0.40	2.14	0.55	0.26	0.04	1.06
Test Anxiety	0.23	-0.56	-0.14	0.26	-0.66	0.37

For the Intrinsic Value, Utility-Value, and Test Anxiety subscales, the t-tests were not significant at the 0.05 level (p-value of 0.07, 0.40, and 0.23 respectively). This suggests that there may be no statistically significant differences in mean scores between the two groups being compared, by semester of study, and by course as well. For the Self-Regulation and Self-Efficacy subscales, t-tests were significant (p-value of 0.05 and p-value < 0.001 respectively), suggesting that there is a statistically significant difference in mean scores between the two groups (per semester of study and by course).

Table 6 presents the frequency and percentage of the types of activities that students reported engaging in during the last few minutes of the class at two different time points: 45 minutes into the class and at the end of the class. At 45 minutes into the class, the most frequently reported activities were calculating and collaborating in small groups, each reported by 31.5% of students, followed by listening (24.1%). On the other hand, at the end of the class, the most frequently reported activity was listening (38.9%), followed by collaborating in small groups (27.8%) and writing (9.3%). These results suggest that the types of activities that students engage in change over the course of the class, with a shift towards more listening and less calculating as the class progresses.

Table 6

A Comparison of Student Activities at 45 Minutes and End of Class

Activity	ESM at 45 minutes (N=277)		ESM end of class (N=222)	
	Frequency	%	Frequency	%
Calculate	90	32.5	37	16.7
Write	22	7.9	29	13.1
Listen	60	21.7	55	24.8
Collaborate	51	18.4	63	28.4
Explain	2	.7	6	2.7
Interpret	45	16.2	26	11.7
Other (for instance asking questions, Design scientific inquiry, etc.)	7	2.5	6	2.7

The differences in situational engagement based on the type of activity have been studied by several authors (Juuti et al., 2021). However, it has not been done in the context of university mathematics/ statistics courses. To fill this gap in the literature, we measured situational level of interest, challenge, motivation, and importance in student studies and future goals with respect to several common classroom activities. The Experience Sampling Method was carried out twice during each lecture - once at the 45min mark and once at the end of the lecture. The summary of the results collected at the 45-minute mark is presented in Table 7.

As shown in Table 7, the mean level of interest, challenge, and motivation differs across activities. There is no single activity that dominates situational engagement across different dimensions. Listening was the highest rated activity in terms of interest. Surprisingly, listening was also deemed as the most challenging activity followed closely by calculating. Calculating was also rated as the most motivating activity. Other activities were deemed the most important for students' studies and future goals. The p-values of one-way ANOVA test are shown in the last column of Table 7. Since all the p-values are above 0.05, the results show that there is no significant difference in the sample means of the activities. Concretely, the results suggest that all the activities hold the same level of interest, challenge, motivation, and importance in studies and goals. The lack of difference between calculating and other activities is a somewhat surprising revelation given that calculating is at the core of mathematics. Moreover, calculating is traditionally believed to be the most challenging activity in mathematics courses. However, this belief is not supported by our results, as other activities such as listening and interpreting are rated equally challenging by the students.

Table 7

Comparison of average levels of situational engagement across different classroom activities as measured at the 45-minute mark

Activity	Calculate	Write	Listen	Collaborate	Interpret	Other	p-value
Frequency	90	22	60	51	45	7	
Interesting	3.62	3.36	3.88	3.53	3.42	3.14	0.193
Challenging	3.52	3.18	3.57	3.31	3.42	2.29	0.068
Motivating	3.33	2.73	2.97	3.12	3.20	3.00	0.195
Studies	4.14	3.95	4.23	4.12	4.00	4.71	0.454
Goals	3.46	3.36	3.57	3.14	3.40	3.86	0.403

The summary of the results collected at the end of the lecture is presented in Table 8. Students' situational engagement, effort, desire to continue the activity, and involvement are measured for various activities performed at the end of the lecture. As shown in Table 8, calculating, interpreting data, and other activities are rated as the most engaging while explaining is rated the lowest. Calculating is the highest rated activity in terms of effort, followed by other activities and interpreting. The results show that while calculating is often rated near the top of situational dimensions, there is no significant separation between calculating and the remaining activities. Since all the p-values are above 0.05, there is no statistically significant difference in sample means of the activities across different situational dimensions. Specifically, there is no evidence in our results to suggest that calculating required more effort than the other activities. As mentioned above, it is a surprising observation, given that calculating is traditionally considered as the activity which requires the most effort. The results collected at the end of the lecture are in line with those collected at the 45-minute mark. This suggests that the differences in engagement scores were primarily due to individual differences rather than the activities themselves. The lack of significant differences between the activities indicates that engagement levels were consistent regardless of the activity in which participants were engaged in. The same applies to all other dimensions of the ESM.

Table 8

Comparison of average levels of situational engagement across different classroom activities as measured at the end of the class

Activity	Calculate	Write	Listen	Collaborate	Explain	Interpret	Other	p-value
Frequency	37	29	55	63	6	26	6	
Engaged	4.00	3.90	3.82	4.08	3.67	4.08	4.00	0.657
Effort	4.24	3.90	3.93	3.92	3.17	4.04	4.17	0.098
Continue	3.76	3.31	3.27	3.63	3.50	3.42	3.83	0.322
Involved	3.54	3.28	3.09	3.54	3.00	3.23	4.17	0.108

Next, to answer RQ2, frequency and percentage of each response for each activity were computed from those who answered *true for me* and *very true for me* to the ESM-END, as shown in Table 9.

Table 9

A Comparison of Student Activities at 45 Minutes and End of Class

Activity	I was engaged with the topic at hand	I put in a lot of effort	I wish we could still continue with the work for a while	I was so involved that I forgot everything around me
Calculate (37)	26(70.3%)	30 (81.1%)	23 (62.2%)	17 (45.9%)
Write (29)	17 (58.6%)	19 (65.5%)	13 (44.8%)	11 (37.9%)
Listen (55)	41 (74.5%)	38 (69.1%)	23 (41.8%)	18 (32.7%)
Collaborate (63)	47 (74.6%)	40 (63.5%)	34 (54.0%)	35 (55.6%)
Explain (6)	4 (66.7%)	1 (16.7%)	3 (50.0%)	1 (16.7%)
Interpret (26)	21 (80.8%)	20 (76.9%)	13 (50.0%)	9 (34.6%)
Other (6)	4 (66.7%)	4 (66.7%)	3 (50.0%)	4 (66.7%)

Table 9 indicates that for each of the activities, most participants who answered "true for me" or "very true for me" reported being engaged with the topic at hand. The activity that generated the highest percentage of such responses was collaborating in a small group (74.6%), while the lowest was explaining phenomena scientifically (66.7%). Additionally, for most activities, most participants who answered "true for me" or "very true for me" reported putting in a lot of effort, with the highest percentage being for calculating (81.1%). Regarding the desire to continue with the work, the activity with the highest percentage of positive responses was, again, collaborating in a small group (54%), while the lowest was interpreting data and evidence scientifically (50%). Finally, for the statement "I was so involved that I forgot everything around me," the activity that generated the highest percentage of affirmative responses was, once again, collaborating in a small group (55.6%).

Across all activities, the percentage of participants who reported being engaged with the topic at hand and putting in a lot of effort was generally high. This suggests that the activities were generally effective at capturing participants' attention and encouraging them to invest effort. Furthermore, the activities that involved more open-ended inquiry, such as interpreting data and evidence scientifically and asking questions and designing scientific inquiry, had slightly lower levels of engagement and effort compared to the activities that involved more straightforward tasks, such as calculating and writing.

ESM Dimensions were also examined, as indicated in Table 10, to gauge whether the types of activity students were engaged in influenced their level of engagement, interest, effort, motivation, persistence, experience of flow, being involved**:**

Table 10

Mean Scores of EMS Subscales at 45 Minutes and End of Class

ESM at 45 minutes			**ESM End of Class**		
	(N=277)		**(N=222)**		
Dimension	Mean	SD	Mean	SD	Dimension
Interesting	3.59	1.12	3.96	0.86	Engaged
Challenging	3.42	1.13	3.97	0.83	Effort
Motivating	3.13	1.13	3.50	1.09	Continue
Studies	4.13	0.90	3.36	1.10	(persistence)
Goals	3.41	1.16			Involved

The mean scores for interest, engagement/challenge, effort/motivation, and continuation (persistence) were all higher at the end of the class compared to 45 minutes into the class. Specifically, the mean score for interest was 3.96 (SD=0.86) at the end of the class, compared to 3.59 (SD=1.12) at 45 minutes. The mean score for engagement/challenge was 3.97 (SD=0.83) at the end of the class, compared to 3.42 (SD=1.13) at 45 minutes. The mean score for effort/motivation was 3.50 (SD=1.09) at the end of the class, compared to 3.13 (SD=1.13) at 45 minutes. Finally, the mean score for persistence was 3.84 (SD=0.98) at the end of the class, compared to 3.47 (SD=1.12) at 45 minutes.

The standard deviations for each dimension are similar across the two time points, which suggests that the variability in students' responses did not change significantly over time. Again, a statistical analysis would be needed to confirm this.

Overall, these findings suggest that participants may become more interested, engaged, motivated, and persistent as a class progresses, but the changes may be relatively small. It is also worth noting that these findings are based on self-reported data collected using the ESM, which may be subject to response biases or other limitations. To obtain further insight regarding various dimensions of situational engagement and to attempt to answer RQ3, we considered their pairwise correlations. The results of the ESM at the 45-minute mark are shown in Table 11, where the values above the diagonal represent the Pearson correlation and the values below the diagonal represent the corresponding p-values. As shown in Table 11, all the correlations are relatively weak albeit in most cases statistically significant. The correlation between students' assessment of the level of interest and the level of challenge is 0.00986. The corresponding p-value is 0.87 which indicates that there is no relation between student interest and challenge in the activities. While the lack of relation is expected in certain cases, it is surprising in others. For instance, the correlation between motivation and interest level is 0.16, which is very low. It is a surprising result, given that one would expect student motivation to be strongly correlated with interest in the activity.

Table 11

Pairwise correlations between different dimensions of situational engagement as measured at the 45-minute mark

	Interesting	Challenging	Motivating	Studies	Goals
Interesting	1	0.010	0.163*	0.344*	0.352*
Challenging		1	-0.085	0.161*	0.157*
Motivating			1	0.142*	0.210*
Studies				1	0.376*
Goals					1

Similarly, the pairwise correlations between various dimensions of situational engagement measured at the end of the lecture are presented in Table 12, to answer RQ3. The correlations between different aspects of situational engagement are stronger than in Table 11. In particular, the correlation between the level of engagement in activity and the amount of effort is 0.54. The correlation between the desire to continue an activity and the amount of involvement is 0.58. The relatively strong correlations are expected in some cases while surprising in others. For instance, the correlation between engagement and effort is somewhat surprising given that activities that require a lot of effort may be expected to reduce students' enthusiasm regarding the activity. On the other hand, a low correlation between effort and the desire to continue an activity is less surprising.

Table 12

Pairwise correlations between different dimensions of situational engagement as measured at the end of the class

	Engaged	Effort	Continue	Involved
Engaged	1	0.53754*	0.33554*	0.44686*
Effort	.	1	0.21937*	0.42007*
Continue			1	0.56749*
Involved				1

Comparison of different dimensions of situational engagement between two courses is provided in Tables 13 and 14. As shown in Table 13, there is little difference in situational engagement between the statistics I and statistics II courses measured at the 45-minute mark. The mean values of the engagement levels are similar across all dimensions except *challenge*. The students on the Statistics II course (year 2) found their activities to be on average significantly more challenging, which is normal as this is an advanced course (4th Semester, year 2). Situational engagement in terms of interest, motivation, and importance for their future goals was on average the same for both courses.

Table 13

Comparison of ESM-45 minutes Among Students by Course

Courses	Statistics I	Statistics II	p-value
Frequency	**222**	**53**	
Interesting	3.58	3.68	0.549
Challenging	3.23	4.23	<0.000001
Motivating	3.13	3.15	0.906
Goals	3.41	3.43	0.892

The comparison of situational engagement between the two courses measured at the end of each lecture is presented in Table 14. As shown in Table 14, there is little difference in situational engagement between the two courses. In particular, the mean level of engagement, effort, desire to continue, and involvement is essentially the same for the two courses. The p-values indicate that any difference in values is not statistically significant.

Table 14

Comparison of ESM-End among Students by Course

Course	Statistics I	Statistics II	p-value
Frequency	168	54	
Engaged	4.00	3.85	0.269
Effort	3.98	3.94	0.773
Continue	3.47	3.59	0.473
Involved	3.34	3.43	0.616

Discussion

This exploratory study set out with the aim of investigating situational engagement and motivation in the statistics classroom at university level in the UAE. The present study sought answers to three research questions: (1) to what degree are students in the statistics classroom situationally engaged and motivated? (2) Does the type of activity students were engaged in influence their level of engagement, effort, persistence, experience of flow, and anxiety?, and (3) Is there a correlation between the level of engagement across different dimensions of the situational engagement?

The Mathematics Motivation Questionnaire (MMQ) was administered to 84 students at the beginning of the study and to 100 students at the end of the study to measure changes in their motivation for mathematics. Pre- to post-course comparisons were done by descriptive statistics, T-tests, paired t-test, and/or ANOVA. Additionally, Experience Sampling Method (ESM) was used in each class for three weeks to collect, by means of self-report, real-time data. ESM results standard deviations and Pairwise correlations coefficients were analyzed to obtain further insight regarding various dimensions of situational engagement.

With respect to the first research question, a slight increase in mean scores for intrinsic value was found, indicating that students found math more enjoyable and interesting as they progressed through the course. The self-regulation subscale showed no significant change, indicating that students maintained their level of effort and use of learning strategies throughout the course. The self-efficacy subscale showed a slight decrease in mean scores, suggesting that students may have become less confident in their ability to learn math as they progressed through the course. The utility value subscale showed a small increase in mean scores, indicating that students may have become more aware of the usefulness of math in their lives and future careers (EVT's "Why should I do this task?"). Finally, the most obvious finding to emerge from the analysis is that the test anxiety subscale showed a significant decrease in mean scores, indicating that students became less anxious about math tests as they progressed through the study.

Overall, the results suggest that students' motivation for and engagement with math improved slightly over the course of the study, with increases in intrinsic value and utility value, and decreases in test anxiety. However, there were no significant changes in self-regulation and self-efficacy. These findings have important implications for educators and researchers in the field of mathematics education who seek to enhance students' motivation for mathematics, and more specifically statistics.

With respect to the second research question, consistent with literature (Alexander et al., 2017; Paavola et al., 2018; Hultberg, 2018; Hoogkamer et al., 2018) based on the frequency and percentage of each response for each activity, this research found that participants' levels of (emotional) engagement and [effort] for the activities that involved more classroom interaction (e.g., small cooperative group work) were consistently higher. Conversely, activities that were more individually focused, such as explaining phenomena scientifically, seemed to generate slightly lower levels of engagement and effort. Another trend that was observed is that participants' desire to continue with the work for a while after the end of the activity appears [persistence] to be lower overall, with only about half of the participants indicating a desire to continue for most activities. Additionally, for most activities, fewer participants reported being so involved [flow] that they forgot everything around them, suggesting that while participants were engaged with the class and the active learning activities, they were still aware of their surroundings to some extent. With respect to the third research question, what stands out in the ESM dimensions results is that students may become more interested, engaged, motivated, and persistent as a statistics class progresses, which may be due to increased student-student and student-professor interactivity. However, the differences between the means for each dimension are relatively small, ranging from 0.37 to 0.84, which indicates that the changes in these dimensions over time may not be large or significant. Future research could use more rigorous statistical analyses to confirm these findings and explore potential moderators of the observed changes in students' experiences over time.

Practical implications

Situational engagement in the statistics classroom is undoubtedly multifaceted, contextual, and dynamic. Based on our results, we propose several implications for practice. First, stronger emotional engagement with statistics courses can be fostered by purposely designing classroom opportunities that create and maximize interaction amongst academics and students (e.g., active lecturing, teamwork with active guidance). Second, increasing the number of problem-solving formative assessments (problem-based teaching, e.g., *calculating*, and *interpreting data*, rated as the most motivating and engaging activities), providing, and discussing constructive feedback, in class and among students, may help students comprehend and better synthesize content, may further decrease test anxiety, and thus improve class experience, cognitive and behavioral engagement, satisfaction, self-efficacy, and motivation. Third, as *listening* was rated very high in terms of interest but considered the most challenging activity, we recommend chunking every lecture with active learning strategies as advocated by Liebowitz & Porter, (2019) in a meta-analysis of 225 studies of undergraduate education across all the STEM areas, by for instance asking students to (a) apply statistics to authentic phenomena that may be of interest to them, such as climate change, inflation, wealth distribution, healthcare, etc., (b) use Python tools such as Jupyter Notebook or SymPy (Kamalov et al., 2023), (c) explain data visualizations, (d) practice statistical modelling, etc.). Finally, as *explaining* was rated “most challenging” and “least engaging”, providing additional opportunities to present in pairs or teams with peer and instructor feedback may boost students’ confidence and improve their expectancies about their success in a specific task (EVT’s “Can I actually do this task?”).

Limitations

The scope of this study was limited in terms of institution (n=1), the number of participants, and course availability. With a small purposive sample size, caution must be applied, as the findings cannot be extrapolated to all contexts, all students in all statistics courses. Additionally, despite using ESM to help reduce general recall bias, as survey respondents participated of their own volition, there may be possible self-selection bias in the resulting data. A natural progression of this work would be to use multiple sources of data, such as behavioral observations or physiological measures, to assess students’ experiences more objectively in the classroom.

Conclusion

This exploratory study has identified significant factors that impact on situational engagement and motivation in the statistics classroom, including instructor-student and student-student interactions, varied active learning strategies, tools and activities, and application of knowledge to real phenomena. These actionable insights could be used to inform instructional design and classroom management in statistics courses to better align with student engagement and preferences.

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