Applying Utility-Value Writing Prompts to Science Education

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Abstract

Helping junior high and high school students remain interested in science increases the chance that they will pursue careers in science. However, there are many different ways to trigger or sustain interest. Utility-value writing assignments represent a type of motivation intervention that has consistently demonstrated a positive effect on students' interest and performance in science. In this paper, we describe expectancy-value theory as the framework giving rise to utility-value interventions and review evidence of the effectiveness of the intervention. Then we provide educators with concrete steps for writing and scoring utility-value writing assignments.

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Often the top-listed careers in North America involve science in some capacity (*Canadian Business* 2017; *U.S. News* 2019). To attain these types of careers, individuals require advanced education in the field of science. The likelihood of any student pursuing advanced education related to science is dependent on, at a minimum, maintaining interest in science content (Renninger, Nieswandt and Hidi 2015). Thus, it seems that more than ever, many parents, teachers, researchers and government alike are committed to initiating, sustaining and hopefully increasing interest in science (Maltese, Melki and Wiebke 2014). In Alberta, this commitment is evident within the Program of Studies for Science Education (Alberta Education 2003), which explicitly states one of its five goals as "to enable students, of varying aptitudes and interests, to develop a knowledge of the wide spectrum of careers related to science, technology and the environment."

Despite this external focus on the importance of science, students' interest in science, particularly for girls, declines from junior high school through Grade 12 (VanLeuvan 2004). In a large-scale retrospective study of college students' original interest in science, Maltese, Melki and Wiebke (2014) showed that the influence of teachers in sparking students' interest in science is highest in Grades 6 through 12. Despite this potential influence, it can be difficult to know which activities or assignments can build interest in students. As an alternative to refining the structure of an activity, motivation theory suggests that interest can be influenced by changing students' perceptions of the learning. The field of achievement motivation is replete with empirical evidence documenting how motivation principles (eg., Elliot, Dweck and Yeager 2017), designs (eg, Linnenbrink-Garcia, Patall and Pekrun 2016) and interventions (eg, Lazowski and Hulleman 2016) can help increase students' interest. One of the most effective and simple of these interventions extends from the expectancy-value theory of motivation (Eccles and Wigfield 2002). The purpose of this nonempirical paper is to provide an overview of the expectancy-value theory of motivation (Eccles and Wigfield 2002), review utility-value writing interventions as an empirically-supported means of enhancing interest in science (Hulleman and Harackiewicz 2009) and articulate steps that science educators can use to design their own utility-value writing assignments.

Expectancy-Value Theory of Motivation

Expectancy-value theory has a long tradition in science education. In fact, one of the original expectancy-value models (Eccles et al 1983) was proposed with the explicit purpose of explaining why, despite similar performance levels in early grades, girls were less likely to pursue higher-level math courses than boys. According to contemporary expectancy-value theory (Eccles and Wigfield 2002), academic choices including whether or not to persist are largely determined by two subjective beliefs that underpin student motivation. The first belief is related to a student's *expectancy* that he or she will be successful in the task. Fundamentally, it is the student's response to the question: Can I do this task? When the answer is yes, the student has met a minimum threshold to move into action. The second belief is related to the *value* or the overall importance of the task. This belief arises from a student's response to the question: Do I want to do this task? An affirmative response, again, energizes the learner towards investing energy in the task.

Value comes in at least three forms. First, *intrinsic value* refers to wanting to do a task simply because it is enjoyable. Second, *utility value* refers to choosing to undertake a task because it will be useful in the short or long term. Third, *attainment value* applies to students who undertake tasks because it reaffirms their identity and thus meets a personal need. In a multiplicative fashion, when expectancies and values are both high, intrinsic motivation tends to be high as evidenced by sustained interest, persistence and performance (Wigfield, Tonks and Klauda 2009).

In opposition to value, expectancy-value researchers acknowledge that students must balance the cost of each pursuit (Flake et al 2015). Defined as "what an individual has to give up to do a task, as well as the anticipated effort one will need to put into task completion," (Eccles 2005, 113) cost has been touted as the "forgotten component of expectancy value theory" (Flake et al 2015, 232). Just as value had three types, so too was cost hypothesized to take its toll in three ways. First, students may perceive the cost of effort needed to be successful as not worth it. Second, students may experience a reduction in motivation if they suffered a loss of valued alternatives by investing effort in one activity at the expense of others. And finally, students balance their chances for success against the psychological cost of failure. Cost, both in specific dimensions and generally, is negatively correlated with grades, interest and overall motivation (Flake et al 2015), and positively predictive of an intention to leave STEM majors in college (Perez, Cromley and Kaplan 2014).

Hulleman et al (2016) suggest that "as teachers encounter motivation problems with their students, deciding if the problem is an expectancy, a value, or a cost problem is a critical first step in determining how to intervene" (p 258). Although this is true, we focus the remainder of this paper on value in science because the content of utility-value interventions can be applied by teachers to the creation of science writing assignments.

Utility-Value Intervention Evidence in Science Education

Building on the theoretical foundation of expectancy-value theory, and particularly utility-value, Hulleman and Harackiewicz (2009) argued that "[m]aking science courses personally relevant and meaningful may engage students in the learning process, enable them to identify with future science careers, foster the development of interest, and promote science-related academic choices (eg, course enrollment and pursuit of advanced degrees) and career paths" (p 1411). Over the past 10 years, a large body of evidence has accumulated showing that utility-value interventions indeed enhance students' interest in science. For example, Grade 9 science students who received a semester-long motivational intervention in which they were encouraged to draw connections between the science content and their lives reported higher interest and achieved higher scores than students in a control group (Hulleman and Harackiewicz 2009). Moreover, these results are strongest for students with low expectations for success, who may be in the most need of support. Since this foundational evidence, utility-value writing interventions have been applied with similar success in high school and college biology, mathematics and psychology classrooms, resulting an increase of up to 0.80 in GPA on a four-point scale, compared to control groups (eg, Canning and Harackiewicz 2015; Gaspard et al 2015; Harackiewicz et al 2016; Hulleman et al 2010; Hulleman et al 2016; Hulleman et al., 2017).

Why They Work

Researchers stand firm that psychosocial interventions are not magic (Yeager and Walton 2011). They work because researchers understand the psychological processes underpinning the intervention. For utility-value interventions, that process is utility value precisely. In other words, a utility-value writing assignment is likely to affect outcomes because it increases the student's utility value for the content. Although it may also affect related constructs such as expectancy, self-efficacy or effort, these beliefs are not specifically targeted by utility-value interventions and thus a desire to increase these sorts of beliefs may not be met through utility-value writing assignments.

What Students Write

Perhaps because of the precision and rich theoretical backing, at the outset, utility-value researchers focused on the impact of the intervention on outcomes such as interest and persistence without considering students' actual responses. Remedying this, in a study with Grade 5 and Grade 6 students, Akcaoglu et al (2018) examined the types and quality of student responses generated by a utility-value writing intervention. The researchers created a "real-life connections rubric" (p 72) and undertook a content analysis of the student responses. They concluded that students in the intervention group produced essays that included more utility-value statements (ie, links to life and applications) than the control group. This type of writing was characterized by substantially more usage of personal pronouns, along with words such as *family*, *friend* and *insight*. Klebanov et al (2017) also provided a linguistic analysis of written responses with the hope that artificial intelligence (AI) may play a role in scaling up utility-value interventions.

Steps for Creating and Scoring a Utility-Value Writing Assignment

Despite this compelling evidence in favour of utility-value interventions, there has been little attempt to make the principles of the intervention available to science teachers. If teachers were to access the original empirical papers, they would find neither the actual intervention materials nor clear guidance on how to create or score utility-value writing assignments separate from research purposes. The failure to translate intervention materials into materials accessible to teachers represents a shortcoming of the field and one that appears to not adequately bridge theory, evidence and practice.

At our request, the researchers provided us with the exact utility-value intervention materials used but not published in Harackiewicz et al 2016. We reviewed these materials and concluded that there are two primary characteristics of a self-generated utility-value intervention that can be translated into directions in formulating a utility-value writing assignment. First, students must formulate their own question to be answered related to the content covered. Although the content area can be either broad (eg, Grade 9, Unit A, Biological Diversity) or specific (eg, Grade 9, Unit A, key concept: inheritance), it is crucial that students generate their own question. Evidence suggests that self-generated questions and utility-value statements are more effective than statements directly provided to students by someone else (Canning and Harackiewicz 2015), particularly for low-achieving students (Harackiewicz et al 2014). Second, students must make

explicit connections between the course content and its value rather than just summarize the content. More precisely, students have been asked to describe the value for themselves personally, for another individual or for society as a whole (Klebanov et al 2017). Instructions to encourage students to make these sorts of value connections, by audience, are described in Figure 1. We hope that this template will allow teachers to extend these two guiding principles to their own writing assignments.

In addition to extracting two steps to creating utility-value writing assignments, we have adapted the rubric designed by Akcaoglu and colleagues (2018) and included it in Figure 1. We direct the reader to Akcaoglu et al (2018) for specific examples related to scoring. However, generally, utility-value writing assignments do not differ from traditional writing assignments in terms of requiring accurate content to answer the question or upholding standards related to writing style, format, spelling and expression, although the latter does not have to be scored. In scoring utility-value writing assignments, a minimum of three separate components tend to be evaluated:

1. The formulation and inclusion of a question to be answered. This question sets the tone for the assignment and thus should be explicitly stated in the title or in the first paragraph of the assignment and thus graded.
2. Accuracy of the content presented to answer the question. This should be scored by the same standards as any essay or short-answer question. The addition of a utility-value component does not change the importance of accurate content.
3. The depth of utility-value connections. Students produce a wide range of relevance statements, some of which are very convincing and personal and others that are more vague and general. Stronger personal connections to the content should be scored more highly than weaker or generic scoring.

Examples

We have not used utility-value writing assignments with teachers in Alberta. However, based on the existing literature and the samples that were submitted by the researchers, we can envision what such assignments might look like. Imagine having completed a unit on biological diversity (Grade 9, Unit A). A teacher might ask students to generate questions related to sex-linked heritable traits. In response to the self-generated question, “Will I go bald?” one student may explain his own chances of ending up bald based on the other people in his family, concluding that “I will rest easier knowing that it isn’t a guarantee that I’ll be bald.” Another student could pose the question “Will my baby have blue eyes?” and describe the conditions under which her child might end up with blue eyes, even though she has brown eyes. Both of these examples would be considered high in utility-value content and should receive high scores on the utility-value portion of the scoring. Scores should be reduced as the explanations become more as generic, including statements such as “Some people go bald” or “The colour of a child’s eyes is related to the colour of parents’ eyes.”

An Important Caveat

Teachers will have to determine the effectiveness of this type of assignment for their students on their own and in each case. The purpose of classroom assessment is to determine the extent to

which learner outcomes have been reached, and thus enhancing utility value is obviously a secondary consideration for teachers and should not interfere with students' abilities to show what they have learned.

Conclusion

Although the empirical data supporting the effectiveness of utility-value interventions is compelling, the translation of research design into materials for teachers is lacking. Our purpose was to determine the key components of utility-value writing prompts so that they may be used by teachers. By extracting key steps based on the experimental materials (Harackiewicz et al 2016), we hope science educators will consider adapting some assessments to be more congruent with a utility-value perspective, thereby increasing the chances that students will remain (or become more) interested in science.

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Figure 1.
Explanatory Steps and Instructions for Creating a Utility-Value Writing Assignment

	Standard Assignment	Utility-Value for Self	Utility-Value for Other	Utility-Value for Society
Rationale	None provided	This assignment is designed to help you understand major concepts covered and focus on the relevance of one particular topic for your own life.	This assignment is designed to help you understand major concepts covered and focus on the relevance of one particular topic for someone in your life.	This assignment is designed to help you understand major concepts covered and focus on the relevance of one particular topic for society.
Instructions	Please answer the following question based on what we have learned in the unit.	1. Select a concept that was covered in the unit and write a question you would like to answer. Here is a sample question: What is the difference between heritable and nonheritable characteristics?		
	You need to organize your response logically. Be sure to summarize what you have learned in about one to two pages.	2. After writing your question, use the relevant information to write a one- to two-page response. You must answer the question correctly based on the content we learned and discuss its personal relevance to your own life. Include examples about how the information applies to you personally.	2. After writing your question, use the relevant information to write a one- to two-page letter to a family member or friend who could benefit from this information. You must answer the question correctly based on the content we learned and discuss its personal relevance to the other person. Include examples of how this information applies to them.	2. After writing your question, use the relevant information to write a one- to two-page answer. You must answer the question correctly based on the content we learned and discuss its relevance to society in general. Include examples about how the information applies to people living in our society.
Sample Question	What is the difference between heritable and nonheritable characteristics?		Why does my sister have blue eyes if both her parents have brown eyes?	Why were there so few children with blue eyes in my elementary school?
Possible Scoring for Response	Level 0—just a summary Level 1—application or example without personalization; eg, people have different-coloured eyes Level 2—specific application to appropriate audience but mechanism is not fully explained; increased use of pronouns; eg, I have blue eyes but my mom has brown Level 3—specific application to appropriate audience and mechanism is explained; lots of pronouns and reasoning language such as “because”; eg, I have blue eyes, my mom has brown, but my child may have brown because …			