Looking into Gateway: Expectancy-Value Profiles Predict Undergraduates' Intent to Persist in Physics after Introductory Course

Yannan Gao, Anna-Lena Dicke, Nayssan Safavian, & Jacquelynne Eccles

Abstract:

Additional to the lack of gender and ethnic diversity, the attrition rate among Physics and Engineering undergraduates is as high as 40%. Considering the impact of STEM gateway course on students' choice of major, we investigated the association between students' Expectancy-Value beliefs at the beginning of the class with their intent to persist in Physics by the end of an introductory Physics class using a sample (N = 337) diverse in sociodemographic composition. Motivational profiles predicted students' intent to continue a career in Physics and an increase in their certainty about their choice but did not predict a decrease in such certainty. First-generation college students and Latino/a were more likely to become less certain by the end of class.

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For more information, please contact: yannang@uci.edu

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1. Objectives and theoretical framework

High dropout rates in STEM college majors are a persistent problem in science education (Chen, 2015). Attrition rates are particularly high in Physics and Engineering with more than 40% of undergraduate students leaving these majors (Chen & Ho, 2012). Furthermore, the field of physics and engineering is characterized by an underrepresentation of diverse student groups as less than a third of students are female or from underrepresented student groups (National Science Board, 2018).

The decision to leave a STEM major occurs early in college (Seymour & Hewitt, 1997). This is especially true for students from underrepresented backgrounds (Watkins & Mazur, 2013). As such, introductory STEM college courses can serve a key role in addressing these challenges as they can profoundly impact students' motivation and subsequent engagement in STEM fields (Gasiewski et al., 2012).

To better understand the underlying processes, this study focused on students' decision-making process in their first Physics college course using a demographically diverse sample. Specifically, we used the Expectancy-Value (E-V) Theory (Wigfield & Eccles, 2000) as our theoretical framework. Based on the E-V theory, students' choice of career is determined by their confidence in their ability to do well in the field (i.e. expectancy) and their valuing of the career (e.g. interest, attainment value and utility value). Expectancy-value beliefs influence a wide range of important career outcomes, such as performance and achievement in class, course-taking intentions, career plans and dropout decisions in STEM fields (e.g. Jones, Paretti, Hein & Knott, 2010).

To date much of the research on students' persistence within their majors and career choices have been using regression models that test the associations of a single E-V belief and outcome while holding other beliefs. However, it might be the specific interplay of the different E-V beliefs rather than the impact of single E-V beliefs that matter for student outcomes. To address this issue, we use a pattern-centered approach to investigate how students' E-V profiles relate to their career choices. We examined two research questions in this study:

RQ 1: What E-V beliefs profiles do undergraduates have at the beginning of an introductory Physics class?

RQ 2: To what extent do students' motivational profiles and sociodemographic characteristics predict their intent to persist in Physics at the end of the course?

2. Methods and Data Sources

This study uses longitudinal data from an introductory Physics course in a four-year public university in California. The course is the first part of the course sequence required for students majoring in the physics and engineering fields. Students completed two surveys about their beliefs and attitudes towards their study in Physics. One survey was administered the first week of the term and the second in the last week of term. Students received $5 gift card for completing each of the surveys. Participants are 337 undergraduates (36% women; 37% first-

generation college students [FG]; see Table 1 for details) recruited from three sections over two quarters.

Measures

Students' E-V beliefs were surveyed at the beginning of the course and their intent to persist in Physics were surveyed at the end of the course.

Expectancy. Expectancy measures students' confidence in their ability to do well in the course. The scale consists of four items with a 7-point Likert scale (1 = "Not at all true", 7 = "Very true"; α = .91, "*I am confident that I will do well in this course*.").

Interest. The scale of interest assesses students' enjoyment of learning in the class. It consists of 10 items with a 7-point Likert scale (1 = "Not at all true", 7 = "Very true"; α = .93, "*I enjoy learning about Physics*."). One time that was negatively worded ("*To be honest, I just don't find chemistry interesting*") was reversely coded.

Attainment value. Attainment value examines the extent to which the study of Physics is important for students' identity. The scale includes 4 items with a 7-point Likert scale (1 = "Not at all true", 7 = "Very true"; α = .89, "*Learning about chemistry will help me become the person I want to be*.").

Utility value. The scale of utility value measures the usefulness of learning Physics to the students. It consists of 7 items on a 7-point Likert scale (1 = "Not at all true", 7 = "Very true"; α = .87, "*Chemistry can be useful in my everyday life*.").

Intent to persist. Students intent to persist on their career path in the physical and engineering sciences was measured using two items on a 7-point Likert scale (1 = "Definitely not", 7 = "Definitely will"; α = .83; e.g. "*Do you intend to obtain a degree or certificate in the physical and engineering sciences?*").

Change in choice of major. The influence of the course on student's choice of major was measured by one multiple-choice question: "*How has this course affected your major choice?*" Students chose from one of the three options, "*It made me less certain about my original major*", "*It had no effect*", or "*It made me more certain about my original major*".

Gender. Students' gender was coded dichotomously (0 = men, 1 = women).

Race/ethnicity. Students reported their racial/ethnic identification by selecting from 10 options along with one open-ended option. Their responses were coded and aggregated into 5 groups for sufficient group size for analyses: White, Latino/a, East or South Asian, Southeast Asian and Other (including Black/African American, American Indian, Middle Eastern, and Pacific Islander).

First-generation college-going status. Students' reported the education level of their parents (or guardian). A dummy variable was created to indicate whether any of the parents have a Bachelor's degree (1 = FG students, neither of the student's parents own a Bachelor's degree; 0 = Continuing-generation [CG] college students, at least one of the student's parents own a Bachelor's degree).

We conducted latent profile analyses in M*plus* 8 to identify homogenous groups of students who are similar in the combination of their Expectancy-Value beliefs (Muthen & Muthen, 2017). We ran separate cluster analyses in Ropstat as a robustness check for solutions. After identification of the profiles, we created a categorical variable to indicate students' membership in one of the profile groups. To evaluate the association between students'

motivational profile and their persistence in Physics, we carried out one-way Analysis of Covariance (ANCOVA) and multinomial logistic regression in SPSS predicting to the two outcome measures *intent to persist* and *change in choice of major*, respectively.

3. Results

Estimates from the latent profile analysis and the hierarchical cluster analyses agreed on a three-factor solution: Profile 1 “Physics is not my thing” (N = 55), Profile 2 “Physics is not a bad choice” (N = 197), and Profile 3 “Physics is the way to go” (N = 85) (Figure 1). The three profile groups differed in all four beliefs: Profile 1 had the lowest level of expectancy and values towards physics, Profile 2 the middle and Cluster 3 the highest level of expectancy and values towards Physics (see Table 1). All three groups had similar sociodemographic composition with one exception. Women were underrepresented in Cluster 3 and overrepresented in Cluster 1, $\chi 2 = 20.02$, $df = 2$, $p < .001$.

One-way ANCOVA tests, controlling for socio-demographic background, showed that students in the three profiles had different levels of intention to pursue a career in Physics in the future [$F(2,313) = 15.69$, $p < .001$]. Bonferroni post hoc test suggested that students with Profile 1 were less willing to persist in Physics relative to students within Profiles 2 or 3. Students with Profile 2 or Profile 3 did not differ in their intent to persist.

More than half of the class (N = 223; 60%) reported no change in their choice of major by the end of the class. The rest of the students were evenly split in either becoming more certain (N = 76; 20%) or becoming less certain (N = 78; 21%) about their major choice. Multinomial logistic regression estimates showing how motivational and sociodemographic characteristics related to the change in students’ certainty about their major versus no change can be found in Table 1. FG and Latino/a students were more likely to become less certain about their major choice than their peers, whereas students in Profile 3 were more likely to become more certain about their major than students in Profile 2.

4. Scientific significance

These findings highlight the role of motivational profiles in students’ major and career intention within an introductory Physics course. Students with different combinations of E-V beliefs differed in their intent to persist in the physical and engineering sciences. Students in the profile characterized by lower levels of motivation reported to be less likely to persist in the physical and engineering sciences at the end of the introductory course. More importantly, gender played a role in this matter. Females were more likely to adhere to this particular motivational profile than to the motivational profile characterized by high levels of motivation. These lower levels of initial motivation coming into the major thus seem to put more females at risk for attrition than males—foreshadowing females’ increased likelihood of discontinuing their persistence within the major. One way to minimize the rate of attrition for females, thus, might be, to specifically target their expectancy and values using motivational interventions. Interestingly, students with high initial levels of motivation were more likely to be reaffirmed in their major choice, which will likely lower the risk of drop out in the future. However,

sociodemographic background was also influential for students' major plan. In particular, underrepresented student groups, i.e., FG and Latino/a students, were more likely to doubt their major, which could increase their likelihood to dropout in the future. Our findings corroborate previous findings in highlighting the importance and influence of gateway science courses. Given our findings, particularly underrepresented students, such as female, FG and Latino/a students, seem to be swayed in their intent to persist. To avoid attrition within these groups, interventions and support should, thus, be provided early on their college career starting with their first introductory courses.

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Figure 1

Profiles of Students' Expectancy-Value Beliefs

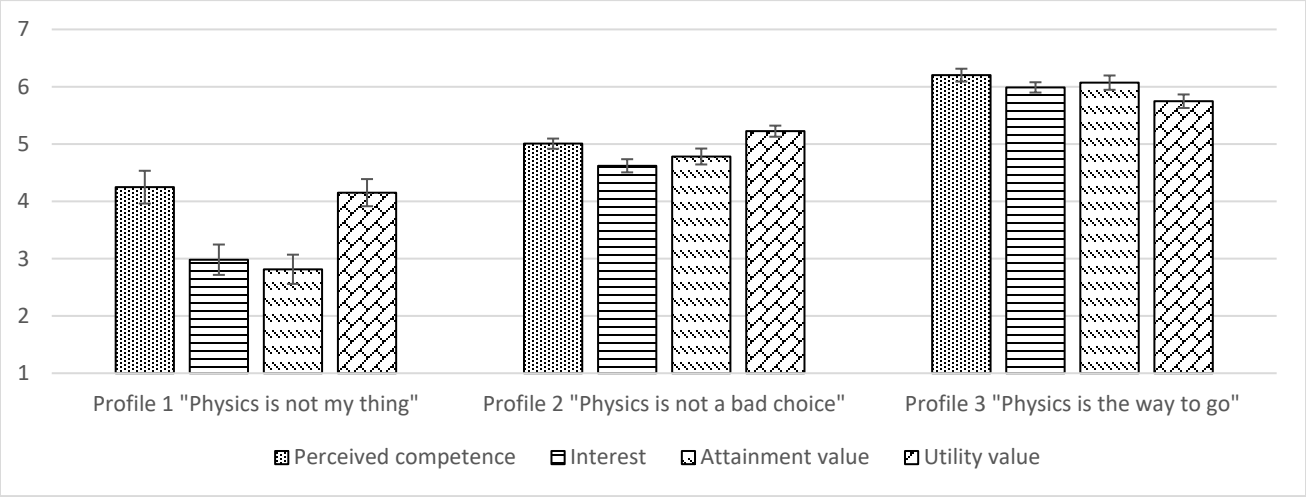

Figure 1. Mean of motivational beliefs in the three-class solution of latent profile analysis. All beliefs were measured on a seven-point Likert scale, with higher score indicating greater expectancy/valuing.

Table 1

Descriptive Information for Sample and Profile Groups

	Whole sample	Class 1	Class 2	Class 3	χ^2	*df*	*p*	Cramer's V
Girls	120	29^{+}	76	15^{-}	20.02	2	< .001	0.24
Ethnicity	--	--	--	--	5.90	8	0.66	0.10
White	53	7	29	17	--	--	--	--
Latino	51	10	32	9	--	--	--	--
East/South Asian	113	16	67	30	--	--	--	--
Southeast Asian	63	13	39	11	--	--	--	--
Other	35	5	21	9	--	--	--	--
FG	125	24	75	26	2.89	2	0.24	0.09
	M (SD)	M (SE)	M (SE)	M (SE)	F	*df*	*p*	
Perceived competence	5.15 (1.06)	4.25^{a} (0.29)	5.01^{b} (0.09)	6.20^{c} (0.11)	80.71	2	< .001	
Interest	4.65 (1.31)	2.98^{a} (0.27)	4.62^{b} (0.12)	5.99^{c} (0.09)	285.39	2	< .001	
Attainment value	5.16 (1.22)	2.81^{a} (0.26)	4.78^{b} (0.14)	6.07^{c} (0.13)	282.40	2	< .001	
Utility value	4.73 (1.44)	4.15^{a} (0.24)	5.22^{b} (0.1)	5.75^{c} (0.12)	68.97	2	< .001	
N	337	55	197	85	--	--	--	

Note. FG = first-generation college students. SD = standard deviation. $^{+}$adjusted standard residual greater than 1.96. $^{-}$adjusted standard residual less than -1.96. ^{ab} group averages differ at $p < .001$.

Table 2

Multinomial Logistic Regressions Results of Association between Motivational Profiles and Certainty about Major

		Outcome: Less Certain (1) vs No change (0)							Outcome: More Certain (1) vs No change (0)						
							95% CI of OR							95% CI of OR	
	Predictor	B	SE	Wald	*p*	OR	Lower	Upper	B	SE	Wald	*p*	OR	Lower	Upper
Profile 2 as reference group	Intercept	-1.99	0.32	39.08	<.001	--	--	--	-1.90	0.32	35.31	<.001	--	--	--
	Girls	0.38	0.32	1.40	0.24	1.46	0.78	2.72	0.49	0.34	2.09	0.15	1.62	0.84	3.13
	SA	0.39	0.41	0.90	0.34	1.47	0.66	3.26	0.33	0.40	0.67	0.41	1.39	0.63	3.05
	Latino/a	0.83	0.41	4.10	0.04	2.30	1.03	5.13	-0.28	0.53	0.28	0.60	0.76	0.27	2.13
	Other	0.68	0.49	1.94	0.16	1.98	0.76	5.15	0.64	0.47	1.90	0.17	1.90	0.76	4.73
	FG	0.73	0.32	5.11	0.02	2.08	1.10	3.93	0.44	0.34	1.71	0.19	1.55	0.80	3.00
	Class 1	0.59	0.39	2.31	0.13	1.80	0.84	3.82	0.14	0.46	0.10	0.76	1.15	0.47	2.86
	Class 2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Class 3	0.11	0.40	0.08	0.78	1.12	0.51	2.44	0.81	0.36	5.08	0.02	2.25	1.11	4.57
Profile 3 as reference group	Intercept	-1.87	0.38	24.39	<.001	--	--	--	-1.09	0.31	11.88	0.001	--	--	--
	Profile 1	0.38	0.32	1.40	0.24	1.46	0.78	2.72	0.49	0.34	2.09	0.15	1.62	0.84	3.13
	Profile 2	0.39	0.41	0.90	0.34	1.47	0.66	3.26	0.33	0.40	0.67	0.41	1.39	0.63	3.05
	Profile 3	0.83	0.41	4.10	0.04	2.30	1.03	5.13	-0.28	0.53	0.28	0.60	0.76	0.27	2.13
	Girls	0.68	0.49	1.94	0.16	1.98	0.76	5.15	0.64	0.47	1.90	0.17	1.90	0.76	4.73
	FG	0.73	0.32	5.11	0.02	2.08	1.10	3.93	0.44	0.34	1.71	0.19	1.55	0.80	3.00
	Latino/a	0.47	0.49	0.93	0.33	1.60	0.61	4.20	-0.67	0.52	1.68	0.19	0.51	0.19	1.41
	SA	-0.11	0.40	0.08	0.78	0.89	0.41	1.95	-0.81	0.36	5.08	0.02	0.44	0.22	0.90
	Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Note. CI = confidence interval. OR = odds ratio. SE = standard error. FG = first-generation college students. SA = Southeast Asian.

Table 3

ANCOVA Results of Association between Motivational Profile Classes and Intent to Persist in Physics

Source	Sum of Squares	*df*	Mean Square	F	*p*	Partial Eta Squared
Corrected Model	139.55	5	27.91	8.65	< .001	0.12
Intercept	949.11	1	949.11	294.00	< .001	0.49
Female	6.78	1	6.78	2.10	0.15	0.007
Ethnicity	0.15	1	0.15	0.05	0.83	0.000
FG	8.63	1	8.63	2.67	0.10	0.01
Profile	101.28	2	50.64	15.69	< .001	0.09
Error	991.08	307	3.23	--	--	--
Total	9371.00	313	--	--	--	--
Corrected Total	1130.63	312	--	--	--	--
Intent to persist (M[SD])	Class 1	Class 2	Class 3	--	--	--
	3.84^{a} (0.25)	5.30^{b} (0.13)	5.59^{b} (0.21)	--	--	--

Note. FG = first-generation college students. ^{Ab} group averages differ at $p < .001$.