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Development of an Academic Dashboard for Empowering Students to be Adaptive Decision-Makers

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Abstract

This paper provides a summary of activities and accomplishments of an NSF CAREER project, "Empowering Students to be Adaptive Decision-Makers." We discuss our progress on (1) identifying indicators of poor academic fit in engineering majors; (2) examining relationships between the measures of theoretical constructs (Decision-Making Competency Inventory, DMCI) with the real-world, academic behaviors (major choice and major change); (3) revisions to the DMCI; and (4) development of the Academic Dashboard for putting students in the driver's seat of their education. A prototype of the Academic Dashboard and its functionality are described.

Project Overview and Prior Accomplishments

The objective of this NSF CAREER project is to help students learn to make adaptive decisions that lead to academic and personal success. It includes two major research goals as well as an education component.

The first research goal seeks to identify indicators of poor academic fit in engineering majors as well as their corresponding paths of success across multiple institutions. Our work to accomplish this goal has included identifying indicators of overpersistence [1] and how confidence in major choice correlates with major change [2], [3]. Initial indicators of overpersistence in Mechanical Engineering include high school GPA, SAT Verbal score, and college GPA. While the first term GPA is the most explanatory of the term GPAs, cumulative GPA gains explanatory power with each semester [1]. We have also found that a single item measure of confidence in major choice is a better indicator of whether first-year students will matriculate into their originally intended engineering major from a common first-year engineering program than the Decision-Making Competency Inventory (DMCI) [2], [3]. This paper includes a discussion of indicators of overpersistence that have been identified using Youden's J statistic.

The second research goal is to determine how measures of theoretical constructs align with real-word, academic behaviors. The constructs being considered include decision-making competency, major fit and satisfaction, and intent to persist. To help accomplish this goal, we have revised the Decision-Making Competency Inventory (DMCI) [4], [5] from its original single scale by adding items that allow it to map more directly to the components of Byrnes's Self-Regulation Model of Decision Making [4]. The first revision included three factors – Generation and Evaluation, Impulsive / Lack of Process, and Reflection [6]. A second revision, which included an additional four items expected to load onto the Reflection factor, resulted in four factors – Learning (previously Reflection, with three of the new items), Avoidance, Information Gathering, and Impulsivity [7]. In this paper, we will also discuss new findings between the DMCI and major changes as well as the third revision of the instrument.

The project's education component is to create an online system for the sharing of research results with students and advisors. This system, the Academic Dashboard, has previously been storyboarded and illustrated with cartoons to show anticipated functionality. A prototype version of the dashboard and its functionality are described in this paper.

Identifying Indicators of Overpersistence

Using our definition of "overpersisters" as first-time college students who enroll full-time at a university for at least one year and either (i) leave the university without a degree or (ii) are enrolled in the same major for six years and have not graduated [1], we are examining a different method to identify potential indicators of overpersistence. The method we are exploring in the current paper is the use of Youden's J statistic [8] with historical data of Mechanical Engineering (ME) students from our original sample as described in [1]. This sample included 902 full-time, first-time-in-college students who were enrolled at a single institution for more than one calendar year whose first degree-granting major and last major were both ME. There are 11 more students than in [1] due to a programming error in the prior work that excluded students taking exactly 12 hours in their first semester. The study institution has a first-year engineering program that would be categorized as "FYE" by the Chen *et al.* taxonomy [9]. Youden's J statistic is a rating of the value of a test in predicting a binary outcome. In our work, the test variables include individual course grades, GPAs, and standardized test scores, and the binary outcome is being an overpersister or not. For each of these variables, a range of cutoff values (e.g., GPA in increments of 0.01) was tested and the optimum cutoff was selected based on the maximum J statistic. A positive or negative test prediction was assigned based on a student's individual metric compared to the test's cutoff value. A positive prediction indicates that the student is likely to be an overpersister in the major and thus should consider whether that major is their best path to success. A negative prediction indicates that the student is not likely to be an overpersister in the major and therefore is expected to graduate in the major within six years of matriculation.

Known cases are sorted into four groups as shown in Table 1. A predicted outcome that matches the student's actual outcome is deemed true, and a predicted outcome that does not match the student's actual outcome is deemed false.

The two actual outcomes are that the student was an overpersister in ME (i.e., did not earn a degree in six years) or that the student was not an overpersister (i.e., earned a degree in ME within six years).

Table 1. Categories used to calculate Youden's J Statistic.

		Actual Outcome	
		Student is an overpersister	Student is not an overpersister
Predicted Outcome	Student is expected to be an overpersister	True Positive	False Positive
	Student is not expected to be an overpersister	False Negative	True Negative

$$J = \left(\frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}\right) + \left(\frac{\text{True Negatives}}{\text{True Negatives} + \text{False Positives}}\right) - 1$$

Equation 1. Youden's J statistic.

The J statistic is calculated as shown in Equation 1. The possible values for Youden's J statistic range from a lower bound of 0, which indicates that the test has no predictive value, to an upper bound of 1, which indicates that the test is a perfect predictor. For each indicator variable, several values were tested as cutoff points, and the largest J was selected as the cutoff point for each test.

The cutoff points that yielded the largest J values are shown in Table 2. Using the first semester term GPA (which is equivalent to first semester cumulative GPA) as an example, students with a GPA less than 2.76 are predicted to be overpersisters and students with a GPA equal to or higher than 2.76 are not predicted to be overpersisters. Of the students expected to be overpersisters, 115 were overpersisters (true positives), but 211 were not overpersisters (false positives). Of the students not expected to be overpersisters, 484 were not overpersisters (true negatives), but 92 were overpersisters (false negatives). Inserting these values into Equation 1 results in a J statistic of 0.252.

Table 2. Youden's J statistic calculations for many potential variables of overpersistence. Rows are ordered with decreasing values of Youden's J.

Indicator	N†	Cutoff Value	True Positive	False Positive	True Negative	False Negative	J
Sem 6 Cum. GPA	896	2.25	103	147	548	98	0.301
Sem 5 Cum. GPA	898	2.28	105	161	534	98	0.286
Sem 4 Cum. GPA	899	2.43	117	207	488	87	0.276
Sem 1 Term GPA	902	2.76	115	211	484	92	0.252
Sem 3 Cum. GPA	902	2.51	116	224	471	91	0.238
Sem 3 Term GPA	902	2.30	123	248	447	84	0.237
Calculus IV‡	868	B	114	256	421	77	0.219
Calculus III‡	889	B	118	248	437	86	0.216
High School GPA	888	2.63	108	223	460	97	0.200
Sem 4 Term GPA	899	2.75	148	366	329	56	0.199
General Chemistry‡	820	B	95	190	435	100	0.183
Sem 2 Cum. GPA	902	2.83	137	334	361	70	0.181
Sem 6 Term GPA	896	2.41	117	281	414	84	0.178
Calculus I‡	588	B	70	144	301	73	0.166
SAT Verbal Score	902	500	108	260	435	99	0.148
Statics‡	892	C	74	152	536	130	0.142
Sem 5 Term GPA	898	2.57	150	422	273	53	0.132
Calculus II‡	837	B	106	267	375	89	0.128
Sem 2 Term GPA	902	2.07	66	134	561	141	0.126
SAT Score	902	1160	120	345	350	87	0.083
ACT Score	902	26	154	485	210	53	0.046
SAT Math Score	902	600	75	235	460	132	0.024

† The number of students with data reported vary by indicator. For example, every student has a first semester GPA, but not all take Calculus I (due to transfer credit) or persist at the institution to their sixth semester.
‡ For students who took a course multiple times, only the first course grade was used in calculations.

The indicators that yielded the best results were the cumulative GPAs for the 1st, 4th, 5th, and 6th semesters. However, because the 5th and 6th semester are late identifiers of overpersistence, these will likely be excluded from future analysis. The cutoff values for the cumulative GPAs for the 1st and 4th semesters are 2.76 and 2.43, respectively; the J statistics are 0.252 and 0.276, respectively. Of the individual course grades, Calculus III (Multivariable Calculus) and Calculus IV (Differential Equations) yielded the highest Youden's statistics of the six classes considered each with cutoff grades of B, except Statics with a cutoff grade of C. The J statistics for Calculus III and IV are 0.216 and 0.219, respectively. SAT Verbal is more predictive than SAT Math. The results of using Youden's J are consistent with those previously found by regression in [1], with the added benefit that an optimal cutoff point has been identified.

Changes between Intended Major and Actual Major One Year Later by DMCI Score

After investigating how confidence in major choice correlates with major change, we have also studied how decision-making competency correlates with major change. Students in a first-year engineering program were asked their intended major at the beginning of their first year of study along with the items from the Decision-Making Competency Inventory (DMCI) [4], [5]. Students' official majors were obtained from institutional data one year later. Students with DMCI scores in the top quartile switch intended majors less frequently than students in the bottom quartile. More students with a higher DMCI score intended to major in Bioengineering (24% in top quartile and 11% in bottom quartile). Further, more of the students in the top quartile who intended to major in Bioengineering were actually enrolled in it a year later (52% in top quartile and 23% in bottom quartile). There are also more students with a lower score who remained in the first-year engineering program one year later compared to students with a higher DMCI score (18% in bottom quartile and 4% in top quartile).

Instrument Development

After completing the second revision [7] of the Decision-Making Competency Inventory [4], [5], we began a third revision of the instrument. This revision includes three items expected to load onto the Impulsivity factor and one onto the Avoidance factor. This version has been completed by 684 students in the first two weeks of a first-year engineering course. A final, revised instrument will be published soon.

Development of the Academic Dashboard

In its completed form, the Academic Dashboard will be an interactive, online tool available to students to provide research results beneficial to their development including strategic pathways in a form that can provide support for student decision-making. The dashboard will also allow students to track their study habits and grades as well as explore resources about decision-making strategies and information about majors available to them.

The current prototype of the dashboard is being developed in Microsoft Excel using Visual Basic. The dashboard accepts user inputs, including GPA, DMCI score, and course schedule. Based on the values entered on the dashboard, it provides the user with certain tools and prompts. The prototype dashboard can also read research results published on a website for real-time updating as more data is collected and analyzed. A development manual has been created for future iterations of the dashboard; the manual is available from the first author upon request.

Figure 1 displays screen captures from the prototype version of the Academic Dashboard. The lower image is the interface that users interact with upon opening the dashboard. The four pop-ups above the user interface are user forms that appear when the associated buttons are selected. On the upper row of user forms in Figure 1, the first pop-up, on the left, allows users to enter their GPA which has been identified as an important factor for identifying overpersistence. The second pop-up requests users to enter their DMCI score which has been correlated with major changes and movements. The last two pop-ups are used to enter a course schedule for the current semester. The two buttons in the center column of the user interface that do not have pop-ups pictured allow users to track their study time and estimate their grades to encourage more self-regulated behaviors.

The dashboard will include scaffolds to help students make use of the information presented, and they can also bring their data to advising or academic coaching meetings to allow for a richer advising session. This is consistent with our project's original goal – to supplement and enhance advising, not replace it.

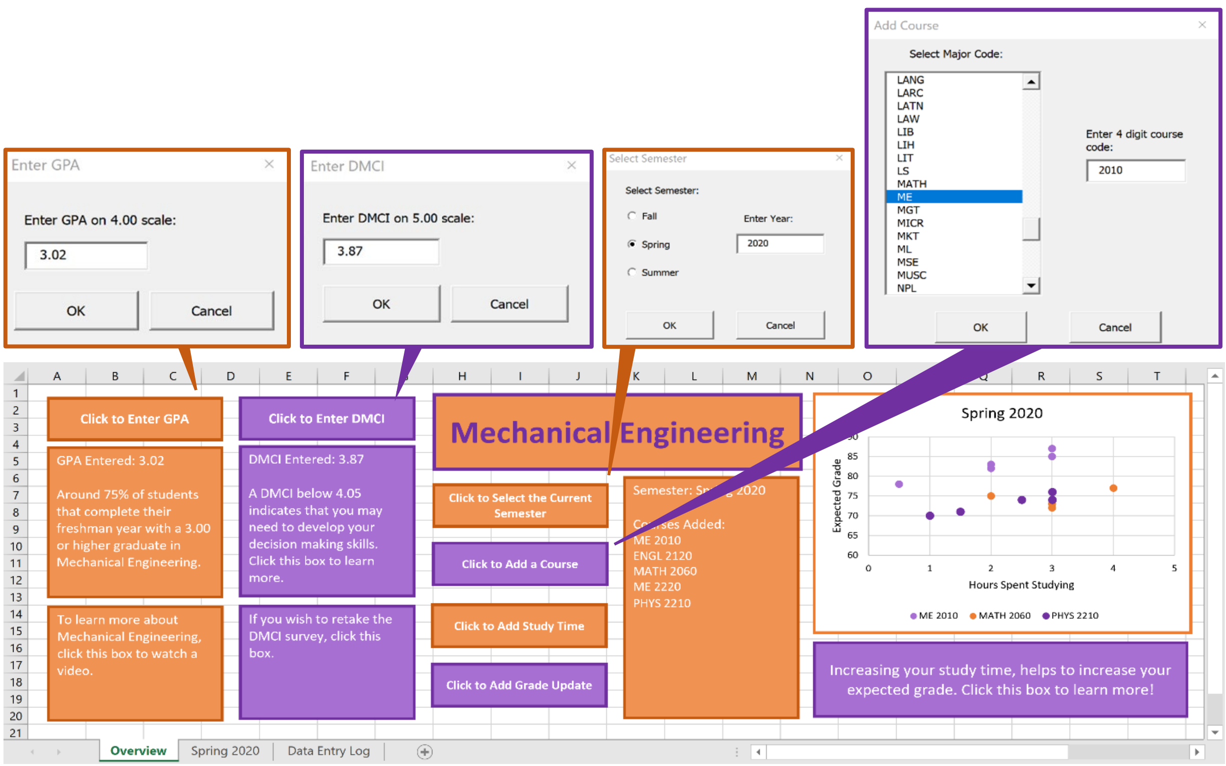

Figure 1. The prototype version of the Academic Dashboard. The upper four images are all pop-ups that appear when the associated button is selected in the dashboard.

Conclusions and Path Forward

We have made progress on identifying indicators of overpersistence in Mechanical Engineering at one institution and will expand to other disciplines at the same institution as well as Mechanical Engineering at other institutions using the Multiple-Institution Database For Investigating Engineering Longitudinal Development (MIDFIELD) [10]. Analysis of each program will also include identification of strategic alternative pathways (other majors that may be a better fit). Additionally, we are preparing the final Revised Decision-Making Competency

Inventory for publication and are examining the relation between it and engineering major choice and persistence. A prototype Academic Dashboard has been created and we continue to add and improve functionality. The prototype of the Academic Dashboard will also be user-tested to identify coding errors and other areas for improvement with the user interface.

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