2017

Pursuing the "Half Empty Question": Biology Undergraduates' Differential Engagement in a Brief Relevance Writing Intervention

Ting Dai
Temple University

Avi Kaplan
Temple University

Ying Wang
Temple University

Jennifer G. Cromley
University of Illinois at Urbana-Champaign

Tony Perez
Old Dominion University, acperez@odu.edu

See next page for additional authors

Original Publication Citation

Dai, T., Kaplan, A., Wang, Y., Cromley, J. G., Perez, T., Mara, K. R., & Balsai, M. (2017, April). *Pursuing the "half empty question": Biology undergraduates' differential engagement in a brief relevance writing intervention* [Paper presentation]. Paper presented at the 2017 annual meeting of the American Educational Research Association, San Antonio, Texas.

Paper Title Pursuing the "Half Empty Question": Biology Undergraduates' Differential Engagement in a Brief Relevance Writing Intervention

Author(s) Ting Dai, Temple University; Avi Kaplan, Temple University; Ying Wang, Temple University; Jennifer G. Cromley, University of Illinois at Urbana-Champaign; Tony Perez, Old Dominion University; Kyle R Mara, University of Southern Indiana; Michael Balsai; Yo

Session Title Interventions for Enhancing Cognitive and Motivational Outcomes

Session Type Paper

Presentation Date 4/28/2017

Presentation Location San Antonio, Texas

Descriptors Engagement, Motivation, Achievement

Methodology Mixed Method

Unit Division C - Learning and Instructions

DOI https://doi.org/10.3102/1175253

Objectives

Multiple studies from the US and Europe suggest that having undergraduate students write about the relevance of the academic content to their life and goals increases their course achievement and interest in the domain (Hulleman et al., 2010; Gaspard et al., 2015). However, a persistent finding in this line of research is that the notable benefits of the interventions manifest only for some students, mostly those with lower initial motivation, and not for others (Harackiewicz et al., 2015). Interestingly, such a differential effect is found across types and target of social-cognitive educational interventions (e.g. relevance, mindset, value affirmation, belonging; Schwartz et al., 2016). Schwartz et al. labeled this persistent finding the "half empty question" of brief social-psychological interventions: "why do the interventions only benefit a particular population, when there are reasons to believe most students might benefit?" (p. 397). The aim of the current mixed-methods study was to investigate the role of students' prior motivation, cognition, and achievement in their patterns of engagement in an intervention targeting their perceived relevance of academic content, and the relations of different patterns of engagement to students' course success.

Research questions

1. How do students' prior motivation and cognition profiles relate to their patterns of engagement in the relevance writing intervention?
2. Are different patterns of engagement in the relevance writing intervention associated with student achievement in course assignments?
3. What insights on the target processes might be gained from analyses of individual students' writing in the relevance assignments and their feedback on their experience in the assignments?

Theoretical Framework

Interventions to promote students' perceived relevance of academic content have been guided by multiple theoretical perspectives (Hartwell, 2014). All of these perspectives, however, view relevance as a connection between the academic content and an aspect of the student's self. For example, recent studies have followed Eccles' (1983) Expectancy-Value Theory (EVT) to conceptualize perceived relevance as utility value—perceiving the academic content as useful or instrumental to pursuit of personal goals (e.g., career goals). Researchers have intervened to promote relevance by asking students to write about the connection of the content to their life and goals (Hulleman & Harackiewicz, 2009). Other researchers who conceptualize relevance as attainment value (another value-component of EVT that refers to perceiving the content as important to sense of identity), or who adopt a multi-dimensional conception of relevance (Hartwell & Kaplan, 2014) also employ student writing about the connection of content to the self to promote students' perceived relevance with the aim of enhancing their motivation and achievement.

Brief relevance writing assignments reflect a broader approach to interventions on students' social-cognitive beliefs through instructional assignments or experiences (Lin-Siegler et al., 2016; Yeager & Walton, 2011). The theoretical rationale behind these interventions is that they begin a recursive process by which change in students' subjective beliefs results with

change in interpretations of events and their outcomes, which, in turn, reinforces these beliefs. Yet, a repeated finding in this line of research is that the interventions seem to change motivation and achievement only for some students and not others (Schwartz et al., 2016). Relevance writing interventions have been found to be effective among students with low expectancies for success, but not among students with high outcome expectancies. This has prompted calls for research that investigates various individual differences and situational factors that may moderate the effect of such interventions (Schwartz et al., 2016).

In the current study, we investigated the role of students' prior motivation and cognition (i.e., subject domain reasoning) in their patterns of engagement in relevance writing tasks. The study employed a mixed-method semester-long longitudinal design, investigating students' pre-intervention quantitative measures, patterns of completion of four relevance writing tasks, achievement in course assignments, and content and depth of their relevance constructions and perceived experience of engaging in the writing assignments.

Study Overview

The current study took place within a larger IES-funded intervention project in undergraduate introductory biology for majors at a large Mid-Atlantic university that aimed to improve students' motivation, learning, and achievement. All participants were randomly assigned within a study-specific Blackboard™ site to one of nine different experimental conditions—each comprising one of three cognitive intervention components combined with one of three motivational components—or a no-treatment control group. Data in the current study focus on participants who were randomly assigned to participate in the relevance-writing intervention.

Methods

Procedure

Participants consented and completed untimed pre-intervention measures in the first two weeks of the semester, engaged with the four relevance-writing tasks throughout the semester, and completed identical post-intervention measures at the end of the semester. All interventions and measures were delivered and completed by the participants on the study Blackboard™ site.

The relevance-writing intervention, on which the current study focused, involved writing a brief, free-form reflective essay in response to a prompt asking students to connect a central concept in the course curriculum to their own lives, as well as writing a short reflection on completing the task (see Table 1). The four prompts were administered approximately three weeks apart during the semester, corresponding to four central biology concepts taught in the course—evolution, biodiversity, animal physiology, and ecology. Students received email reminders when a relevance-writing prompt was available for them to complete.

Participants

Data in the current study were collected from the 96 students (M_{age} = 19.6 (2.1)*;* 61% female; 40.6% freshmen, 29.2% sophomores, 20.8% juniors; 34.4% White, 40.6% Asian, 7.3% Black; 43.7% first-generation college students) who were randomly assigned to receive the relevance writing intervention as part of the first semester of the project (N = 315, spring 2015).

Measures

Pre-intervention measures included a demographics form, a measure of biology reasoning, nine motivational subscales, and an intention to remain in STEM measure. Table 2 provides details of the measures.

Course achievement. We received exam grades on quizzes, labs, four benchmark exams, final exam, and final course grade. Course grade was made up of benchmark exam scores (lowest score dropped; 30%), quiz scores (5%), lab scores (30%), and final cumulative exam score (30%)[1]. Cronbach's alpha reliability across those 4 scores was .73.

Analytic Approach

To obtain students' profiles of motivation and biology reasoning proficiency, we conducted a hierarchical cluster analysis based on squared Euclidean distances with the Ward's method on standardized scores (Milligan, 1996) of the pre-intervention measures (except demographics). We then described students' patterns of engagement in the relevance-writing intervention based on the degree and timing of completion, and used chi-square and independent-samples *t* tests to compare participants with different engagement patterns on motivation-cognition profiles and course achievement. Finally, we selected representative individuals from the different engagement patterns and explored characteristics of their engagement (e.g., length and content of their writing, feedback about their experience of writing).

Results

Profiles of Motivation and Biology Reasoning Proficiency

Descriptive statistics are presented in Table 3. We first sought to identify student profiles of motivation and cognition at the beginning of the semester. A hierarchical cluster analysis with pre-intervention survey responses, including self-efficacy, interest in biology, academic efficacy, values, costs, intention to remain in STEM majors, and biology reasoning scores, indicated a total of 3 distinct profiles. Cluster-1 (C1) students (n = 30) showed relatively high self-efficacy, interest in biology, intention to remain in STEM majors, and proficiency in biology reasoning. They also perceived medium-level values and relatively low costs towards the biology course. Cluster-2 (C2) students (n = 38) manifested an opposite motivation profile to that of Cluster-1, and scored at a mid level on biology reasoning. Lastly, the Cluster-3 (C3) students (n = 24) perceived high value of the biology course, mid-level costs of taking the course, and scored medium on all other motivation variables, however, they scored lowest on biology reasoning.

Students with different profiles were comparable in age, parents' highest education, SATs, sex, and race, and were not significantly different in any course achievement measure, but they did differ in prerequisite chemistry course grade (F[2, 89] = 6.253, MSE = .895, p = .003; C1 > C2 = C3). These findings implied that, although students had different profiles in motivation and prior achievement before the intervention, these profiles did not predict their biology course achievement.

[1] The other 5% of the course grade is for attendance and participation, which was not analyzed separately in the current study.

Intervention Engagement Patterns

Completing of the relevance writing assignment included writing the essay and a short reflection. A total of 54 participants completed at least one assignment, 39 completed at least two, 31 completed at least three, and 22 completed all four. We explored the data and identified completing at least two relevance-writing assignments (i.e., 50% of the intervention) as a critical cutoff. We also scrutinized the data for participants' timing of completion (i.e., proximity to administration). Assignments completed after the course final exam were categorized as incomplete. A total of 32 participants completed at least 50% of the intervention in a timely manner (Pattern 1), with the rest (Pattern 2; $n = 64$) either completed less than 50% or engaged late in the assignments.

Students with the two engagement patterns were not significantly different in profiles of motivation and biology reasoning proficiency ($x^2[2] = 1.558$, $p = .459$), prerequisite chemistry grade ($t[94] = -.948$, $p = .345$), or demographic variables that we measured. However, in comparison to students with Pattern 2, students with Pattern 1, who completed at least 50% of the intervention in a timely manner, received significantly higher biology course achievement by a medium effect size. Figure 2 shows how Pattern-1 students achieved significantly higher scores in Exam 4 ($t[88.174] = -2.917$, $p = .004$, $d = -0.60$), final exam ($t[93.364] = -3.270$, $p = .002$, $d = -0.64$), labs ($t[88.053] = -3.142$, $p = .002$, $d = -0.59$), and quizzes ($t[85.982] = -2.820$, $p = .006$, $d = -0.57$). Cumulatively, they significantly differed in the overall course grade ($t[87.958] = -3.402$, $p = .001$, $d = -0.64$). Thus, while pre-intervention motivation-cognition profiles did not predict students' pattern of engagement in the relevance-writing intervention, timely engaging and completing at least 50% of this intervention was associated with better grades. These findings suggested the positive influence of the relevance writing intervention on course achievement.

Individuals' Experience of Relevance Writing

While the quantitative findings pointed to the different patterns of engagement with the relevance writing as meaningfully related to differential course achievement, the analysis of individual students' engagement and experience in the relevance writing suggested within-pattern dynamics and diversity in promptness, length, writing quality, perceived value, and assignment grades. For example, two students who completed all four writing prompts in a timely manner (Pattern 1) manifested quite different experiences of engagement in the writing, with differences in the amount of time dedicated to completing the assignments (on average 25 vs. 11 mins), number of words in the assignments (on average 200 vs. 79 words), type of relevance construction (e.g., usefulness to career versus explanatory of life experiences), and evaluation of the value of engaging in the writing ("very useful" vs. "somewhat useful"). Each student also manifested intrapersonal differences in these experiences across the four writing prompts.

Scholarly Significance

The current study teased out different effects of the relevance-writing intervention on student achievement in a gateway biology course in terms of the pattern of engagement in the intervention and individuals' experiences when engaging in the relevance-writing tasks. Findings indicated that students who diligently engaged in the relevance-writing tasks achieved higher grades throughout the semester, regardless of their initial motivation and biology reasoning

proficiency. While this finding does not correspond completely with earlier findings about positive effects for students with low outcome expectancy, it highlights the importance of tracking different engagement patterns in the intervention. The fine-grained analysis of diligent completers also highlighted the diversity and complexity of students' relevance-writing experiences. Overall, the findings support the positive effect of relevance writing on student achievement, but call for a careful examination and interpretation of the intervention effects in terms of the degree of relevance-writing engagement (i.e. quantity and quality), timing of engagement, and student perception of the relevance-writing tasks.

References

Eccles, J. S., Adler, T. F., Futterman, R., Goff, S. B., Kaczala, C. M., Meece, J. L. & Midgley, C. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* (pp. 75–146). San Francisco: W. H. Freeman.

Gaspard, H., Dicke, A. L., Flunger, B., Brisson, B. M., Häfner, I., Nagengast, B., & Trautwein, U. (2015). Fostering adolescents' value beliefs for mathematics with a relevance intervention in the classroom. *Developmental psychology*, *51*(9), 1226-1240.

Harackiewicz, J. M., Canning, E. A., Tibbetts, Y., Priniski, S. J., & Hyde, J. S. (2015, online first). Closing achievement gaps with a utility-value intervention: Disentangling race and social class. *Journal of Personality and Social Psychology*,

Hartwell, M. (2014). *Relevance in the science classroom: A multidimensional analysis* (Unpublished doctoral dissertation). Temple University, Philadelphia, PA.

Hartwell, M., & Kaplan, A. (2014, April). *A multidimensional analysis of context-specific perceived relevance among students with differing expectancy-value profiles*. Paper presented at the annual convention of the American Educational Research Association, Philadelphia, PA, USA.

Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology, 102*(4), 880-895.

Hulleman, C. S., & Harackiewicz, J. M. (2009). Promoting interest and performance in high school science classes. *Science*, *326*(5958), 1410-1412.

Lin-Siegler, X., Dweck, C. S., & Cohen, G. L. (2016). Instructional interventions that motivate classroom learning. *Journal of Educational Psychology*, *108*(3), 295-299.

Milligan,G.W. (1996).Clustering validation: Results and implications for applied analyses. In P. Arabie, L. J. Hubert, & G. De Soete (Eds.), Clustering and classification (pp. 345-379). River Edge, NJ:World Scientific.

Schwartz, D. L., Cheng, K. M., Salehi, S., & Wieman, C. (2016). The half empty question for socio-cognitive interventions. *Journal of Educational Psychology*, *108*(3), 397-404.

Yeager, D. S., & Walton, G. M. (2011). Social-psychological interventions in education: They're not magic. *Review of Educational Research*, *81*(2), 267-301.

Table 1
A Sample Relevance-Writing Prompt

Part	Evolution
Relevance Essay	Research demonstrated that when students make meaningful personal connections between the content they learn and their own life, they find the content more interesting, important, or useful, they understand it better, and they do better on the exam. In Bio 1111, we are studying now about **Evolution**. How might the material about Evolution have relevance to you personally? Different students make different types of connections between the material they learn and their personal life. For example, some students find something in the material on Evolution that connects to topics that they have a special interest in. Other students find something in the material that they consider very important, because they value knowing it, or they see how it relates to the kind of person they are. Many students connect knowing the material on Evolution to their career goals. And there are students who use something in the material on Evolution - for example, the concept of Adaptation of the species, or the process of Natural Selection - as an analogy to something in their life (for example, to personal experiences or characteristics, or to their social relationships). How might knowing about Evolution be interesting, or important, or useful for you? You can be creative and think of any connection that is meaningful to you. The more meaningful the connection is, the more likely it is to contribute to your learning and understanding of it and to your performance on assignments. In the space below, explain in as much detail as possible: (1) What aspect of the material in Evolution you chose to connect to your life? (2) What in your life did you connect it to? (3) What is the connection between that aspect of Evolution and your own life? and (4) Why and how much is the connection meaningful to you?
Short Reflection	Please share any reflections, ideas for improvement, or other feedback on the writing you just completed.
Rating of Usefulness	Please rate how much you agree with the following statement: I think this writing is helpful for my learning. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree

Table 2
Pre-Intervention Measures Details

Measure	Items/format	Author(s)	Sample Item	α
Biology reasoning	15 / multiple-choice	Dai & Cromley (2014)	One key feature of the immune system is immunological specificity. That is the ability of certain kinds of lymphocytes to zero in on specific pathogens and eliminate them. Any molecular feature that triggers antigens are certain proteins at the surface of pathogens or tumor cells, or ones that are unbound but toxic. As you will see, lymphoctyes can recognize nonself because they have receptors that bind to such targeted "foreign" features. Which of the following would be most useful in order to understand the passage? a. Pathogens have evolved defenses against the immune system b. The body has non-specific defenses as well as specific ones c. Some kinds of lymphocytes attack all pathogens indiscrimately d. The surface molecules of each pathogen are unique	.78
Self-efficacy for biology	5 / Likert-scale	Reworded from Perez's 2012 adaptation of PALS (Midgley et al., 2000)	I am certain I can master the skills taught in my biology course. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree	.89
Interest in biology	9 / Likert-scale	Reworded from Perez's 2012 adaptation of situational interest in psychology (Harackiewicz et al., 2000)	I think the biology field is interesting. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree	.94

Measure	Items/format	Author(s)	Sample Item	α
Self-perceived biology ability	4 / Likert-scale	Reworded from Perez's 2012 adaptation of Eccles & Wigfield's (1995) expectations for success and ability beliefs	Even if the work in this biology course is hard, I can learn it. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree	.86
Interest value for biology	7 / Likert-scale	Expanded from Perez et al.'s (2014) adaptation of Eccles & Wigfield's (1995) task values intrinsic subscale	How interesting do you find this biology course? 1. Very boring 2. Boring 3. Somewhat boring 4. Somewhat interesting 5. Interesting 6. Very interesting	.96
Attainment value in biology	4 / Likert-scale	Expanded from Perez et al.'s (2014) adaptation of Eccles & Wigfield's (1995) task values attainment subscale	I feel that, to me, being good at solving problems in this biology course is 1. Not at all important 2. Not important 3. Somewhat not important 4. Somewhat important 5. Important 6. Very important	.73
Utility value for biology	5 / Likert-scale	Expanded from Perez et al.'s (2014) adaptation of Eccles & Wigfield's (1995) task values utility subscale	How useful is this biology course for what you want to do after you graduate? 1. Not at all useful 2. Not useful 3. Somewhat not useful 4. Somewhat useful 5. Useful 6. Very useful	.86

Measure	Items/format	Author(s)	Sample Item	α
Effort costs for biology	5 / Likert-scale	Reworded from Perez et al.'s (2014) adaptation of Battle & Wigfield's (2003) Value of Education effort costs subscale and also including items from Conley (2012)	I am not sure if I've got the energy do well in my biology course. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree	.80
Opportunity costs for biology	4 / Likert-scale	Reworded from Perez et al.'s (2014) adaptation of Battle & Wigfield's (2003) Value of Education opportunity costs subscale	I'm concerned that I have to give up a lot to do well in this biology course. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree	.86
Psychological costs of biology	5 / Likert-scale	Reworded from Perez et al.'s (2014) adaptation of Battle & Wigfield's (2003) Value of Education psychological costs subscale	I'm concerned that I'm not a good enough student to do well in this biology course. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree	.89
Intention to remain in STEM	6 / Likert-scale	Reworded from Perez et al. (2014)	I am likely to remain in my science major or science related track through to graduation or completion of my program of study. 1. Strongly disagree 2. Disagree 3. Somewhat disagree 4. Somewhat agree 5. Agree 6. Strongly agree	.88

Table 3
Descriptive Statistics by Profiles of Motivation and Biology Reasoning Proficiency and by Patterns of Relevance Writing Engagement

Variable	Total	Profile of Initial Motivation and Biology Reasoning Proficiency			Pattern of Relevance Writing Engagement	
	(N = 96)	Cluster 1 (n = 30)	Cluster 2 (n = 38)	Cluster 3 (n = 24)	Pattern 1 (n = 32)	Pattern 2 (n = 64)
Sex						
Male	34	14	13	5	12	22
Female	61	16	25	18	20	41
Race						
Non-Asian	57	22	17	12	17	40
Asian	39	8	19	12	15	24
Year in College						
Non-Freshmen	57	20	26	24	20	37
Freshmen	39	10	12	14	12	27
Parent Education						
Not College Graduate	42	15	12	13	14	28
College Graduate or Higher	54	15	26	11	18	36
Profiles of Motivation and Bio Reasoning Proficiency						
Cluster 1	30	--	--	--	13	17
Cluster 2	38	--	--	--	14	24
Cluster 3	24	--	--	--	3	21
Age	20.2 (3.5)	20.8 (3.8)	19.8 (1.7)	20.1 (5.2)	19.6 (1.4)	20.5 (4.2)
SAT Verbal	558.8 (90.9)	593.7 (84.9)	551.5 (92.4)	531.3 (93.3)	577.1 (60.0)	550 (102)
SAT Quantitative	609.0 (76.2)	613.3 (66.1)	613.7 (86.0)	593.5 (73.1)	626.5 (68.3)	600 (79)
Prerequisite Chemistry Grade	5 (2)	6 (2)	5 (2)	5 (2)	5 (2)	5 (2)
Biology Course Achievement						
Exam 1	64.5 (22.6)	66.7 (26.2)	64.3 (20.1)	62.7 (18.9)	65.9 (18.3)	63.8 (24.6)
Exam 2	65.1 (24.8)	67.7 (28.4)	66.5 (20.3)	60.7 (24.4)	71.3 (18.7)	62.0 (26.9)
Exam 3	65.0 (26.0)	63.7 (31.5)	63.3 (26.9)	66.3 (16.8)	69.3 (20.0)	62.9 (28.5)

Exam 4	58.8 (26.0)	60.1 (32.4)	56.0 (23.3)	63.3 (19.6)	68.0 (18.1)	54.1 (28.2)
Final exam	53.3 (21.8)	51.3 (25.3)	52.6 (24.7)	54.5 (11.2)	61.6 (13.0)	49.2 (24.1)
Labs	64.6 (21.9)	63.9 (28.0)	63.5 (22.4)	65.4 (11.9)	72.0 (9.1)	60.8 (25.2)
Quizzes	72.4 (24.4)	65.6 (30.2)	77.2 (20.2)	71.7 (21.5)	80.9 (17.6)	68.2 (26.2)
Overall course grade	63.5 (18.9)	62.2 (24.9)	63.0 (18.8)	64.1 (9.2)	70.4 (7.8)	60.1 (21.7)

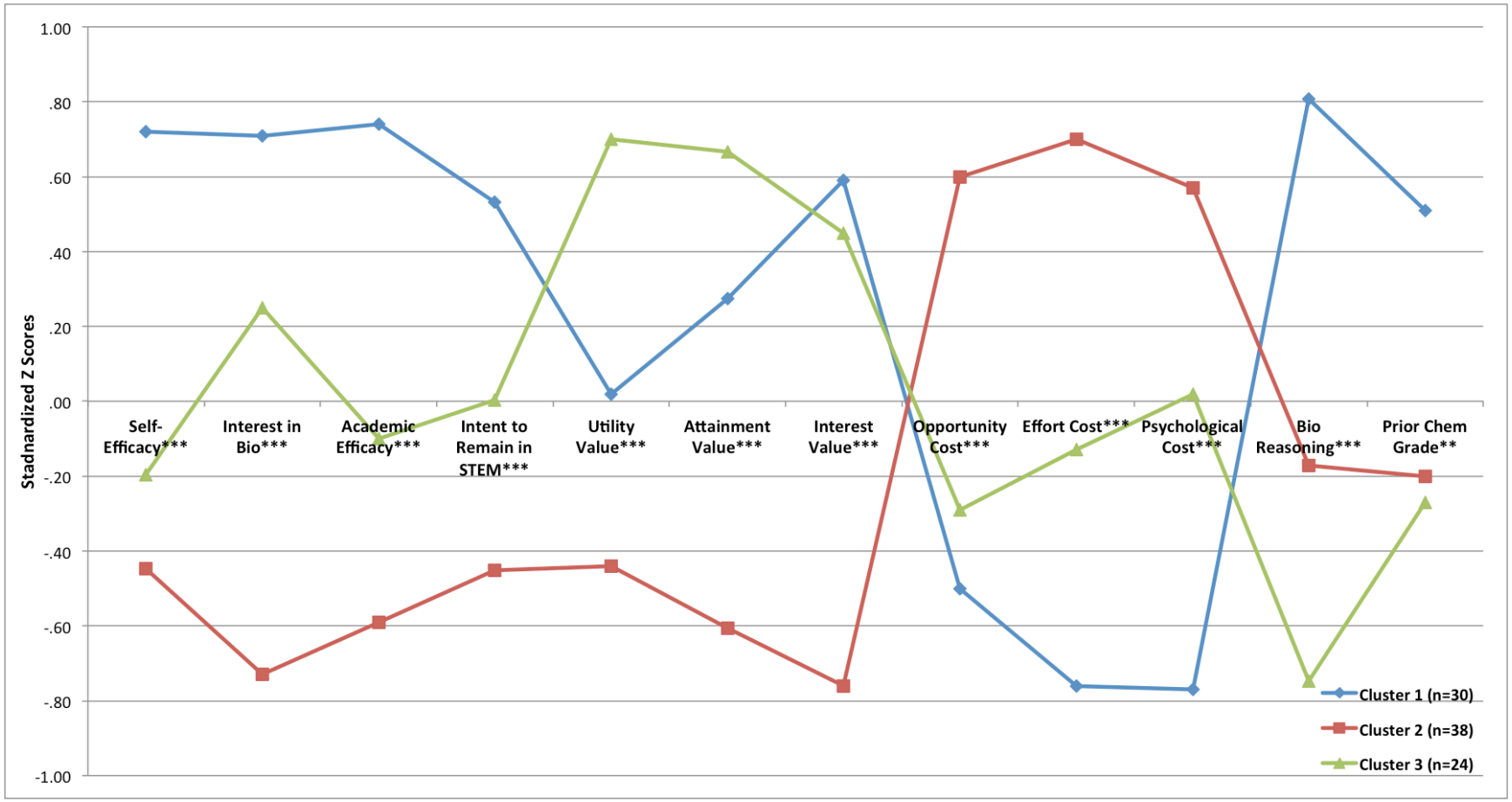

Figure 1. Three profiles of students' initial motivation and biology reasoning proficiency. Those with different profiles differed significantly in prerequisite chemistry course grade. ~ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

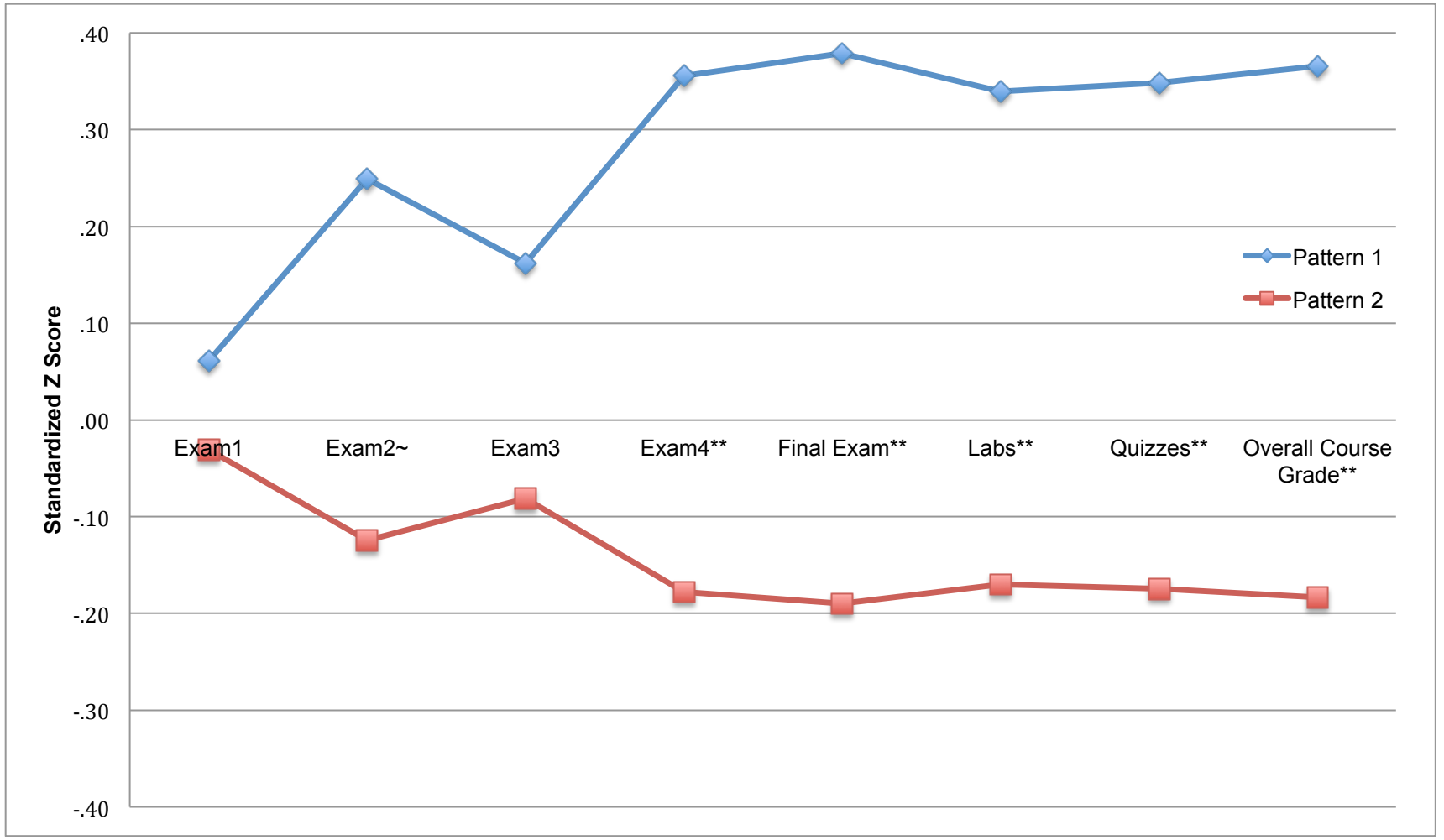

Figure 2. Differences in course achievement between students with the two patterns of relevance writing intervention engagement. ~ $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$