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Student Perceptions of Instructional Activities, Engagement, and Performance in an Undergraduate Systems Analysis and Design Course*

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Scholarship in engineering education has emphasized the use of instructional activities based on active learning approaches to improve student engagement and performance. While the literature in engineering education generally supports the effectiveness of active learning, its effectiveness in computer science has yielded mixed results. Most of these mixed results are attributed to the design and implementation of instructional activities. It is thus important to capture students' perceptions of the design and the outcomes of these activities. In this study, following the Interactive, Constructive, Active (also known as Attentive), and Passive (ICAP) framework, we examined students' perceptions (N = 88) of instructional activities and their engagement in an undergraduate computer science course (i.e., systems analysis and design). Specifically, we examined the relationship between student perceptions of instructional activities, performance, and engagement. We also investigated the combined impact of instructional activities and engagement on performance. The findings showed that instructional activities statistically significantly predicted engagement. Contrary to earlier studies on the ICAP framework and in alignment with literature on computer science, there was no statistically significant impact of instructional activities and engagement on student performance. Moreover, no statistically significant interaction effect between instructional activities and engagement was observed on student performance. The results offer novel insights into the subjective nature of instructional activities and students' preferences for these activities. The paper situates the findings within the context of previous literature. Implications and considerations for educators are discussed for the design and implementation of active learning activities.

Keywords: active learning; ICAP framework; engagement; student perceptions; performance

1. Introduction

Prior research has shown that traditional modes of instruction (e.g., lecturing only) often cannot effectively foster a deep understanding of the subject matter [1, 2]. When such instructional strategies are employed in classrooms, students often exhibit reduced engagement and struggle to comprehend the material thoroughly [1, 3]. Due to the issues with traditional instructional strategies, studies have emphasized the use of student-centered instructional activities based on active learning approaches [4, 5]. Active learning is the process of acquiring knowledge through participation in class activities, contributing to the learning process, and maintaining physical and mental presence [6, 7]. Studies indicate that such strategies effectively improved students' performance [8, 9] and academic engagement in most cases [10, 11].

Considering the overwhelming body of literature supporting the benefits of active learning, researchers have investigated several instructional approaches based on active learning, including flipped classroom models [12], project-based learning [13], and problem-based learning [14]. However, active learning is an umbrella term, and there are variations within different types of active instructional activities and the resulting outcomes. Prior literature has associated several different cognitive and non-cognitive outcomes with active instructional activities. Some examples include students' academic engagement [10], self-efficacy [15], task value [16], and performance [9]. However, it is noteworthy that most studies have examined the impact of these instructional activities on a single outcome. For example, a common theme was investigating the impact of instructional activities on students' academic performance [8, 9].

By focusing on only one outcome per study, we argue that there exists a possibility of ignoring the combined effect of these instructional activities on students' academic performance and other related outcomes. Considering that student academic engagement is often directly impacted (positively or negatively) by the type of instructional activity, this study focuses on exploring the role of instructional strategies on both students' academic engagement and academic performance. Specifi-

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cally, this study utilizes students' perceptions of their academic engagement to understand how various instructional activities impact student performance. This paper addresses the following research questions.

1. How do students' perceptions of the instructional activities impact their performance and engagement in a systems analysis and design course?
2. Do the types of engagement moderate the relationship between active instructional activities and student performance?

2. Theoretical Framework and Literature Review

This study focuses on three key constructs, i.e., instructional activities, academic engagement, and performance. These constructs are informed by the principles of the Interactive, Constructive, Active (also known as Attentive), Passive (ICAP) framework [17, 18] and student involvement theory [19], both of which form the theoretical foundation for this study. The premise of the ICAP framework allows examination of the relationship between instructional activities, academic engagement, and student performance. Moreover, student involvement theory provides the principles to explore the relationship between different aspects of engagement and performance.

2.1 The ICAP Framework

The ICAP Framework [17, 18] provides a mechanism to classify instructional activities into four modes based on the learner's overt behaviors and their level of engagement: interactive, constructive, active, and passive. Learners in interactive mode co-infer knowledge through dialogue and contribute to one another's understanding, such as through collaboration on a project. Learners in constructive mode perform activities that require them to apply knowledge, which involves self-reflection and making connections between prior knowledge and new knowledge, such as drawing a concept map. Learners in an active/attentive mode (*is not synonymous with active learning*) engage in activities that emphasize their knowledge, thereby filling the gaps in their learning, such as taking notes during a lecture. Lastly, learners in passive mode receive information without overt interaction with the material, such as listening to a lecture.

The first three ICAP modes (interactive, constructive, active) are categorizations of the generic concept of active learning. Broadly, active learning refers to learning characterized by students' engagement and meaningful interaction with the content [20]. During active learning, students tend to be more engaged in the learning process, resulting in improved outcomes [21, 22]. Each ICAP mode is subject to distinct underlying learning processes, resulting in varied learning outcomes [17]. Given the different underlying processes, the ICAP framework hypothesizes that student understanding in an interactive mode is greater than in a constructive mode, which is greater than in an active and attentive mode. Lastly, the passive mode is said to produce the lowest learning outcomes (Interactive > Constructive > Active/Attentive > Passive).

Instructors' adoption of ICAP instructional modes has been observed to have a positive impact on student participation, achievement, and performance [23]. By implementing activities according to the ICAP framework guidelines, instructors can utilize non-conventional mechanisms to improve students' performance. For example, Wiggins and colleagues [24] used interactive activities in an introductory biology course. They asked participating students to make groups and co-generate an understanding of the topic in cell biology among their peers. Results indicated a significant impact on students' performance in knowledge building and better grades compared to students who participated in constructive activities. Similarly, Lim and colleagues [25] validated the ICAP hypothesis among health professionals and found that students demonstrated a better understanding when engaged in active learning activities before discussions.

Although the ICAP hypothesis suggests that students demonstrate higher engagement during interactive activities than other modes, studies have found mixed results. Many studies conducted in undergraduate STEM classes indicate significant gains in engagement and performance when interactive and constructive activities are used over traditional lecture-based instruction [26–28]. Similarly, the passive mode of instruction has been linked to students' distraction [29]. On the other hand, some studies indicate negative or non-significant impacts [30, 31]. For example, Halpern [31] reported that active instructional strategies may not yield the same benefits as previously suggested by research. Also, the stated advantages may vary based on whose perspective we seek (i.e., teacher or student or independent observer) [30, 32, 33] time of evaluation (immediately after engaging in activities or at the end of the semester for short and long-term perspectives), and how we measure their impact (sources and modes of data collection) [34–36].

Building on prior studies that utilize the ICAP framework, this study employs the ICAP framework as a lens to examine the relationship between instructional activities, engagement, and performance. Guided by the ICAP hypothesis, we hypothesize that instructional activities will predict student performance and academic engagement. For brevity, from this point forward, we use 'activity' to refer to instructional activity. Hence, an interactive activity refers to an instructional activity in which students are engaged in an interactive behavioral mode. Similarly, constructive and active activities refer to instructional activities where students are engaged in the constructive and active/attentive modes, respectively.

2.2 Student Involvement Theory

The academic engagement aspect of this study is rooted in the student involvement theory [19], commonly known as student engagement theory, which explains the interconnected nature of engagement and learning. This study utilizes student engagement to investigate the connection between performance and instructional activities. According to student involvement theory, student development and learning are closely tied to academic engagement, where increased engagement is expected to improve learning outcomes (e.g., performance). Based on student involvement theory, student interaction with the environment improves learning and social outcomes. Additionally, student academic engagement is subject to change due to contextual factors such as the school setting, environment, or the type of instructional activity used.

Student involvement theory has been widely used in research as a theoretical framework, testing its main hypothesis: student development and retention increase as student involvement increases. Prior studies have examined several student outcomes using student involvement theory, such as achievement [37], engagement [38], and retention [39]. One study used student involvement theory as a framework to analyze qualitative interview data. The researchers employed the theory to understand students' involvement during the COVID-19 pandemic and identify the necessary support [38]. Another study employed the theory as a theoretical lens to analyze interview data on students' levels of involvement in their academic environment and its impact on student outcomes. Students reported positive impacts on academic performance and organizational skills, such as time management [37]. In another study, researchers used several student involvement metrics, including student interactions with peers and Faculty, utilization of campus resources, and participation in extracurricular activities, to predict first-year retention in college programs [39]. They found involvement impacted student retention in their program.

2.3 Engagement and Performance

In the academic context, student engagement has been conceptualized as a multidimensional construct with several definitions. For example, it has been defined as a student's psychological investment in their learning and the effort made to understand and master learning materials and associated skills [40]. Alternatively, Kuh and colleagues [41] described engagement as active participation in learning activities both inside and outside the classroom, which may impact their learning outcomes. A popular framework for academic engagement proposed by Fredricks and colleagues [42] outlined three primary aspects of engagement to describe the ways that students engage with learning activities: (1) Cognitive engagement, which refers to students' willingness to learn from the instructional activities [42], (2) Affective-emotional engagement, which refers to the type of feelings or emotions students experience when engaged in instructional activities [43, 44], and (3) Behavioral engagement, which refers to how students behave during the learning activities [45].

Given its multidimensional nature, measures of course-level academic engagement cater to the cognitive, affective, and behavioral components of engagement in the classroom [46]. For example, Handelsman and colleagues [47] measure course engagement, which encompasses four aspects of engagement, including cognitive, affective, and behavioral dimensions: skills engagement, emotional engagement, participation/interaction engagement, and performance engagement. Another measure, the Student Engagement Survey (SE), assesses cognitive and behavioral dimensions of engagement in terms of learning and cognitive and skill development [48]. Similarly, the StRIP survey [49] collects students' perceived value, positivity, and participation corresponding to cognitive, affective, and behavioral engagement. Positivity measures students' affective reactions toward class activities, including anxiety, interest, and feelings of belonging. The second construct, participation, refers to the behavioral engagement exhibited by students in the classroom. It encompasses their active involvement, contribution, and interaction with the learning materials, discussions, and activities. Lastly, value refers to cognitive engagement and self-regulated motivation that drive students to pursue learning and excel in a course actively.

Previous research has investigated engagement in various contexts. For example, positivity has improved students' concentration and enhanced their commitment to completing a task [50]. Moreover, the overall impact of positivity results in a lower likelihood of distraction, thus helping students perform better [51]. Similarly, researchers have reported a positive relationship between participation and exam performance in conceptual computer science courses but not in more skill-based courses [52]. Lastly, students' cognitive engagement in learning activities such as online discussion forums is associated with their performance [53]. While student involvement theory explains student learning outcomes in terms of engagement, to investigate the impact of instructional activities in conjunction with engagement, we use the ICAP framework.

Together, these theoretical underpinnings of the study, i.e., the ICAP framework [17] and student involvement theory, provide the elements to examine the interplay between instructional activities and students' academic engagement. Fig. 1 illustrates the theoretical framework of the study. The ICAP framework posits that activities requiring higher levels of engagement promote deeper learning and consequently improved student performance. However, the ICAP framework does not adequately address the multidimensional nature of engagement, as it categorizes engagement based solely on overt behaviors. Combined with student involvement theory, the theoretical framework enables the examination of the impact of three dimensions of engagement, along with instructional activities, on student performance. Additionally, the theoretical framework enables the measurement of the contextual nature of the engagement based on the type of instructional activity. Based on these theoretical foundations, we hypothesize that the interplay of instructional activities and engagement will predict performance.

Although studies have examined various aspects of student-centered instructional activities, this study uniquely examines these activities combined with student engagement. Moreover, in our analysis, we use student perceptions of these constructs, which are often overlooked. Specifically, we utilize the theoretical framework to examine how various forms of engagement are associated with the ICAP framework's learning modes and student performance.

3. Research Design

We designed a correlational study to answer the research questions and analyzed the data using a multi-method approach.

3.1 Site and Participants

The focus of the study was an undergraduate Systems Analysis and Design course. The course was offered at a large public institution in the Midwestern United States. The class curriculum spanned various aspects of the software development process, including topics on requirements engineering, analysis, design, development, and evaluation of the system. The instructor used various active learning instructional strategies to keep the students engaged with the learning material.

Out of the 125 students in the class, 88 students voluntarily participated in the study. Most participants identified as male (66%), while the rest identified as female (34%). Most respondents identified as White/Caucasian (66%), followed by Asian (19%). To maintain the statistical plausibility of the results, the remaining students (15%) were grouped into one group called AHN (African American/Black, Hispanic/Latinx, and Native American/Alaskan Native).

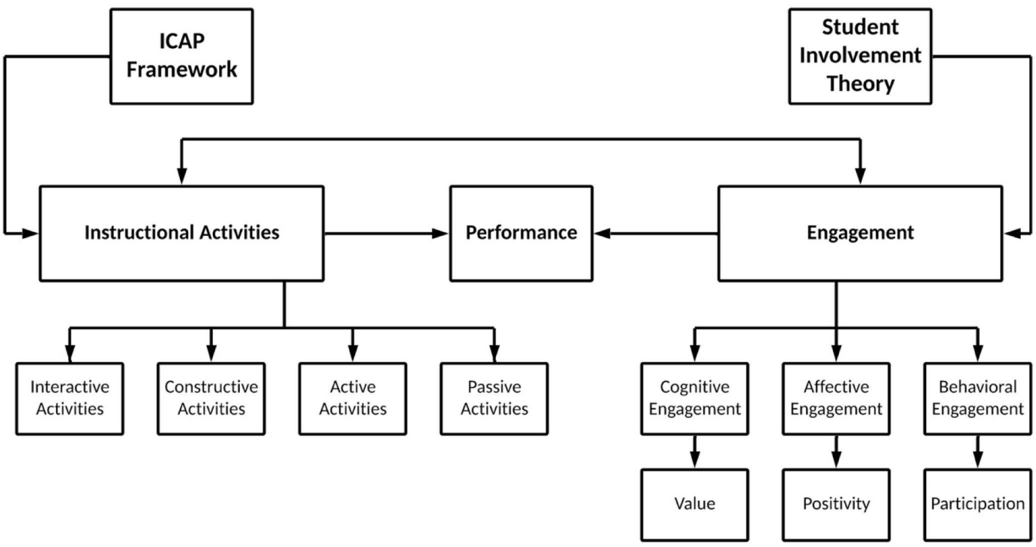

Fig. 1. Theoretical framework of the study.

3.2 Measures and Data Collection

We collected students' performance data and their perceptions about instructional activities and their academic engagement. Students' performance data were collected using their final exam scores, where they were asked to develop artifacts for a given case study. The exam included three questions, collectively worth 88 points. The instructional team graded the exams.

To assess perceptions of instructional activities and academic engagement, we administered an end-of-semester survey, in which students self-reported the frequency of instructional activities and their level of engagement. We used a previously validated instrument called the Student Response to Instructional Practices (StRIP) survey [49]. The instrument was designed and validated for use in engineering classrooms, based on the ICAP framework. The instrument comprises four subscales corresponding to the four modes of the ICAP framework, categorizing instructional activities as interactive, constructive, active, or passive. Moreover, it provides subscales for students' perceived engagement regarding their participation, positivity, and the value they assign to instructional activities.

The survey included six items each for the interactive, constructive, and active subscales, as well as three items for the passive subscale. Additionally, there were three items within the subscale value, three for positivity, and six for participation. Students were asked to report how often they engaged in the specified activity for each item. The item responses were based on a 5-point Likert scale format, where 1 represented 'almost never' and 5 represented 'very often'. Table 1 provides a sample survey item for each subscale.

3.3 Procedure and Analysis

As an initial step, we prepared the data for analysis and reverse-coded the four negatively phrased questions. To get a representative value for each subscale, we aggregated the item responses into a mean value. Moreover, we created one dummy-coded variable to represent sex, with females as the reference group. Similarly, we created two dummy-coded variables to represent the participants' race and ethnicity. We assigned White as the reference group and Asian and AHN as the focal groups. The two dummy-coded variables represent comparisons between Asian and White groups, as well as between AHN and White groups.

To answer the first research question, we first conducted a sequential multiple regression analysis to determine the impact of instructional activity types on student performance while accounting for students' background variables. Second, we conducted a sequential multiple regression analysis for each engagement variable (value, positivity, and participation) to predict engagement from instructional activity types after accounting for background variables. We tested all models for regression assumptions, including normality, linearity, homoscedasticity, and multicollinearity. We checked for normality for each variable using the skewness and kurtosis of the unstandardized residuals. Moreover, we conducted a significance test for skewness and kurtosis of residuals and did not find evidence to suggest a departure from normality ($p = 0.10$). Lastly, we analyzed the scatter plot between studentized residuals and fitted values and found no evidence to suggest a violation of the assumptions of linearity and homoscedasticity. We followed it with the Cameron-Trivedi decomposition, and the result confirmed our interpretation ($p = 0.15$). Lastly, the Variance Inflation Factor (VIF) for each predictor variable was less than two, indicating no evidence of multicollinearity.

Using a multi-method approach for the second research question, we first conducted multiple linear regression analyses to examine the role of the three types of engagement in students' academic performance. Next, we conducted a separate sequential regression analysis for student performance against each instructional activity type and its interaction with each mode of engagement. Nine

Table 1. Sample survey items

Instructional Activity Subscales **"How often did you do each thing in this course?"**	
Interactive	"Solve problems in a group during class."
Constructive	"Make and justify assumptions when not enough information is provided."
Active	"Make individual presentations to the class."
Passive	"Listen to the instructor lecture during class."
Student Responses to Instruction Subscales **"How often did you react in the following ways?"**	
Value	"I felt the time used for the activity was beneficial."
Positivity	"I felt positively towards the instructor."
Participation	"I participated actively (or attempted to)."

regression analyses were conducted to assess the role of engagement in predicting performance from active instructional activities. The assumptions of linearity, normality, and homoscedasticity were checked for each model. All statistical analyses were conducted using Stata, version 18.0 [54].

4. Findings

We analyzed the descriptive statistics to observe the initial trends in the data. Table 2 summarizes the descriptive statistics of the instructional activity types, engagement types, and exam scores. The students reported most frequently engaging in interactive activities, followed by passive, constructive, and active activities. Regarding engagement, the participation mean was higher than the positivity mean, which was higher than the value mean, although the differences were marginal.

4.1 Instructional Activities and Student Performance

We conducted a sequential multiple regression analysis to examine the relationship between students' perceptions of instructional activities and performance while accounting for sex and ethnicity. In the sequential model, sex and ethnicity were introduced in the first step, and instructional activities were added to the model in the second step. Table 3 summarizes the analysis results.

The results indicate a non-significant relationship between instructional activities and students' performance after accounting for sex and ethnicity, F (7, 80) = 0.63, p = 0.73, R^2 = 0.05. The instructional activities alone accounted for 5% of the variability in student performance, ΔF (4, 80) = 1.07, p = 0.38, ΔR^2 = 0.05. However, this effect was not statistically significant.

4.2 Instructional Activities and Engagement

We conducted a sequential regression analysis to examine the impact of instructional activity types on students' perceived value after accounting for sex and ethnicity. Table 4 presents the results of this analysis.

The results indicated that, after accounting for sex and ethnicity, instructional activities statistically significantly predicted students' perceived value of the activities, F (4, 80) = 14.11, p < 0.01, R^2 = 0.44. Moreover, holding all other variables constant, Asian students were expected to rate the perceived value of instructional activities 0.40 units higher than White students, the reference group (B = 0.40, t = 2.19, p < 0.05). These results suggest that, for the same instructional activities, Asian students perceived greater value compared to their

Table 2. Summary of Statistics

Variable	Mean	Std. dev.	Min	Max
Interactive	3.81	0.48	2.50	4.83
Constructive	3.68	0.48	2.66	5.00
Active	2.58	0.47	1.50	4.00
Passive	3.78	0.59	2.00	5.00
Value	3.67	0.80	1.67	5.00
Positivity	3.68	0.69	1.67	5.00
Participation	3.80	0.50	2.50	5.00
Score	62.58	8.55	31	76.00

Table 3. Sequential Regression Analysis Predicting Performance from Activity Types After Accounting for Sex and Ethnicity

Step and Variable	B	β	SE	R^2	ΔR^2
Step 1				0.001	
Sex	0.41	0.02	1.98		
Asian	0.17	0.01	2.41		
AHN	0.77	0.03	2.68		
Step 2				0.05	0.05
Sex	0.65	0.04	2.01		
Asian	–0.87	–0.04	2.56		
AHN	1.12	0.05	2.8		
Interactive	3.47	0.20	2.15		
Constructive	–2.60	–0.15	2.22		
Active	1.82	0.10	2.18		
Passive	–1.51	–0.11	1.80		

** p < 0.05, *** p < 0.01.

Table 4. Sequential Regression Analyses Predicting Value from Activity Types After Accounting for Background

Step and Variable	B	β	SE	R^2	ΔR^2
Step 1				0.05	
Sex	–0.07	–0.04	0.18		
Asian	0.43	0.22	0.22		
AHN	–0.07	–0.03	0.24		
Step 2				0.44***	0.39***
Sex	–0.14	–0.09	0.14		
Asian	0.40**	0.20**	0.18		
AHN	0.06	0.03	0.20		
Interactive	–0.10	–0.06	0.15		
Constructive	0.20	0.12	0.16		
Active	0.15	0.09	0.16		
Passive	0.78***	0.58***	0.13		

** $p < 0.05$, *** $p < 0.01$.

Table 5. Sequential Regression Analysis Predicting Positivity from Activity Types After Accounting for Background

Step and Variable	B	β	SE	R^2	ΔR^2
Step 1				0.04	
Sex	–0.16	–0.11	0.16		
Asian	0.32	0.19	0.19		
AHN	0.01	0.003	0.21		
Step 2				0.44***	0.40***
Sex	–0.23	–0.16	0.12		
Asian	0.30	0.17	0.16		
AHN	0.10	0.05	0.17		
Interactive	–0.02	–0.02	0.13		
Constructive	0.22	0.15	0.14		
Active	0.13	0.09	0.13		
Passive	0.64**	0.55**	0.11		

** $p < 0.05$, *** $p < 0.01$.

White peers. Uniquely, instructional activities accounted for approximately 39% of the variability in value, indicating a substantial effect. However, individually, only passive activities statistically significantly predicted perceived value ($B = 0.58$, $t = 6.08$, $p < 0.01$)

Next, we conducted a sequential regression analysis to examine the impact of instructional activity types on students' positivity. The results of the analysis are presented in Table 5.

The analysis revealed that instructional activities statistically significantly predicted positivity after accounting for students' background, F (4, 80) = 14.19, $p < 0.01$, $R^2 = 0.44$. The instructional activities uniquely accounted for over 40% of the variability in positivity $\Delta R^2 = 0.40$). Moreover, a one-unit increase in a student's perceived frequency of passive activities was expected to increase their positivity by 0.64 units ($B = 0.64$, $t = 5.75$, $p < 0.01$).

Lastly, we conducted a sequential regression analysis to examine the impact of instructional activity types on students' participation, controlling for student background variables. After accounting for background variables, F (4, 80) = 7.24, $p < 0.01$, $R^2 = 0.27$, the results showed a statistically significant impact of instructional activities on participation. Instructional activities accounted for approximately 26% of the variability in participation. As observed in the models for value and positivity, only passive activities statistically significantly predicted participation ($B = 0.32$, $t = 3.45$, $p < 0.01$). Table 6 presents the findings.

4.3 Engagement Moderation Between Instructional Activities and Student Performance

To answer question two, we first conducted a sequential regression analysis to examine the relationship between performance and engagement types after accounting for student background variables, as presented in Table 7. We found that engagement types did not statistically significantly predict performance, F(6, 81) = 0.21, $p = 0.97$, $R^2 = 0.02$.

As engagement types were not significant predictors of performance, we explored the interplay between engagement and instructional activities. In the next step, we conducted three sets of three

Table 6. Sequential Regression Analysis Predicting Participation from Activity Types After Accounting for Background

Step and Variable	**B**	β	**SE**	$\mathbf{R^2}$	$\mathbf{\Delta R^2}$
Step 1				0.01	
Sex	0.04	0.04	0.12		
Asian	0.05	0.04	0.14		
AHN	–0.06	–0.05	0.16		
Step 2				0.27***	0.26***
Sex	–0.02	–0.02	0.10		
Asian	0.04	0.03	0.13		
AHN	–0.05	–0.03	0.15		
Interactive	0.09	0.09	0.11		
Constructive	0.18	0.17	0.11		
Active	0.05	0.05	0.11		
Passive	0.32***	0.38***	0.09		

** $p < 0.05$, *** $p < 0.01$.

Table 7. Summary of Multiple Regression Coefficients Predicting Performance from Types of Engagement

Step and Variable	**B**	β	**SE**	$\mathbf{R^2}$	$\mathbf{\Delta R^2}$
Step 1				0.001	
Sex	0.42	0.02	1.98		
Asian	0.17	0.01	2.41		
AHN	0.77	0.03	2.68		
Step 2				0.02	0.014
Sex	0.28	0.02	2.02		
Asian	0.08	0.003	2.50		
AHN	0.84	0.04	2.71		
Value	1.71	0.16	1.87		
Positivity	–1.85	–0.15	2.09		
Participation	–0.97	–0.06	2.21		

** $p < 0.05$, *** $p < 0.01$.

sequential regression analyses to assess whether student engagement moderated the relationship between types of instructional activities and performance. The first set of analyses assessed the role of engagement in the relationship between interactive activities and performance. The second set targeted the role of engagement between constructive activities and performance. The last set of analyses targeted engagement as a moderator between active instructional activities and performance. In the first step, we only included the student demographic variables for each model. In the second step, we introduced the activity type. In the third step, we introduced the engagement type and its interaction with the activity type into the model.

4.3.1 Interactive Activities, Engagement, and Performance

For each mode of engagement, we conducted a separate analysis to predict student performance based on the type of interactive activity, after accounting for sex and ethnicity. After accounting for background variables, we found that interactive activities explained 2% of the variability in performance, F (4, 83) = 0.37, p = 0.83, R^2 = 0.02. Moreover, the addition of value and the interaction between value and interactive activity did not statistically significantly increase the predictive power of the model, ΔF (2, 81) = 1.92, p = 0.15, ΔR^2 = 0.05. Therefore, value exhibited no significant impact on the relationship between interactive activities and performance.

Similarly, after accounting for background and interactive activity type, positivity and the interaction between positivity and interactive activities did not statistically significantly predict performance, F (6, 81) = 1.51, p = 0.19, R^2 = 0.10. Although the overall model did not reach statistical significance, the addition of positivity and its interaction term significantly improved the model fit, explaining over 8% of the variability in performance, ΔF (2, 81) = 3.75, p < 0.05, ΔR^2 = 0.08. Lastly, the participation model presented a similar trend. After controlling for background and interactive activities, participation and the interaction between participation and interactive activities did not statistically significantly predict performance, F(6, 81) = 0.35, p = 0.90, R^2 = 0.02.

4.3.2 Constructive Activities, Engagement, and Performance

As with interactive activities, we used a sequential regression approach to gauge the impact of engagement types and their interaction with constructive activities on performance. After accounting for sex and ethnicity, constructive activities explained only about 1% of the variability in performance, $F(4, 83) = 0.20$, $p = 0.93$, $R^2 = 0.01$. After controlling for background variables and constructive activities, value and its interaction with constructive activities uniquely explained 4% of the variability in performance, ΔF (2, 81) = 1.50, $p = 0.23$, $\Delta R^2 = 0.04$. However, this effect was not statistically significant. Moreover, positivity and the interaction of positivity with constructive activities did not statistically significantly predict performance after accounting for background and constructive activities, ΔF (2, 81) = 0.62, $p = 0.54$, $\Delta R^2 = 0.02$. Similarly, after controlling for background and constructive activities, the interaction between participation and constructive activities did not statistically significantly predict student performance, ΔF (2, 81) = 0.70, $p = 0.50$, $\Delta R^2 = 0.03$.

4.3.3 Active Activities, Engagement, and Performance

In the third set of analyses, we used sequential regression models to test the impact of engagement types and their interaction with active activities on performance. Active activities explained approximately 1% of the variability in performance after controlling for sex and ethnicity, F (4, 83) = 0.16, $p = 0.96$, $R^2 = 0.01$. After controlling for active activities and background variables, value and the interaction between value and active activities uniquely explained 3% of the variability in performance, ΔF (2, 81) = 1.25, $p = 0.29$, $\Delta R^2 = 0.03$. Moreover, after controlling for background and active activities, positivity and the interaction between positivity and active activities explained approximately 3% of the variability in performance, ΔF (2, 81) = 1.37, $p = 0.26$, $\Delta R^2 = 0.03$. Lastly, keeping all other variables constant, participation and the interaction between participation and active activities explained only about 0.41% of the variability in performance, ΔF (2, 81) = 0.17, $p = 0.85$, $\Delta R^2 = 0.004$. In addition to the model significance tests, none of the observed effects for active activities and engagement were statistically significant.

5. Discussion and Implications

Research on active instructional activities is usually confined to the associated achievement outcomes alone. Moreover, students' perceptions of the activities are not often considered. This study examines students' perceptions of instructional activities in an undergraduate systems analysis and design course and their relationship to students' performance and engagement. Additionally, this study examines the multidimensional nature of student engagement and investigates the combined effects of engagement (cognitive, behavioral, and affective) and instructional activities on student performance. The theoretical lens of the study is grounded in the ICAP framework [17] and student involvement theory [19]. We used the StRIP survey instrument [49] to collect students' perceptions of instructional activities and their engagement in class. The instrument gathered students' perceptions of how frequently they were involved in active, constructive, or interactive activities throughout the semester and how they received and responded to them.

To address the first research question, we first assessed the impact of instructional activities on performance, controlling for students' gender and ethnicity. The results showed that instructional activities did not significantly predict students' performance in the course. Contrary to our results, there is ample evidence across domains indicating significant gains in learning outcomes when ICAP's higher modes of learning are implemented [23, 24, 28]. Conversely, some studies show mixed results or no significant effect of active learning activities on student performance [55–57]. In a literature review on the efficacy of active learning activities, Bernstein [58] concluded that the introduction of such activities alone does not guarantee improved performance; instead, the efficacy of active learning activities depends on several factors, including fidelity of implementation, learner characteristics, and the context. Our findings highlight an important consideration regarding the study design. As this study examined students' perceptions of the frequency of activities, the results indicate how students' perceptions influence their performance, which may differ from other perspectives (e.g., teachers and observers) [30]. These results align with the literature, which suggests that such instructional activities may not always relate to academic performance and are dependent on the nature, time, and method of data collection [31].

The second part of the analysis examined the relationship between instructional activities and students' academic engagement, specifically their perceived value of the activities, positivity, and participation, after controlling for gender and ethnicity. The three sequential regression models were statistically significant, indicating instructional activities are strong predictors of engagement. This result is consistent with the premise of the

ICAP framework. Each mode of instructional activity engages students differently and evokes distinct responses among them [17]. However, we found that among all predictors, only the passive mode of instruction demonstrated a statistically significant impact on students' value, positivity, and participation. The active learning modes of ICAP (interactive, constructive, active) did not statistically significantly predict engagement. This result suggests that incorporating active learning activities did not contribute to students' perceptions of value, positive affect, or participation in the course. Prior research in computer science education has produced mixed results on the impact of active learning activities on students' motivational constructs, including engagement. Studies have found that incorporating active learning activities enhances student engagement, as well as retention and performance [59, 60], while others have found that active learning activities are related to a decline in engagement [55]. This absence of effects for active learning modes may indicate a preference for passive instructional activities. These findings echo the student resistance to active learning documented in prior literature. For example, one study found that student evaluations were higher when a lecture-based format was used than in discussion groups [61]. These results may also be associated with the course's nature, where students need more structure and instruction before they can explore the concepts independently [62].

The second research question examined whether the relationship between instructional activities and performance varied according to levels of student engagement. We tested the three forms of student engagement (value, positivity, participation) as possible moderators for instructional activities and performance. The results showed no impact of engagement on the relationship between instructional activities and performance. In addition to the lack of significant interaction between instructional activities and engagement types, the level of engagement did not significantly contribute to student performance either. This finding is curious, given the documented impacts of engagement in the literature [51–53].

Collectively, these results raise some important questions for instructors and educators. From the instructors' perspective, they may have introduced and designed many activities to engage students, which should ultimately impact their performance; however, student perceptions may vary. What factors in the classroom influence students' experiences of these activities? Could these results be different for diverse students? For example, studies have shown that identity, language barrier, and low self-esteem may result in less participation from students and a likely drop in their performance [63]. Additionally, could the social dynamics of the class influence students' perceptions? An activity may be stressful for some students due to the way groups are formed [64], teamwork dynamics [65, 66], and cultural orientations [67, 68], among other factors. Considering these questions, we urge researchers to adopt a multifaceted approach when introducing instructional activities and designing innovative curricula to support students' learning.

6. Limitations and Future Directions

Several limitations affect the findings of this study. First, the correlational research design limits the interpretation of the results. To establish a cause-and-effect link, future studies should adopt an experimental approach that isolates and studies the modes of instruction. Second, we did not collect data on possible confounding variables such as students' prior performance, their reflections, and the social dynamics of the classroom. Moreover, other predictors of performance, such as learners' motivation and self-efficacy, were not collected, which would have strengthened the model. Given the absence of other possible predictors, we would expect a small effect size for instructional activities alone, which is hard to observe in a smaller dataset of one classroom. Moreover, this study focuses on classroom engagement, excluding students' experiences outside the class. Future work should measure and contextualize experiences outside of class that may be categorized as academic engagement. Additionally, we did not collect data on how the activities were conducted in the class or the level of autonomy students were allowed. Without this information, it is hard to interpret the absence of significant effects. Future studies should gather data on the aspects mentioned above and consider using additional data collection methods, such as classroom observations, to enhance the understanding of these concepts. Third, the current study used final exam scores to measure performance. Given the active nature of activities, additional measures of student performance should be used, including formative assessments. Other competencies associated with student-centered activities, including problem-solving, teamwork, and critical thinking skills, could also be evaluated. Lastly, it is worth noting that active learning in engineering classrooms requires a reflection component to map the activities to the introduced concepts and facilitate an understanding of the content [69]. Without this component, it isn't easy to gauge the nature of the activities.

7. Conclusion

Although a vast body of knowledge has been dedicated to active learning activities, relatively little is known about how students perceive these activities and how they engage with them. This study addresses that gap and contributes to the existing research on active instructional strategies, utilizing the ICAP framework. We explored the impact of active instructional strategies and student engagement on student performance in an undergraduate computer science course. The lack of alignment between our results and prior literature poses several implications for educators. Since instructor and student perspectives may vary, it is important to consider multiple perspectives when designing an activity. Secondly, considering engagement as a multidimensional construct, instructional activities should target more than one aspect of it. Moreover, examining student perspectives can reveal aspects of learning that may be overlooked and provide insight into the needs of different learners. The findings suggest the need to consider instructional design in conjunction with other factors to enhance student performance. Students' level of preparedness and comfort with active learning activities should be considered, and initial structure and scaffolding should be provided to ensure the success of these activities.

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