Supplemental Online Materials

Two Paths in Persistence: STEM Course and Career Motivation Develop Distinctly and Relate to Different Precursors to STEM Career Pursuit in College Physics

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1. Other Published Work from This Dataset

This manuscript is one of three papers being produced from a broader dataset. All three papers have substantially different aims and no overlap in research questions. In one other paper, Beymer et al. (2026) examined how students' perceptions of significant course assignments each week related to their weekly motivation. In the other, Muenks et al. (in preparation) examined how students reported that various social and contextual factors influenced their weekly career motivation. The present study overlaps with this prior research only in its use of some of the same items to assess baseline career- and course-related motivational beliefs.

2. Complete List of Scale-Score Questionnaire Items Used in the Present Study

Construct	Items
Course-Related Motivational Beliefs:	
Expectancy Beliefs *Source: Kosovich et al. (2015)*	I am confident that I will do well in my physics class. I expect to get a good grade in my physics class. I believe that I can be successful in my physics class.
Utility Value *Source: Conley (2012)*	Physics is valuable because it will help me in the future. Physics will be useful for me later in life. Physics is practical for me to know. Physics helps me in my daily life outside of school. Being good in physics will be important for my future (like When I get a job or go to graduate school).
Intrinsic Value *Source: Conley (2012)*	I enjoy the subject of physics. I enjoy doing physics. Physics is exciting to me. I am fascinated by physics. I like physics.
Perceived Cost *Source: Flake et al. (2015)*	This class will demand too much of my time. I will have to put too much energy into this class. This class will take up too much of my time. This class will be too much work. This class will require too much effort. I'll have to sacrifice too much to be in this class. This class will require me to give up too many activities I value. Taking this class will cause me to miss out on too may other things that I care about. I won't spend as much time doing other things that I would like because I am taking this class. I'll worry too much about this class. This class will be too exhausting. This class will be emotionally draining. This class will be too frustrating. This class will be too stressful.

	This class will make me feel too anxious.
Career-Related Motivational Beliefs:	
Expectancy Beliefs: *Source: Adapted from Eccles & Wigfield (1995) in Author (2024)*	I think I will do well in this career. I think I will be good at this career. Compared to other students, I expect to do well in this career. Compared to all the other students who intend to pursue this career, I would consider myself as one of the best at it.
Utility Value *Source: Adapted from Conley (2012) in Author (2024)*	This career is valuable because it will help me in the future. Pursuing this career will be useful for me later in life. The skills associated with this career are practical for me to know. The skills associated with this career will help me in my daily life.
Intrinsic Value *Source: Adapted from Conley (2012) in Author (2024)*	I think I will enjoy this career. I think I will enjoy doing the tasks associated with this career. This career is exciting to me. I am fascinated by this career. I think I will like doing this career.
Perceived Cost *Source: Adapted from Flake et al. (2015) in Author (2024)*	This career will demand too much of my time. I will have to put too much energy into this career. This career will take up too much of my time. This career will be too much work. This career will require too much effort. I'll have to sacrifice too much to do this career. This career will require me to give up too many other activities I value. This career will cause me to miss out on too may other things that I care about. I won't spend as much time doing the other things that I would like because of this career. I'll worry too much about this career. This career will be too exhausting. This career will be emotionally draining. This career will be too frustrating. This career will be too stressful. This career will make me feel too anxious.
Career Satisfaction *Source: Author (2024)*	How satisfied are you with your current long term career plans?
Career Certainty *Source: Author (2024*	How certain are you that you will pursue this career?

3. **Details of Career Plan Coding and Classification of Physics Importance for Career Plans**

Details of Career Coding Rules

As part of data collection, we asked students to write in their long-term career plans with an open-ended item that read: “Right now, what is the career you expect to be doing 10 years after you graduate college?” Each student’s write-in career plan was then coded by matching it to the closest career title from the O*Net Career Database (www.onet.org). This database is run by the U.S. Department of Labor and Bureau of Labor Statistics and it provides a comprehensive taxonomy of common career paths in the United States. In the database, there is a list of career titles along with detailed information for each title about the amount of different types of knowledge, skills, and education that is typically required for each career. Data for the occupational statistics was collected via a survey of employers and employees for each type of occupation (see the database website for more details).

Not all career plans were coded in exact alignment with O*Net titles. First, for the career path of becoming a physician, we coded all students reporting any type of physician career goals as the general category of “physician” instead of coding specialties (as O*Net does). We did this because many students articulate the general physician title instead of expressing a specialty, and because students’ undergraduate training looks highly similar across types of doctor roles so the specialties were not relevant to our research questions. Second, some participants identified clear professional plans, but their responses were still too general to match O*Net’s detailed career options (e.g., a student who wrote in “engineer”, while O*Net categorizes specific types of engineers). For five career paths in our sample (i.e., engineers, data analysts, high school teachers, professors, researchers), we created general codes to represent these paths, which did not map onto O*Net. Third, some students wrote that they were considering multiple career paths, wrote that they were undecided, or they did not answer the question at all. These students were classified using codes for “considering multiple careers”, “undecided”, or they received missing data codes. Finally, some students wrote in very general career goals (e.g., work in the health care industry). Our team used two codes to represent “vague career plans” or “industry specific plans.

In order to facilitate coding, our research team created a database of ~230 common O*Net career titles reported among college STEM students, along with example jobs for each title (e.g., “Director of Pharmaceutical Company” was listed as an example of the O*Net career title “Natural Science Managers”). The database also contained the “doctor” career code, the five general career path codes, and the five codes for vague or uncodable responses outlined in the prior paragraph. Coders were instructed to search the spreadsheet for job titles and use the matching O*Net specific classification whenever relevant. If there was no match, they could search O*Net for a better career title, and if that did not work they could use one of the general classification codes. This process helped ensure higher reliability in coding and better use of coders’ time, as searching O*Net directly for each career path can be cumbersome.

Coding Process and Interrater Reliability

Two trained research assistants implemented the initial O*Net career coding for each participant. In order to learn the career coding scheme and rules, these two coders completed several initial rounds of training and pilot coding with the first author using career responses from a different data set. Next, the two coders independently coded all of the responses from the present study. The two coders’ agreement on career classifications was 89.4%, suggesting

high reliability. A third trained coder (the first author, who has extensive experience using this coding scheme from prior studies) resolved all disagreements. We believe reliability in this sample was high in part because of our addition of non-O*Net careers which allowed for agreement on career paths that might otherwise be too vague or ambiguous to code reliably, and in part because this sample of college students thinking forward to their 10-year career goals was able to articulate their paths clearly.

Results of Coding

Ultimately, of 738 participants, the team was able to code the vast majority of career plans into a clear professional title (93.8% of responses). Sixteen participants did not answer the career plan question, four were undecided, six were considering multiple, and twenty participants articulated vague career plans that could not map onto a specific profession, with eight of those individuals wanting to work in computer science. Beyond these, there were 194 participants whose career titles were not exactly aligned with O*Net careers, but the vast majority of these were physicians whom we grouped together in a general category for ease of interpretation (144 participants). There were 50 other participants who received a general professional code (38 engineers, 6 teachers, 3 data analysts, 2 researchers in a STEM field, and 1 graduate school in a non-STEM field). Not all career plans were coded in exact alignment with O*Net titles. First, for the career path of becoming a physician, we coded all students reporting any type of physician career goals as the general category of “physician” instead of coding specialties (as O*Net does). We did this because many students articulate the general physician title instead of expressing a specialty, and because students’ undergraduate training looks highly similar across types of doctor roles so the specialties were not relevant to our research questions. Second, some participants identified clear professional plans, but their responses were still too general to match O*Net’s detailed career options (e.g., a student who wrote in “engineer”, while O*Net categorizes specific types of engineers). For five career paths in our sample (i.e., engineers, data analysts, high school teachers, professors, researchers), we created general codes to represent these paths, which did not map onto O*Net. Third, some students wrote that they were considering multiple career paths, wrote that they were undecided, or they did not answer the question at all. These students were classified using codes for “considering multiple careers”, “undecided”, or they received missing data codes. Finally, some students wrote in very general career goals (e.g., work in the health care industry). Our team used two codes to represent “vague career plans” or “industry specific plans.

Table S1 reports the most common career paths reported by students in the current study’s sample.

Table S1

Most Common Career Plans Reported by Students in Physics Sample

Career Plan Name	**Number Reporting (% of sample)**
Physicians (all subtypes collapsed together)^	133 (18.0%)
Mechanical Engineers	81 (11.0%)
Physician Assistants	50 (6.8%)
Aerospace Engineers	43 (5.8%)
Physical Therapists	38 (5.1%)
Software Developers	37 (5.0%)
Engineers (subtype not specified, or subtype not listed separately in O*Net)^	38 (5.1%)
Civil Engineers	23 (3.1%)
Electrical Engineers	22 (3.0%)
Surgeons	18 (2.4%)
Chemical Engineers	17 (2.3%)
Magnetic Resonance Imaging Technologists	14 (1.8%)
Chemists	13 (1.8%)
Dentists (all subtypes collapsed together)^	12 (1.6%)
Bioengineers and Biomedical Engineers	13 (1.8%)

Note: Distinct career paths with more than 10 students listing them are noted. Percentage reflects percentage out of the total sample (*N* = 738). ^indicates a broad category that is not directly listed in O*Net or reflects multiple O*Net categories collapsed together.

After classifying career titles for each participant, we moved to quantifying the importance of physics knowledge required for each student in the sample's future professional career plans. To obtain this information, we exported data from the O*Net database about the importance of physics knowledge in each career path that they list (which is scored on a 0-100 scale). This information could directly be obtained for most participants (~500 out of 738). For the remaining participants, we used decision rules to classify the amount of physics required as follows:

- For the 144 doctors in the sample, we used the importance of physics score that was reported in O*Net for internal medicine physicians (40), which could be thought to reflect the baseline training experience for physicians before specializing further.
- For engineers who did not specify a sub-field, there is not one "average" type of engineering profession to use as a baseline, so we took an average score of the importance of physics across the different types of engineers that were in the O*Net database, in order to reflect an average (67).
- For data analyst or data scientist, we used the score for "statistician" which is a closely related occupation listed on O*Net (18)
- For teachers, we used the O*Net score for the career path "Secondary School Teachers, Except Special and Career/Technical Education" (16).
- For anyone with broad or vague career plans classified as not being related to STEM fields, we gave the physics importance a score of 0.
- Eight individuals who wanted to work in the computer science industry. Even though these were "vague" plans, they were specific enough to gauge the amount of physics required. Thus we gave a score for computer programmers to these individuals (28).
- There were also a few careers in O*Net that did not have a physics importance score but were reported in our sample. For these we used the score for the

closest matching career path in O*Net (surgeons: we used internal medicine physicians; data scientist: we gave a score for statistician; penetration tester: we used the score for computer systems analyst).

Any remaining participants did not receive a physics importance score and were excluded from the robustness check analyses, because their responses were not clear enough to map onto a corresponding specific professional plan.

Altogether, we were able to obtain physics importance scores for 701 participants out of 738 (94.9% of participants). The mean score for this measure was 47.741 (*SD* = 20.21), suggesting that there was a fairly normal distribution of career plans in the sample with respect to the importance of physics knowledge for careers.

4. Robustness Check of Results for Students with High Physics Importance Scores

We used the classification of physics importance scores for careers, noted in the prior section, to do robustness tests of the associations between course and career motivational beliefs in our sample. To do this, we first grouped all participants in the study whose importance scores could be classified into two groups: High physics knowledge required, and low physics knowledge required. Grouping was based on individuals whose importance scores were above the mean for physics knowledge in the sample (47.71) versus at or below the mean.

Within both groups, we separately examined the associations between course motivational beliefs and corresponding career motivational beliefs, both within and across time points. Results of these analyses are reported in Table S2. As can be seen, the correlations between baseline

The main correlation of interest is that of baseline course beliefs relating to final career beliefs (i.e., the first column in the table), because this correlation best represents the extent to which the development of career beliefs might be associated with course beliefs. As can be seen, evidence does not support the idea that students with high physics importance in their career plans showed stronger relations between course and career beliefs. The baseline course to final career correlations were not systematically higher among the high-importance-group students for expectancy beliefs, intrinsic value, or cost perceptions. Utility value perceptions were slightly higher in the high-importance group (r = .217) versus the low-importance group (r = .140), but even in the high-importance group the correlation was still small and much smaller than the time-lagged associations between the same constructs in any group (for reference, the correlations between baseline utility value and final utility value were r = .439 for courses and .402 for careers in the low importance group, and r = .694 for courses and .421 for careers in the low-importance group). For completeness, we also examined within-time-point associations of the course and career constructs at baseline and final, but similar trends were observed for these variables. At baseline and final, within the time points, utility and intrinsic value had slightly larger correlations in the high-importance group, but correlation magnitudes overall remained small even in the high-importance group. Taken together, we conclude that correlations between corresponding course and career motivational beliefs are small within and across time points, even among students who required physics for their future career plans.

Table S2

Correlations Among Corresponding Course and Career Beliefs for Individuals with Different Levels of Physics Importance for Long-Term Career Plans

Low Physics Importance for Careers Group			
Variable	**Baseline Course and Final Career**	**Baseline Course and Baseline Career**	**Final Course and Final Career**
Expectancy Beliefs	.291*	.399*	0.371*
Utility Value	.140*	.281*	.121
Intrinsic Value	.031	-.003	.079
Cost	.390*	.427*	.485*
High Physics Importance for Careers Group			
Variable	**Baseline Course and Final Career**	**Baseline Course and Baseline Career**	**Final Course and Final Career**
Expectancy Beliefs	.266*	.306*	.206*
Utility Value	.217*	.294*	.263*
Intrinsic Value	.115	.214*	.149*
Cost	.390*	.522*	.477*

*$p < .05$