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# IUSE: Motivation and Cognitive Engagement in Engineering Courses: Employing a Learning Management System to Present Pre-Requisite Content for Classroom Preparation

**Dr. Renee M Clark, University of Pittsburgh**

Dr. Renee Clark is Associate Professor of Industrial Engineering at the University of Pittsburgh. She also serves as a Data Engineer and Director of Assessment for the Engineering Education Research Center (EERC) within the Swanson School of Engineering at Pitt. She uses data analytics to study techniques and approaches in engineering education, with a focus on active learning techniques and the professional formation of engineers. Dr. Clark is currently funded as Principal Investigator by the National Science Foundation for her research, which includes defining and assessing engineering judgment as well as the use of adaptive online learning in the engineering classroom, for which she is developing the BeSharpStats Youtube channel. Dr. Clark teaches Statistics for IE undergraduates and also serves as a study abroad instructor. She is an Associate Editor for Advances in Engineering Education. She has over 30 years of experience as an engineer and IT analyst in industry and academia. She completed her post-doctoral studies in engineering education at the University of Pittsburgh.

**Prof. Autar Kaw, University of South Florida**

Autar Kaw is a Professor of Mechanical Engineering and the Jerome Krivanek Distinguished Teacher at the University of South Florida, nationally recognized for his contributions to engineering education. He earned his Ph.D. in Engineering Mechanics from Clemson University. Professor Kaw's work spans engineering education research, personalized and blended learning, flipped classrooms, open courseware development, composite materials mechanics, sports analytics, and bascule bridge design. His research has been supported by the National Science Foundation, Air Force Office of Scientific Research, Florida Department of Transportation, and Wright-Patterson Air Force Base. Since 2001, he has served as the lead Principal Investigator on seven NSF-funded engineering education projects totaling $3.3 million. These initiatives have explored the impact of innovative learning environments on metacognitive development, conceptual understanding through multiple representations, group collaboration, student perceptions, and activation of prior knowledge. Under his leadership, his team developed and refined open educational resources (OERs) in Numerical Methods, which attract over 1 million page views and YouTube lecture views annually, and 60,000 visitors to the widely followed "Numerical Methods Guy" blog. Professor Kaw has authored more than 135 refereed technical papers, and his opinion pieces have appeared in The Tampa Bay Times, The Tampa Tribune, and The Chronicle of Higher Education. His work has been featured and cited in Inside Higher Ed, ASEE Prism, Voice of America, NSF Discovery, The Chronicle of Higher Education, the U.S. Congressional Record, and Florida Senate Resolution. Among his many honors, he received the 2012 U.S. Professor of the Year Award for doctoral and research universities, presented by the Carnegie Foundation for the Advancement of Teaching and the Council for Advancement and Support of Education.

**Dr. Ahmed Dallal, University of Pittsburgh**

Dr. Dallal is an associate professor at the Department of Electrical and Computer Engineering, University of Pittsburgh. Dr. Dallal's primary focus is on education development and innovation. His research interests include biomedical signal processing, biomedical image analysis, and computer vision, as well as machine learning, networked control systems, and human-machine learning.

**Kelly Maren Kibler, University of Central Florida**

Dr. Kelly Kibler is an Associate Professor of Water Resources Engineering in the Department of Civil, Environmental and Construction Engineering at the University of Central Florida. She is faculty of UCF's National Center for Integrated Coastal Research and a Faculty Fellow of UCF's Center for Global Economic and Environmental Opportunity. Dr. Kibler obtained her Ph.D. in Water Resources Engineering and M.Sc. in Forest Engineering from Oregon State University, and her B.Sc. In Environmental Science from the University of North Carolina at Chapel Hill. Dr. Kibler worked with the United Nations Environmental, Scientific and Cultural Organization (UNESCO) before joining UCF faculty, where she teaches Engineering Fluid Mechanics, Open Channel Hydraulics, Ecohydraulics and Water Policy. Dr. Kibler's Ecohydraulics Laboratory conducts interdisciplinary research at the crossroads of water resources engineering and aquatic ecology. Targeting coupled biological and physical variables in river and estuarine systems, the Kibler Ecohydraulics Lab advances basic scientific knowledge in flow-biota interaction and its influence to hydrodynamics and sediment transport. Dr. Kibler's research findings are applied to the design of natural infrastructure used to protect communities from climatic hazards, such as erosion and flooding. The Ecohydraulics Lab's study of environmental fluid mechanics within complex three-dimensional canopies improves understanding of flow resistance and sediment transport mechanisms within natural aquatic features, such as vegetation or shellfish reefs. Dr. Kibler's research has been supported by grants from the U.S. National Science Foundation (NSF), U.S. National Oceanic and Atmospheric Administration (NOAA), the Defense Advanced Research Projects Agency (DARPA), The Nature Conservancy (TNC), Environmental Protection Agency (EPA) National Estuaries Program, Florida Department of Environmental Protection (FDEP) and Florida Department of Transportation (FDOT). Dr. Kibler is Chair of the River Restoration Technical Committee of the American Society for Civil Engineers, Associate Editor of the Journal of Hydrology, and active in committees of the American Geophysical Union.

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## 1. Introduction

Research is underway by a team of engineering instructors to deliver online pre-requisite content for students for use before class. Two methods for delivering this classroom preparation content are being compared as part of this research. The first intervention has been implemented in four courses across three universities. It involved the use of the Canvas Learning Management System (LMS) for content delivery and assessment. The second intervention will make use of adaptive learning software (i.e., RealizeIT) for delivery and assessment [1]. Adaptive learning software is designed for personalized learning. The two methods will be compared based on affective outcomes and direct measures of student learning. The results for the affective outcomes with the LMS method – academic motivation and in-class cognitive engagement – are the topics of this research brief. These interrelated affective outcomes, which were measured using two validated inventories, impact student achievement and learning [2-3]. Our questions for this research brief are therefore as follows:

> *To what extent is pre-class, pre-requisite preparation using an LMS associated with motivation and in-class cognitive engagement in engineering courses? To what extent are motivation and in-class cognitive engagement correlated in this context?*

## 2. Literature

### 2.1 Classroom Preparation, Prior Knowledge, Motivation, and Engagement

Classroom preparation in the form of pre-class reading assignments is a desirable "homework" activity [4]. These assignments create self-paced time for introductory learning and promote the ability to follow along and get the most out of class time, thus conceivably impacting the expectation of success, motivation, and engagement and ultimately learning and performance [3-5].

Likewise, when students connect prior knowledge with new knowledge, they learn and retain more since new knowledge adheres better when there is previous knowledge to which it can "bind" [5]. This suggests a synergy between preparing before class with pre-requisite knowledge and learning new material.

### 2.2 The MUSIC Model of Academic Motivation

The MUSIC Model contains five distinct dimensions of student motivation – e**M**powerment, **U**sefulness, **S**uccess, **I**nterest, and **C**aring [3, 6]. A sample of questions from the MUSIC Model and their corresponding dimension are as follows:

1) I had control over how I learned the course content. (eMpowerment)
2) I will be able to use the knowledge I gained in this course. (Usefulness)
3) I felt that I could be successful in meeting the academic challenges in this course. (Success)
4) The coursework held my attention. (Interest)
5) The instructor cared about how well I did in this course. (Caring)

### 2.3 Student Course Cognitive Engagement Inventory (SCCEI)

Cognitive engagement is the psychological investment a student makes in learning and is driven by meaningful, non-shallow cognitive processing, thereby driving meaningful learning [2, 7]. It relies upon students expending the effort to understand complex content and master hard skills [2].

The SCCEI, or Student Course Cognitive Engagement Instrument, was developed to measure in-class cognitive engagement with engineering students [7]. The SCCEI encompasses the following dimensions or factors: interactivity with peers, constructive notetaking, active notetaking, active processing, and passive processing. This instrument is based on the ICAP framework for active learning - Interactive, Constructive, Active, and Passive [8]. The following are example representative SCCEI questions that particularly align with our goals for pre-class preparation:

1) I explain concepts to others when discussing course content. (Interactivity with Peers)
2) I add my own content to the course notes. (Constructive Notetaking)
3) I copy solution steps verbatim (meaning word for word…) (Active Notetaking)
4) I connect current concepts with previous course content. (Active Processing)
5) I pay attention to my teacher or whoever is speaking. (Passive Processing)

## 3. Methods

Prerequisite content was assigned to students in four separate engineering courses and majors at three universities using the Canvas Learning Management System (LMS). The content was assigned weekly *before* the lecture, enabling the implementation of active learning exercises during lecture in these blended classrooms. The content consisted of videos, readings, transcriptions, and accountability quizzes. The courses and majors were as follows: electrical circuits (electrical/computer engineering), fluid mechanics (civil engineering), numerical methods (mechanical engineering), and statistical testing (industrial engineering). The development effort was described elsewhere [9].

Academic motivation and cognitive engagement were measured using the MUSIC Inventory and the Student Course Cognitive Engagement Inventory (SCCEI), respectively. Both instruments are validated, with the MUSIC inventory having 26 items and the SCCEI having 18 items [6-7]. The MUSIC inventory uses a 1-6 scale of strongly disagree (1), disagree (2), somewhat disagree (3), somewhat agree (4), agree (5), and strongly agree (6), with the latter indicating a maximum extent for the dimension. The SCCEI has a 1-3 scale of *few to no* lecture periods (1), *some* lecture periods (2), and *most* lecture periods (3). Each inventory was administered using the Qualtrics survey software in the final week or final two weeks of the semester. The Institutional Review Board (IRB) at each university approved the collection and analysis of the data.

For each respondent, a score for each inventory dimension was calculated in accordance with the directions provided by each of the developers [7, 10]. For the MUSIC Model, an average across the items in each dimension is recommended. For the SCCEI, a percent alignment with each dimension is recommended. For each course, the average and standard deviation for each dimension across all respondents were then calculated.

Correlations were calculated between each pair of dimensions of the MUSIC Inventory and SCCEI to assess linear relationships associated with them. The nonparametric Spearman correlation coefficient was calculated given its robustness compared to the Pearson correlation coefficient [11]. Also, since a large number of correlations were computed per course (i.e., 25 correlations), only those correlations with *p*-values of 0.001 or less were reported as significant based upon Bonferroni's adjustment for multiple comparisons [11].

## 4. Results

### 4.1 MUSIC (Motivation) Results

The results in Table 1 indicate differences among the four courses based on average MUSIC dimension scores. For example, the Statistics course had three (3) dimensions with an average score of 5.0 or higher. The Electrical Circuits and Fluid Mechanics courses each had two (2) dimensions with an average of 5.0 or higher. For Numerical Methods, one (1) dimension average was 5.0 or higher. Across the four courses, the minimum dimension average was 4.28. Keeping in mind that a 4 corresponds to Somewhat Agree and a 5 corresponds to Agree, all dimension averages were therefore on the "agreement" side of the scale in terms of students feeling motivated in various ways or by various conditions in the course. This was a positive outcome for our courses, which offered pre-class preparation materials through the LMS to ensure students had reviewed pre-requisite material. By way of illustration, students perceived the coursework in Fluid Mechanics to have the highest *usefulness* on average (M=5.18), and this coursework was of most *interest* to them on average (M=4.90). Students in the Statistics course perceived the most *eMpowerment* (M=4.86) and *success* potential (M=5.30) on average.

**Table 1: Average and (Standard Deviation) by MUSIC Dimension**

| MUSIC Dimension | Electrical Circuits | Fluid Mechanics | Numerical Methods | Statistics |
|---|---|---|---|---|
| ***n*** | 51 | 62 | 51 | 47 |
| eMpowerment | 4.64 (0.84) | 4.45 (0.92) | 4.53 (1.04) | 4.86 (0.69) |
| Usefulness | 5.04 (0.67) | 5.18 (0.78) | 4.62 (1.08) | 5.12 (0.67) |
| Success | 4.52 (1.15) | 4.99 (0.91) | 4.49 (1.29) | 5.30 (0.62) |
| Interest | 4.42 (0.93) | 4.90 (0.99) | 4.28 (1.28) | 4.59 (0.93) |
| Caring | 5.32 (0.61) | 5.15 (0.81) | 5.12 (0.93) | 5.65 (0.43) |

Note: Each student score is an average of items in the dimension (1-6 scale)

### 4.2 SCCEI (Cognitive Engagement) Results

Similar to the MUSIC dimension averages, the SCCEI dimension averages differed across the four courses. As shown in Table 2, students exhibited *active processing* across the four courses to a large degree, with average percent alignments with each dimension of approximately 72% to 86%. It was a feature of our course implementations to utilize active learning exercises during class time, which we hypothesized would be enhanced by pre-class preparation with pre-requisite content. The largest average percent alignments occurred for *passive processing* (i.e., approximately 87% to 96% across the four courses). This was also a good outcome since our goal with pre-class preparation was to enhance the ability during class to follow and absorb complex concepts and material. Based on lower average percent alignments (61% to 72% approximately), there may be opportunities to enhance *peer-to-peer interactivity* during class as well as to encourage students to document class content that exhibits some of their own thoughts (i.e., *constructive notetaking*).

**Table 2: Average and (Standard Deviation) by SCCEI Dimension**

| SCCEI Dimension | Electrical Circuits | Fluid Mechanics | Numerical Methods | Statistics |
|---|---|---|---|---|
| ***n*** | 51 | 62 | 53 | 46 |
| Interactivity w/ Peers | 65.4<br>(18.9) | 70.4<br>(20.7) | 61.0<br>(22.8) | 63.4<br>(20.9) |
| Constructive Notetaking | 66.7<br>(19.5) | 71.7<br>(19.5) | 66.0<br>(20.3) | 64.0<br>(16.9) |
| Active Processing | 86.3<br>(12.6) | 85.9<br>(15.0) | 72.6<br>(16.5) | 82.6<br>(15.3) |
| Active Notetaking | 74.3<br>(17.1) | 79.0<br>(15.7) | 77.4<br>(18.6) | 71.7<br>(19.7) |
| Passive Processing | 92.2<br>(12.7) | 95.6<br>(9.7) | 86.8<br>(15.6) | 91.1<br>(11.4) |

Note: Each student score represents a percent alignment with the dimension

### 4.3 MUSIC and SCCEI Correlation Results

Statistically significant correlations of approximately moderate size were found between the MUSIC and SCCEI dimensions with these four engineering courses [12]. Table 3 contains those correlations that are statistically different from zero at $\alpha = 0.001$ ($p \leq 0.001$). In the Numerical Methods course, *active processing* was significantly correlated with every dimension of the MUSIC Inventory, suggesting a significant linear relationship in this course between *active processing* (i.e., thinking, applying, connecting) and all dimensions of motivation. In contrast, in the Statistics course, another component of *processing* - *passive* - was significantly correlated with *interest*, suggesting students' interest in what was being presented during lecture.

In Fluid Mechanics, both *constructive notetaking* and *active processing* were significantly correlated with *interest*, suggesting the more students took action beyond what was specifically presented to them, the greater their *interest* was. In other words, the more frequently students added their own content to the course notes or thought about or applied material that was covered, the greater their *interest*. In Electrical Circuits, there was a significant correlation between *interactivity with peers* and perceptions of *success* potential, which was also the case for Numerical Methods. Also, in three of the courses (i.e., Electrical Circuits, Fluid Mechanics and Numerical Methods), *active processing* was significantly correlated with *interest*. Significant relationships between *active processing* and various aspects of motivation, particularly *interest*, were a common theme and suggest the importance of *active processing* for students.

**Table 3: Spearman Correlation Coefficients (*p-value ≤ 0.001*)**

| SCCEI Dimension | MUSIC Dimension | Electrical Circuits | Fluid Mechanics | Numerical Methods | Statistics |
|---|---|---|---|---|---|
| | ***n*** | 51 | 62 | 51 | 46 |
| Interactivity w/ Peers | Success | 0.545 *(0.000)* | | 0.442 *(0.001)* | |
| Constructive Notetaking | Interest | | 0.395 *(0.001)* | | |
| Active Processing | eMpowerment | | | 0.556 *(0.000)* | |
| Active Processing | Usefulness | | | 0.513 *(0.000)* | |
| Active Processing | Success | | | 0.504 *(0.000)* | |
| Active Processing | Interest | 0.475 *(0.000)* | 0.486 *(0.000)* | 0.585 *(0.000)* | |
| Active Processing | Caring | | | 0.468 *(0.001)* | |
| Passive Processing | Interest | | | | 0.464 *(.001)* |

## 5. Discussion & Conclusions

Academic motivation and in-class cognitive engagement positively impact learning and performance in higher education. This research article quantified the academic motivation and in-class cognitive engagement in four separate engineering courses when prerequisite content was assigned before class using the LMS. Academic motivation and cognitive engagement were measured using two validated instruments - the MUSIC Model of Academic Motivation and the Student Course Cognitive Engagement Inventory (SCCEI). Results from four engineering courses enable comparisons across contexts, including different academic levels, universities, engineering disciplines, and subjects. For each course, descriptive statistics for the MUSIC and SCCEI dimensions were determined, and differences among the four courses based on the averages were found. The minimum MUSIC average suggested that students in all four courses were motivated (at least to some degree) based on all aspects of the motivation construct. This was a good outcome for our LMS pre-class preparation method. Based on the SCCEI, students in all four courses exhibited *active processing* as well as *passive processing* to considerable degrees, with both types of processing aligning with our goals for pre-class preparation. Correlations among the MUSIC and SCCEI dimensions highlighted student *active processing* as an important aspect of cognitive engagement relative to all aspects of motivation. This study is part of a larger study to compare two online platforms for pre-class, pre-requisite content in engineering courses - the Canvas LMS and the RealizeIT adaptive learning platform. Our goal is to identify the preferred platform based on affective and direct measures. RealizeIT dynamically adjusts lessons based on each student's performance and behavior, discourages guesswork, and promotes mastery. RealizeIT is being implemented throughout 2026 in these courses.

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