2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #32669

Empowering Students to be Adaptive Decision Makers: Finalizing a Multi-dimensional Inventory of Decision-Making Competency

Dr. Marisa K. Orr, Clemson University

Marisa K. Orr is an Assistant Professor in Engineering and Science Education with a joint appointment in the Department of Mechanical Engineering at Clemson University. Her research interests include student persistence and pathways in engineering, gender equity, diversity, and academic policy. Dr. Orr is a recipient of the NSF CAREER Award for her research entitled, "Empowering Students to be Adaptive Decision-Makers."

Baker A. Martin, Clemson University

Baker Martin is a Ph.D. Candidate in the Department of Engineering and Science Education at Clemson University and teaches in the General Engineering Program as part of the first-year engineering curriculum. His research interests include choice and decision making, especially relating to first-year engineering students' major selection. He earned his BS from Virginia Tech and his MS from The University of Tennessee, Knoxville, both in chemical engineering.

Dr. Katherine M. Ehlert, Clemson University

Katherine M. Ehlert is currently an engineering lecturer at Clemson University. She earned her PhD in Engineering and Science Education from Clemson University, her BS in Mechanical Engineering from Case Western Reserve University and her MS in Mechanical Engineering focusing on Biomechanics from Cornell University. Prior to her time in academics, Katherine worked as a Biomedical Engineering consultant in Philadelphia, PA. Her research interests include documenting the influence of co-op experiences on academic performance, student understanding of engineering fundamentals and, student pathways to engineering degree completion.

Haleh Barmaki Brotherton, Clemson University

Haleh Barmaki Brotherton is a graduate student in the Department of Engineering and Science Education at Clemson University. Her research interests include perfectionism, self-regulation, and decision-making. She earned her BS and MS from Middle East Technical University and Istanbul Technical University in Industrial Design respectively. She earned her second MS in Industrial Engineering and Engineering Management from South Dakota School of Mines and Technology.

Jessica Allison Manning, Clemson University

Jessica Manning is a graduate student in the Department of Engineering and Science Education at Clemson University. She is also a Graduate Administrative Assistant for the Bioengineering Department and assists with advising students throughout their academic careers. Her primary research focuses on women and minorities in multiple engineering disciplines. She earned her BS from North Carolina State University, Raleigh, and her MS from Clemson University, Clemson, both in Mechanical Engineering.

NSF Grantees Poster Session
Empowering Students to be Adaptive Decision-Makers: Finalizing a Multi-Dimensional Inventory of Decision-Making Competency

Project Overview

The main objective of this project is to help students learn to make decisions that lead to academic success. Our first goal is to map curriculum pathways, which begins by studying overpersistence (when a student persists in a particular major but does not make timely progress toward a degree). We seek to identify curriculum-specific indicators of overpersistence and corresponding alternative paths that could lead to success. Our second goal is to improve the structure of the Decision-Making Competency Inventory (DMCI) so that it can explain student's decision-making competency in more detail and in congruence with the Self-Regulation Model of Decision-Making. This instrument will be used to map decision-making competency to academic choices and outcomes. The third goal is to develop an Academic Dashboard as a means for sharing relevant research results with students. This will allow students to have access to the strategies, information, and stories needed to make and implement adaptive decisions. This paper highlights our progress in the fifth year of the project and our plans going forward.

Mapping Pathways - Studying Overpersistence

The first part of this research goal is to study overpersistence in a single major (Mechanical Engineering, ME) at a single institution. Here we develop the strategy and necessary measures to chart pathways to graduation or overpersistence and identify variables that are most predictive of overpersistence. We consider students to be overpersisters if they continue enrollment in a major without making timely progress to their degree. In our original work [1], to be included in our study sample, students must have:

- had a first degree granting major in ME,
- had a last major in ME,
- studied full time in their first semester, and
- attended for at least one year.

Students who met these criteria and did not graduate within six years of matriculation were considered overpersisters. We are currently revisiting our initial definition of overpersistence to ensure that the operationalization of the definition is consistent with our conceptual definition of overpersistence. For example, our previous work has excluded students who switch their major very late because their final major is not the same as the initial major. To update our definition of overpersistence, we will relax the requirements of a first and last major in the major of interest as well as the time enrolled at the institution. With an expanded sample, we will then apply different inclusion criteria including time in major, time at the institution, and first and last majors to determine how the rate of overpersistence is impacted and what aligns most closely with our conceptual definition. Our continuing work will reflect the revised definition. We anticipate completing revisions to our definition soon and plan to publish our revised definition and operationalization strategy at the Frontiers in Education Conference in Fall 2021.

Using our definition of overpersistence, the historical sample (with known outcomes) is identified and relevant data markers attached to each student in the sample using R [2]. After being compiled, the data is moved from R to SPSS [3] for analysis. We are using Chi-Squared

Automatic Interaction Detection (CHAID) [4] to identify the indicators of overpersistence. CHAID requires large sample sizes and uses both F and chi-squared tests to create a decision tree and separate the sample into mutually exclusive nodes which share common attributes. Attributes of nodes with a high proportion of students overpersisting will be used to identify currently enrolled students at risk of overpersisting. The variables used to make these determinations can be categorical or continuous. In addition to traditional demographic variables, the variables currently under consideration are listed in Table 1.

Table 1. Predictor variables computed for CHAID analysis

Variable(s)	**Description**
first.term.hours	Number of credit hours attempted in student's first term
first.major & last.major	Majors enrolled in during the student's first and last terms
grad.major	Major of the degree earned by the student, if applicable
sems.in.FYE	Number of semesters enrolled in First Year Engineering
sat.math, .verbal, .total	Scores on the math and verbal section of the SAT; total score
act.composite	Score on the ACT
hs.gpa	GPA earned in high school
hs.percentile	Student rank in high school class as a function of class size
term.NN.sem.gpa	Semester GPA earned during term "NN"
term.NN.cum.gpa	Cumulative GPA from enrollment to term "NN"
Attend.NN	Enrollment status in term "NN"
ever.coop	Binary variable to indicate if the student participated in a co-op
math.placement	First MATH-prefix course enrolled in at the institution
first.course.grade.CRSE	Letter grade in first attempt of course "CRSE"
total.num.attempts.CRSE	Total number of attempts of course "CRSE", including W (withdrawal) and I (incomplete)
course.gpa.CRSE	GPA for all attempts of course "CRSE"
failed.any.SEQ	Binary variable to indicate if the student failed any course in a sequence "SEQ", e.g., the calculus sequence (Calculus I-III and Differential Equations).
SEQ.gpa	GPA for all attempts of all courses in the sequence "SEQ"
count.L.1xxx; count.L.2xxx	Number of specific letter grades "L" earned by a student in 1000-level and 2000-level courses, where L = D, F, I, or W

The second part of this research goal is to identify common indicators of overpersistence in ME at other institutions using the Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD) [5]. For identifying commonalities in ME programs

across institutions, we are developing a spreadsheet to map how curriculum changes have occurred at MIDFIELD institutions over time. This sheet will be useful for tracking both changes within an institution and identifying similar courses between institutions, as well as where the comparable courses fall in the respective curricula.

Instrument Development

We have continued to develop the Multidimensional Inventory of Decision-making Competency (MIDC), which is based on a single-scale instrument, the DMCI, by Miller and Byrnes [6]. The instrument has been developed through four rounds of instrument expansion and refinement [7], [8]. The main goal of these revisions was to explore useful subscales that align with the Self-Regulation Model of Decision-Making [9].

Each revision was distributed to first-year students at a large, land-grant institution in the southeastern United States who were enrolled in first-year engineering classes (samples ranged in size from 167 to 1004). Exploratory and confirmatory factor analysis of our first revision produced three factors: Generation & Evaluation, Impulsivity (lack of process), and Reflection [7]. In the second revision, we added four additional items with the expectation they would load onto the Reflection factor. As a result, this revision was finalized with four factors – Learning (previously Reflection, with three of the new items), Avoidance, Information Gathering, and Impulsivity [8].

Several new items were included in the third revision (with three expected to load onto Impulsivity and one onto Avoidance). Analysis of August 2019 data was conducted in JASP 0.14 statistical software [10]. After the initial data entry, descriptive analysis was performed. Distribution plots provided a helpful understanding of the data and quality check. Then, we performed reliability analyses to investigate the internal consistency (Cronbach's alpha, α) of each factor: five Impulsivity items, eight Learning, nine Avoidance, and six Information Gathering. Based on the results, we:

- included two of the three new items on the Impulsivity factor to solidify the factor,
- removed two items from the Learning factor to increase the internal consistency,
- included one new item and removed six items from the Avoidance factor to improve the face validity of the factor, and
- removed one item from the Information Gathering factor to increase the internal consistency.

A confirmatory factor analysis (CFA) confirmed the four resulting factors. Noting that the Avoidance factor was left with only three items, we engaged in a collaborative process with team members, the external evaluator, and the consultant to select two more items to include in the Avoidance factor. We plan for this to be the final addition to the survey.

In August 2020, the university was entirely online due to COVID-19 and due to logistical changes, the survey was distributed without incentive, yielding low response rates. Without an extra credit incentive, many students started the survey but did not finish. Similar to the 2019 data, we started by conducting a descriptive analysis followed by distribution plots and overall reliability analysis followed by reliability analysis per factor. After conducting descriptive and reliability analysis in JASP, we selected the five most reliable items per factor and computed factor scores. We were not able to conduct CFA due to the small sample size, so we conducted Pearson's correlation between factors to investigate the direction of correlation (Figure 1). The

January 2021 survey administration is now complete, and thanks to a new extra credit agreement, we have enough responses to conduct a full CFA.

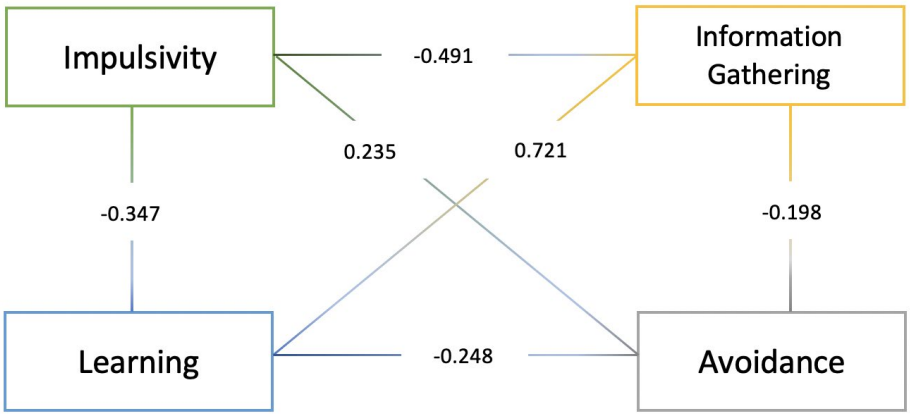

Figure 1. Pearson's r correlation values among factors

Academic Dashboard

We have continued to develop the Academic Dashboard including updates to the Development Manual. Excel with Visual Basic is the platform for the Dashboard prototype. The Dashboard accepts user inputs for GPA and DMCI score. It will eventually link directly to the MIDC. The Dashboard can retrieve numerical research results from a website we created. It then provides dynamic feedback to the user on their data in relation to the information retrieved. Additionally, the Academic Dashboard accepts user inputs regarding time spent studying for each course and expected grades and plots these data. This visual representation provides students with the ability to track their habits and encourages more self-regulated behavior.

Path Forward

On studying **Overpersistence,** we aim to complete final checks on our institutional data and finalize our CHAID analysis of overpersistence for ME. After definitive indicators of overpersistence are established, we will examine pathways of similar students to identify strategic alternative pathways. Our priority is to complete the ME analysis so that findings can be incorporated into the Dashboard. Then we will apply the process to other disciplines at our institution and to ME at other institutions.

For the **Instrument Development** research objective, we intend to run a final confirmatory factor analysis on the latest data collection from January 2021 and then publish the final MIDC instrument in an archival journal. We will use responses from other scales on the survey (self-regulated learning, intent to persist, fit, and satisfaction), as well as academic data as evidence of convergent and predictive validity.

We will work towards incorporating the above results into the **Academic Dashboard**. We will develop feedback based on MIDC scores to help students become aware of their strengths and challenges. We will also add and enhance features to help students self-regulate learning and introduce major exploration where appropriate (based on overpersistence indicators). The design

process of such features will be based on the Self-Regulation Model of Decision-Making which consists of generation, evaluation, and learning phases.

Acknowledgements
The authors would like to thank Becca Spilka for her work on the Academic Dashboard and corresponding manual. This material is based upon work supported by the National Science Foundation (NSF) under Grant No 1745347. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

References

[1] M. K. Orr, R. K. Anderson, and M. L. Rucks, "Work in progress: Developing a procedure for identifying indicators of 'overpersistence,'" in *Proceedings of the American Society for Engineering Education Annual Conference*, 2017.
[2] R Core Team, "R: A Language and Environment for Statistical Computing." R Foundation for Statistical Computing, Vienna, Austria, 2020.
[3] IBM Corporation, "IBM SPSS Statistics for Windows, Version 27.0," 2020. .
[4] G. V. Kass, "An Exploratory Technique for Investigating Large Quantities of Categorical Data," *Appl. Stat.*, vol. 29, no. 2, p. 119, 1980.
[5] M. W. Ohland and R. A. Long, "The Multiple-Institution Database for Investigating Engineering Longitudinal Development: An Experiential Case Study of Data Sharing and Reuse," *Adv. Eng. Educ.*, vol. 5, no. 2, 2016.
[6] D. C. Miller and J. P. Byrnes, "To achieve or not to achieve: A self-regulation perspective on adolescents' academic decision making," *J. Educ. Psychol.*, vol. 93, no. 4, pp. 677–685, 2001.
[7] M. K. Orr, K. M. Ehlert, M. Rucks, and M. Desselles, "Towards the Development of a Revised Decision-Making Competency Instrument," in *Proceedings of the American Society for Engineering Education*, 2018, vol. 2018-June.
[8] K. M. Ehlert, M. L. Rucks, B. A. Martin, M. Desselles, S. J. Grigg, and M. K. Orr, "Expanding and Refining a Decision-Making Competency Inventory for Undergraduate Engineering Students," in *Proceedings of the IEEE Frontiers in Education Conference (FIE)*, 2019.
[9] J. P. Byrnes, *The Nature and Development of Decision Making*. Mahwah, NJ: Lawrence Erlbaum Associates Inc., 1998.
[10] JASP Team, "JASP (Version 0.14.1)[Computer software]," 2020. .