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Age differences in effects of self-generated utility among Black and Hispanic adolescents

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ABSTRACT

This study tested the effects on interest and achievement of a classroom intervention in which students wrote about the utility of science. Participants were predominantly Black and Hispanic students in 7th and 9th grade (N = 268). The results suggest that the self-generated utility intervention may be fairly robust to differences in students' backgrounds, but is sensitive to age. Among seventh graders, the intervention promoted interest in science for students with high success expectancies. This is in contrast to prior research with high school students, and the pattern among ninth grade students in this study, showing somewhat more positive effects among students with low expectancies. Writing content varied by students' grade level and success expectancies in terms of focus (e.g. self) and temporality (e.g. future).

The belief that academic content is valuable can establish an enduring link between a person and a content domain and can contribute to the experience and development of interest (Renninger, 2000). Although value can take different forms (Eccles et al., 1983; Eccles & Wigfield, 2002), utility value describes the extent to which a task or domain is relevant for achieving personal goals. In this sense, perceived utility value can provide a bridge between individuals, their goals, and learning content. Adolescent students who perceive utility value in an academic domain are more likely to identify that domain as a personal interest and demonstrate commitment to learning in that domain (e.g., Eccles & Wigfield, 1995; Hulleman, Durik, Schweigert, & Harackiewicz, 2008; Simpkins, Davis-Kean, & Eccles, 2006). Utility value has also been shown to correlate with task performance, which may be a consequence of increased effort and sustained commitment to tasks that are perceived as personally useful (Bong, 2001; Hulleman et al., 2008; Simons, Dewitte, & Lens, 2000, 2004).

Given that perceived utility value is related to important positive outcomes, interventions have been developed to foster students' perceptions of utility value. One approach prompts learners to self-generate utility value for what they are learning. In one experiment, ninth-grade, predominantly White science students were asked to generate descriptions of how learning about science was personally useful to them or someone they know (Hulleman & Harackiewicz, 2009). Compared with students in the control group who were asked to summarize course-related content, the students that self-generated utility showed higher interest and performance, and these effects were strongest among students who initially had low expectancies for success. The self-generated utility prompts may have helped ninth graders who did not expect to do well to perceive greater value in what they were learning, which in turn may have led to higher interest and greater effort to perform well. Subsequent studies have replicated this effect on interest in a sample of predominantly White college students, again suggesting that self-generated utility is uniquely helpful for individuals who have low expectancies for success (Hulleman, Godes, Hendricks, & Harackiewicz, 2010). This research suggests that utility interventions hold promise, although expectancies for success moderate the effects. It is also worth noting that prior research has also shown effects that are not moderated by expectancies. One study showed that prompting ninth graders to either self-generate utility for math or to evaluate peer quotations regarding the utility of math promoted task values in math for students in general (i.e., not moderated by expectancies; Gaspard et al., 2015).

These promising results may inspire educators to insert self-generated utility interventions into classrooms, with a particular focus on being able to shape students' identities with regard to science, and to do so early in students' schooling. However, before introducing self-generated utility interventions on a broader scale it is prudent to examine the effects of this intervention among populations that are more diverse in terms of age and background.

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1. Considering the process

The process by which self-generated utility interventions work is not entirely clear, but needs to be considered, and might even be illuminated by testing the generalizability of the effects. Self-generated utility is theorized to allow learners to draw on personal experiences to forge a connection between themselves and a domain (Hulleman et al., 2010). As such, students who might not otherwise consider the utility of a learning activity can draw on what they know of the world and themselves in order to find utility and purpose in what they are learning in school. For example, students in a science class who are studying the laws of motion might be able to identify a link between themselves and the course content to the extent that they perceive the content related to personal activities (e.g., driving a car, playing soccer).

As this example suggests, self-generated utility interventions ask students to select a topic that they are studying in science class and to consider how the topic is useful to themselves or to someone they know for purposes beyond the current class. Importantly, this task requires students to connect at least three elements: science content, what they know about the world, and how they perceive themselves in the present and/or in the future. As to the question of whether age, socioeconomic status and race/ethnicity might play a role in the process of individuals connecting these three elements, we consider several different theoretical lenses that guide our thinking. The pattern that emerges might provide insight into how self-generated utility interventions influence outcomes.

2. Self-generated utility among seventh- versus ninth-grade students

The initial work examining the effects of self-generated utility interventions was conducted on samples of students who were predominately mid-adolescent high-school students or late-adolescent undergraduate students and that were predominately White (Hulleman et al., 2010; Hulleman & Harackiewicz, 2009). That said, educators of younger students might be drawn to self-generated utility interventions because students' interest in science and mathematics begins to decline during the middle school years (Fredricks & Eccles, 2002; George, 2000; Gottfried, Fleming, & Gottfried, 2001), and there is some evidence that by the time students enter ninth grade their science interests are already formed (Sadler, Sonnert, Hazari, & Tai, 2012). These findings suggest that interventions targeting interest should be done early, while students' interests may be more malleable. No previous studies were found that targeted self-generated utility for science during the middle school years, but given research suggesting that important developmental changes occur in this time period regarding cognitive capacity, career interest, and curricular focus, it is important to examine whether self-generated utility interventions will be effective among younger adolescents.

Relative to older adolescents, younger adolescents have less developed cognitive capacities that may limit their ability to think about the future (Greene, 1986; Nurmi, 1991; Steinberg et al., 2009; Trommsdorff, Lamm, & Schmidt, 1979). Consistent with this, younger learners have been found to think about themselves and their lives on a much shorter time scale than older learners (Husman & Lens, 1999). In a study of future orientation across age levels, Steinberg et al. (2009) found that young adolescents between the ages of 10–13 years old were less future-oriented than were 15–30-year-olds. Although the researchers did not report differences between smaller age ranges, visual inspection of their plotted data (p. 37) indicates that future orientation may change between the 12 to 13-year-old group (typical middle school age range) and the 14 to 15-year-old group (typical 9th grade age range).

If younger students are less capable than older students of engaging in abstract thinking and planning, both of which are implicated in utility value, then thinking about utility value may not be as meaningful for younger learners. The abstract nature of utility value may mute the effectiveness of self-generated utility interventions. In line with this reasoning, relative to older learners, younger learners are less likely to mention meaning and purpose in the context of a domain they find interesting, and instead focus more on feelings of enjoyment and excitement (Frenzel, Pekrun, Dicke, & Goetz, 2012). These cognitive changes suggest that a utility value intervention might be more beneficial for learners toward the end of early adolescence.

Alternatively, there may be reasons to expect other patterns as well. First, middle school and high school students may not differ from one another in terms of the types of utility value they can generate or in the effects of doing so because the ability to articulate career interests tends to be quite stable across the transition from middle school to high school (Low, Yoon, Roberts, & Rounds, 2005). If students identify utility value through the link between a science course topic and a career interest, there would be no differences between seventh and ninth graders in terms of either the utility value they generate or the effects of doing so. Second, generating utility for science content might be easier for adolescents in middle school than those in high school because the content taught in middle school science classes tends to be more concrete and connected to daily life, relative to content taught in high school (Yager, Ali, & Hacieminoglu, 2010). Therefore, ninth grade students may find it more difficult to make connections between the more abstract content presented in science class and their lives.

Given these various developmental considerations, we consider the question of whether middle and high school students experience similar effects of self-generated utility interventions. Moreover, the patterns of effects that are observed on various outcomes (i.e., interest, perceptions of utility, and performance) may provide insight into the underlying processes.

3. Self-generated utility among students from groups underrepresented in science

Utility interventions are designed to promote interest in science and motivate individuals to enter into science-related careers. Self-generated utility then, may provide a vehicle for encouraging participation in science among groups of individuals who are historically underrepresented in the field. Consistent with this, positive effects of a self-generated utility intervention were found among a sample of college students from racial and ethnic groups that are underrepresented in science. The sample of students, who were of Hispanic, African, or Native American descent (i.e., members of groups underrepresented in science, URM; National Science Foundation, 2008) and also first-generation college students (i.e., those whose parents were not college graduates), earned better grades and were more likely to continue on to a second semester of biology if they had been randomly assigned to the self-generated utility value condition rather than a control condition (Harackiewicz, Canning, Tibbetts, Priniski, & Hyde, 2016). These positive effects suggest that students from historically underrepresented groups who have the academic backgrounds to be admitted to an elite university benefit from connecting course material to their future endeavors. However, because science has broad value in our society, it is also important to examine whether similar effects are observed among younger adolescents from similar racial, ethnic, and socioeconomic groups who are not necessarily on the trajectory to attend an elite university.

The effects of self-generating utility may be similar across racial and socioeconomic lines because learners can draw primarily on knowledge and observations about the world that are shared by people in general. Students may begin the task by focusing first on their knowledge of the world and everyday life (e.g., weather-related events that can pose a threat to humans), and then considering the value of science within that context. Ethnic differences in beliefs about the general importance of math and science are not large, and the desire for achievement tends to be similar across ethnic groups (Bouchey & Harter, 2005; Halfond, Corona, & Moon, 2012). Given the relative homogeneity in individuals' valuation of science, students of different backgrounds may approach the task of self-generating utility in similar ways.

There are, however, other possibilities that should be considered, which implicate the process by which students self-generate utility. Students might begin the task of self-generating utility by focusing first on themselves and their personal goals, which would suggest that a connection can form between the person and the science content only if individuals already have personal goals that can be related to science. It may be more difficult for students from underrepresented groups to identify science goals because they may have fewer external forces fostering those goals (Barton et al., 2013; Bouchey & Harter, 2005), fewer similar role models in science (Roderick, 2003), and less encouragement to pursue those goals (Bouchey & Harter, 2005; Oyserman, Bybee, & Terry, 2006; Pizzolato, 2006). Moreover, for students from groups that are economically disadvantaged and underrepresented in science, the process of thinking about themselves in science may highlight negative stereotypes of their group within the domain (Aronson & Steele, 2002) and limit the possible selves that come to mind when students consider what they can do (Kao, 2000) given various barriers (Yowell, 2002). Although recent work (Harackiewicz et al., 2016) suggests that stereotypes may not interfere with the positive effects of self-generated utility among college students at an elite university, this finding has not been replicated in other samples of underrepresented students.

4. Current study

These considerations prompted us to test the effects of a self-generated utility value intervention among predominantly Black and Hispanic students in seventh and ninth grade who were attending public schools in which a majority of students received free or reduced lunch. We refer to this sample of students by their race or ethnic heritage rather than their minority status largely because these students were not minority students in their school context. Therefore, for descriptive clarity, we refer to the sample as being composed of predominantly Black and Hispanic students. That said, the ultimate purpose is to better understand how to craft school environments to address the larger societal problem of not having proportional representation of different social groups in science careers.

Similar to prior research that has tested self-generated utility interventions, we focused our investigation on interest, and achievement in science as outcomes. We also examined effects on students' perceptions of science utility to better understand the inner-workings of the intervention. The study was aimed to answer questions related to whether the results among socioeconomically disadvantaged seventh and ninth graders would replicate prior research conducted with samples of students who were relatively more advantaged, showing that students with low expectancies for success in science would benefit from the utility value intervention more than those with high expectancies. Moreover, we aimed to test whether this effect varied by grade level, with an eye toward how the pattern might illuminate the process by which students self-generate utility.

5. Method

5.1. Setting

The study was conducted in two feeder middle schools and a single comprehensive high school serving students from a diverse community located on the fringe of a large metropolitan area. Looking across the three schools, the percent of low-income students (as measured by eligibility for free or reduced lunch) ranged from 62% to 77%. The graduation rate for the high school was 75%. Among the students who graduate from high school, approximately 43% subsequently enroll in four-year colleges.

Data were collected from seventh graders who were enrolled in the single science course available to seventh-graders in that district: Thus the seventh-grade sample is highly representative of the middle school population in general in terms of race/ethnicity, and future educational and occupational prospects. In contrast, the ninth-grade sample was drawn from sections of the school's Integrated Science course, which was the science course into which students were placed if they entered high school reading below grade level. At the time of the study approximately 60% of all incoming freshman had been placed in Integrated Science. Because the ninth-grade sample was drawn exclusively from Integrated Science, it is less representative of the general population at this high school, and given the low reading level of students in this course, this population is even less likely to enroll in four-year colleges relative to the overall school population. These features of the context are relevant for the comparison of this study's results with prior research.

5.2. Participants

Participants included students from seventh ($M_{\text{age}} = 12.26$, $SD = 0.46$) and ninth ($M_{\text{age}} = 14.26$, $SD = 0.50$) grade who were enrolled in science classes in a single school district. Seventh-grade participants were drawn from nine different classes taught by two teachers. Ninth-grade participants were drawn from six different classes taught by two teachers. The participation rate was over 90% in each classroom, with some classrooms having a 100% participation rate.

The focal group of participants for this study included 268 students who belong to racial or ethnic groups that are historically underrepresented in science fields. This group included students who identified as Hispanic (62%), Black (15%), Native American (< 1%), or multi-racial that included at least one of these categories (23%). Because < 1% of the sample identified as Native American, we refer to the sample as composed of predominantly Black and Hispanic students. Fifty one percent of the participants were girls, 58% were seventh-graders, and 71% were eligible for free or reduced lunch. Forty-eight percent ($n = 129$) were in classrooms assigned to the utility value intervention and 52% were in classrooms assigned to the writing comparison group ($n = 139$, see below for explanation of treatment groups).

Data were also collected from White, non-Hispanic students ($n = 62$), Asian students ($n = 13$) or mixed White and Asian students ($n = 2$) who were in the same classrooms as our focal sample. These students were not the focus of the current study and the small sample size of these groups, especially by grade and treatment group precluded conducting comparative analyses between them and the larger sample of Black and Hispanic students. That said, exploratory analyses involving students from all racial/ethnic groups are noted.

5.3. Procedure

The self-generated utility treatment and writing comparison conditions were established using cluster random assignment of naturally occurring sections of the seventh and ninth grade science classes. Because each of the four teachers had between 3 and 5 class sections, sections within teacher were randomly assigned as treatment and writing comparison. Specifically, four of the nine classes of 7th graders were assigned to the utility condition, and three of the six classes of 9th graders were assigned to the utility condition. Teachers were unaware of which of their class sections were in which conditions, and were not present when the study intervention was described to their students.

Prior to the intervention (during the first quarter of the school year), participants completed an initial survey that included measures of race/ethnicity, expectancies for success, and baseline measures of other motivation variables to be used as covariates. During each of the six intervention weeks (second quarter), students in both conditions were prompted to write briefly about a topic they were studying in science

Table 1
Utility essays by qualitative coding category.

Category	Excerpts from essays
Specificity of utility	If every one used a different unit then you could never understand who is right. This could be useful in a daily life when you want to buy a kilo of sugar but all they have is grams then you could convert kilo to gram.
Clear future focus	Distance and displacement relates to real life in a lot of ways … And, besides, I will probably use it in the future any ways because I've always wanted to be a mapping guide. I just like the way they figure out the distance and displacement
Use of personal pronouns	Weather relates to me to see if me and my team can play the soccer game. Also to see if me and my friend can hang out. Another thing is if I can go walk. It will also matter If I want to go to the park and play. Also if I can go ride my bike around.
Agentic content	…. right now in class we are studying the solar system. …. This information can be useful to my cousin who is studying to be an astronaut.
Practical content	When I was at my brother's baseball game it got all dark and started raining… on the way home the tornado siren went off. We learned that the difference between a severe weather warning and watch is that a warning means it has been spotted and a watch means the weather is right for it. That day it was a warning. It's important so when it happens I know what to do.
Fun/Hobby content	…I skateboard and my skateboard has acceleration. I plan on being a skateboarder in my future.

class. Participants in the self-generated utility condition were asked to choose one of the topics or ideas that was covered in class in the past week and write at least 5 sentences about how the topic or idea relates to ‘real life.’ The writing prompts were the same across weeks and allowed students to choose each day how they articulated utility: “how could information about this topic… be useful in your daily life?…be related to your future plans?… be useful to someone you know?” Following the writing prompts, students were provided with an example of how one might write about utility if they were studying nutrition (this topic was not covered during the study).

Participants in the writing comparison condition instead responded to the prompt: “Pick one of the topics or ideas that was covered in class in the past week. Write at least 5 sentences summarizing the main parts of this topic or idea.” Following the writing prompt, students were provided with an example of how one might summarize the main parts of a lesson on nutrition (again, this topic was not covered during the study). The writing prompts and examples in both writing conditions were similar to those used in prior research involving utility value interventions (Harackiewicz et al., 2016; Hulleman & Harackiewicz, 2009). Participants reported their perceived utility and interest in science in a follow up survey after the conclusion of the intervention and students' grades were obtained from school records at the end of the academic year.

5.4. Measures

5.4.1. Initial success expectancies

Prior to the intervention, students were asked about how well they expected to do in science class and how capable they were of learning new things in science (e.g., “How well do you expect to do in science this year?”, items from Eccles & Wigfield, 1995). These two questions were combined to create a measure of success expectancies. Cronbach's alpha for initial success expectancies was 0.79.

5.4.2. Perceived utility

Students' perceptions of the utility of science was assessed at baseline and after the intervention to examine whether the intervention directly impacted perceptions of utility. The items asked students to rate the degree to which they could apply what they were learning in science to real life and perceived science as useful to know (e.g., “I can apply what we are learning in science class to real life.”, items from Hulleman et al., 2010). Three questions were averaged to create a measure of perceived utility at each time point and revealed Cronbach's alphas of 0.80 and 0.88 at baseline and post-intervention, respectively.

5.4.3. Science interest

A science interest measure was created from student ratings of 5 survey items about the importance of science, their excitement about learning science and their interest in science (e.g., “I'm really excited about learning science.”, items adapted from Harackiewicz, Durik, Barron, Linnenbrink-Garcia, & Tauer, 2008). Cronbach's alpha equaled 0.91 at both baseline and post-intervention.

5.4.4. Science performance

Students' science grades (on a 4-point scale) were obtained from school records. Science grades from the second semester of school were used because that was the semester following the intervention. Science grades during the first quarter (pre-intervention) were used as a covariate in analyses predicting performance.

5.5. Essay coding

Students' essays (utility essays and comparison writing essays) were coded in order to assess treatment fidelity and to better understand any emergent effects of the utility intervention on the outcome variables. Coders were blind to the essay condition. Twenty percent of the essays were coded by two independent researchers to establish inter-rater reliability. There was very little divergence between coders, so inter-rater reliability is reported as percent agreement. For the purpose of the present analyses, we focus on the presence and specificity of utility, meta-features of utility, and utility content (see Table 1 for example excerpts of essays).

5.5.1. Presence and specificity of utility

Specificity refers to how explicit the connection was between scientific content and a goal, consistent with the definition of task utility value (Eccles et al., 1983). Essays were coded 0 if there was no connection between scientific content and its utility (e.g., “We're studying weather in school”), coded 1 if the connection focused on general relevance or connection to one's experience without any explicit reference to utility (e.g., “It's important to understand stratus clouds because you see them a lot in the sky”), coded 2 if the connection suggested that science was useful because it affected passive outcomes (e.g., “Weather is important because it determines where tornadoes touch down”), and coded 3 if the connection described how science affects how a person might choose to behave (i.e., self-regulate) in order to achieve a goal (e.g., “It is important to know about weather so you can decide when it's safe to play sports outside”). The distinction between the two highest codes is subtle because in both cases students are connecting science to a future outcome, but to be coded at the higher level, the student must explain how the utility might impact self-regulation toward achieving the goal, whereas lower level connections do not refer to goals, plans, actions, or decisions. Percent agreement between two independent coders of this item was 88%. Specificity ratings were averaged across the essays available for each person (M = 1.57, SD = 0.78).

5.5.2. Meta-features of utility

For those essays that were coded as containing some degree of reference to science utility (i.e., those coded with values of 1 or higher for presence and specificity of utility, see above), two meta-features were coded to examine how students were thinking about utility of science.

Each essay was coded dichotomously based on whether the utility statement was focused on the future. Essays were coded as 0 if no time frame was given (assumed to be all the time) or if the time frame was immediate (this week or month). Essays were coded 1 if the time frame was either in the near (next season) or distal (in a few years) future. Inter-rater reliability on this item was high, as indicated by a 96% agreement between 2 independent coders. These codes were aggregated across essays by identifying the most distant time reflected in any essays written by a given student. In other words, students were given a 0 on the aggregated variable if none of the essays reflected near or distal time frames, whereas students were given a 1 on the aggregated variable if at least one of their essays reflected near or distal time frames. Overall, only 18% of students described utility in the near or distal future at least once.

Two count variables were also used. First, the average number of words was tabulated in order to examine the length of essays across grade level ($M = 46.87$; $SD = 13.52$). In addition, the average number of first-person singular pronouns (e.g., I, me, my) were counted in each essay by a word processing software program in order to evaluate the extent to which the author of the essay was writing from a personal perspective. The number of first-person singular pronouns were averaged across the 6 essays for each person ($M = 1.73$; $SD = 1.60$).

5.5.3. Utility content

The content of each essay that contained utility was coded based on the primary purpose around which the description of utility was centered. The expressions of purpose were grouped as agentic (utility of science for either a career or further education), practical (utility of science for everyday activities and general understanding of the world), and fun (utility for hobbies and extracurricular activities). Inter-rater agreement for each of these utility types ranged from 98 to 99%. The distribution of the scores of each type of activity was skewed suggesting that a dichotomous variable for each type of activity would be most appropriate. Therefore, students were coded for whether at least one of their essays referred to each type of activity. Thus, participants were coded for the absence (coded 0) or presence (coded 1) of having any evidence across their essays of agentic, practical, and fun utility content (13%, 49%, and 13% of participants, across the categories, respectively).

5.6. Manipulation check on essay content

The utility intervention and writing comparison activities were carried out as intended, and yielded dosage results remarkably similar to those reported in Hulleman and Harackiewicz (2009), the study after which the intervention was modeled. Participants in the utility condition wrote an average of 4.0 sentences per essay, and participants in the writing comparison condition wrote an average of 4.5 sentences per essay. Seventy-three percent of the utility essays were coded as expressing some level of connection between science content and life (specificity codes 1–3), whereas only 4% of the writing comparison essays were coded as such. A small number of utility essays (4%, almost all written by 9th graders) were noted because the student mentioned explicitly that science had low utility (i.e., not useful).

Overall, while on average both groups wrote slightly fewer than the requested 5 sentences, a majority of participants in the utility condition actually wrote about utility, whereas almost none of the participants in the writing comparison group did. At the conclusion of the study, teachers were asked whether they were aware of which treatment group had been assigned to which section of their class and no teachers reported awareness.

6. Results

6.1. Predicting post-intervention measures among Black and Hispanic youth

Students were nested in 15 different class sections; therefore, the data were analyzed using the multi-level modeling function in the lme4 package in RStudio (R Core Team, 2016). Class section was included as a random effect in order to estimate appropriate standard errors for the effects of the focal predictors. The outcome measures included perceived utility, interest in science, and school performance. The null (random intercepts only) model was conducted on each of the 3 outcome variables in order to evaluate how much variability could be attributed to class section. Although a very small portion of variance was accounted for by class section (< 1% as indicated by the ICC) the multilevel structure was retained in order to account for the nested data.

The focal predictors included intervention group (entered at the classroom level), a standardized measure of initial expectancies for success, grade level (7th vs. 9th), and their two- and three-way interactions. A baseline covariate (standardized) was also included in the model that was parallel to the outcome measure, but assessed prior to the intervention (e.g., baseline interest was used as a covariate when predicting post-intervention interest).

The intervention was contrast coded such that classrooms in the utility condition (+1) were compared with those in the writing comparison condition (−1). Grade level and gender were also contrast coded to compare ninth graders (+1) with seventh graders (−1), and boys (+1) with girls (−1). Gender was included in models because girls and boys have been found to think differently about themselves within several areas of science (e.g., Francis, 2000; Lightbody & Durndell, 1996; Whitehead, 1996).

In all models, unstandardized coefficients are reported for statistically significant univariate effects. Finally, the degrees of freedom fluctuate somewhat across the analyses due to missing data. See Table 2 for descriptive statistics and correlations among the primary variables in the study.

6.1.1. Perceived utility

First, we wanted to examine whether students exposed to the intervention perceived greater utility in science. The model did not converge when using the standardized versions of the two continuous predictors (initial expectancies and initial perceived utility), but this was rectified by using the variables in their original metric. However, because using predictors that are not centered around zero renders lower-order effects uninterpretable, we first explored the main effects without the interactions, and then added the 2- and 3-way interactions into the model in a hierarchical fashion. When only the main effects were in the model, there was no effect of the utility intervention ($b = 0.01$, $p = 0.98$), but main effects emerged for expectancies

Table 2
Zero-order correlations and descriptive statistics for primary variables.

	Measure	1	2	3	4	5	6
1	Expectancies in science						
2	Science grades (pre)	0.44*					
3	Grade level	0.01	−0.03				
4	Gender	0.06	−0.19*	0.04			
5	Science interest (post)	0.46*	0.12	−0.02	0.19*		
6	Science grades (post)	0.35*	0.74*	−0.19*	−0.27*	0.13	
	M	4.93	2.62	−0.16	−0.02	4.05	2.21
	SD	1.29	1.21	0.99	1.00	1.46	1.21

Note. *N* varies from 222 to 268 as a consequence of missing data. Expectancies and interest could range from 1 (low) to 7 (*high*). Science grades could range from 0 (*F*) to 4 (A). Grade level was coded −1 for 7th grade and +1 for 9th grade. Gender was coded −1 for girls and +1 for boys.

* $p < 0.05$.

($b = 0.17$, $p = 0.04$), suggesting that students with high expectancies perceived greater utility than those with low expectancies. Not surprisingly, baseline utility was also a strong predictor ($b = 0.55$, $p < 01$). None of the interactions were significant when added to the model in subsequent steps.

6.1.2. Interest

Next, the full model was used to predict interest in science. Three effects emerged. The average effect of expectancies for success ($b = 0.18$, $p = 0.03$) was qualified by a three-way interaction of expectancies, the utility intervention, and grade level ($b = -0.21$, $p < 0.01$). Simple effects of the utility intervention were tested at one standard deviation below and above the mean of expectancies, within each grade level (see Fig. 1). These analyses revealed that, among seventh grade students, the utility intervention raised interest for those with higher expectancies for success ($b = 0.26$, $p = 0.03$), but not for those with low expectancies for success ($b = -0.13$, $p = 0.34$). The pattern among ninth grade students was quite different, although neither simple effect was statistically significant. Ninth grade students with low expectancies ($b = 0.28$, $p = 0.11$) reported slightly more interest in response to the intervention, but those with high expectancies ($b = -0.17$, $p = 0.24$) did not. The three-way interaction was also accompanied by a strong effect of initial interest ($b = 0.95$, $p < 0.01$).

6.1.3. Science grades

The model predicting science grades during the second semester revealed a marginally significant three-way interaction between expectancies for success, the intervention, and grade level ($b = -0.11$, $p = 0.08$). Although the effect was only marginally significant, the pattern suggested that the intervention was working differently across grade level among students with low expectancies. Whereas the effect of the intervention was somewhat positive for ninth graders with low expectancies it was somewhat negative for seventh graders with low expectancies. There was an effect of grade level ($b = -0.10$, $p = 0.04$) that favored seventh graders, and an effect of gender ($b = -0.16$, $p < 0.01$) that favored girls. Prior school grades was also a strong predictor ($b = 0.67$, $p < 0.01$).[1]

6.2. Meta-features and content of utility essays

In order to better understand the effects of the utility intervention on interest and performance among the Black and Hispanic sample, we examined the content of students' utility essays. These analyses excluded participants in the writing comparison conditions (because they did not write about utility). The essay content variables were examined at the level of zero-order correlations (see Table 3). We first focus on relationships that emerged with regard to grade level, and then turn to expectancies, science grades and gender.

Although the essays of seventh graders did not differ from those of ninth graders in terms of length, $r(125) = -0.04$, $p = 0.64$, grade level was related to features of students' utility essays in other ways. Consistent with the idea that older students can think further out in time, ninth graders were more likely to describe utility that was

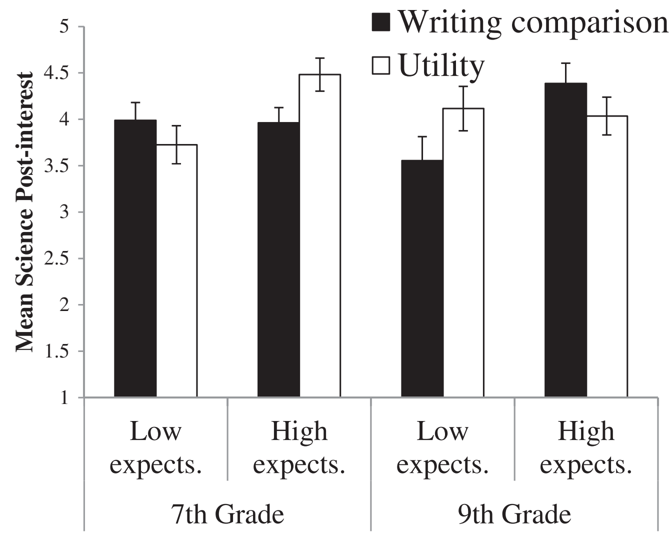

Fig. 1. Predicted values for the three-way interaction on mean interest in science. The error bars represent ± 1 standard error of the estimate of the predicted value.

relevant to a time point that extended further into the future, $r(121) = 0.26$, $p < 0.01$. Ninth graders also more often expressed utility that was oriented around agentic purposes, $r(125) = 0.22$, $p = 0.01$, which may reflect the increasing desire to exercise autonomy that emerges in this age range, and the desire to be effective in those pursuits. The positive correlation between future-oriented and agentic utility suggested that these older students were identifying ways that science could be useful for longer-term, agentic pursuits, $r(121) = 0.51$, $p < 0.01$. However, the negative correlation between grade level and the number of personal pronouns suggested that ninth graders were less likely than seventh graders to refer to themselves in their utility statements, $r(125) = -0.25$, $p < 0.01$. This may be related to the more concrete and relatively more accessible content taught in seventh compared with ninth grade science, and/or that ninth graders had a greater tendency to refer to science as being useful to people more generally.

Expectancies also predicted features of students' utility essays, and whether students tied their essays to themselves and their futures. The positive relationship between expectancies for success and writing about utility in the future suggests that students who began the school year with higher expectancies for success expressed more ideas about how science could relate to or be useful for future goals or events, $r(121) = 0.21$, $p = 0.02$. Moreover, the extent to which students wrote about their futures was also related to the specificity of their utility, $r(121) = 0.21$, $p = 0.02$. In other words, students who wrote essays that were focused on the future were more likely to identify a use for science that could facilitate the achievement of a more specific goal.

Interestingly, although students wrote more about the future if they had higher expectancies for success and the essays focused on the future were more specific in terms of their connections to particular goals, there was no association between students' use of personal pronouns in their essays and either expectancies, $r(125) = 0.01$, $p = 0.89$, or specificity, $r(125) = 0.09$, $p = 0.29$. In other words, these students did not appear to have readily connected the specific and future utility to themselves and their own goals. This is somewhat difficult to understand but suggests that students with high expectancies may have more easily generated ways that science could be useful to people in general, including themselves, but without explicitly stating their role in it.

Finally, practical and fun goals tended to be more specific, $r(125) = 0.55$, $p < 0.01$ and $r(125) = 0.37$, $p < 0.01$, respectively, but unrelated to the future, $r(121) = -0.004$, $p = 0.97$ and $r(121) = -0.002$, $p = 0.98$, respectively. Students who wrote about agentic goals were less likely to write about practical goals, $r(125) = -0.28$,

[1] Analyses identical to those just reported were also conducted with the full sample, which included the 77 White, non-Hispanic and Asian students. Most ($n = 55$) of these students were seventh graders, which compounded the imbalance of students in the various grouping variables and made it impractical to include race as a variable in the analysis. The null models again revealed relatively little variance in outcomes at the classroom level (ICCs ranging from < 1% to 3%), though ICCs were larger than in original models, reflecting that the White and Asian students who were added may have been more sensitive to the classroom context. When we replicated our analysis with the full student sample, the results were similar to those with the Black and Hispanic students alone, but were more muted. Most notably, the 3-way interaction of the utility intervention, expectancies, and grade level was statistically significant ($b = -0.10$, $p = 0.03$) when predicting post-interest. The full analyses are available in online supplemental materials.

Table 3
Zero-order correlations among essay features and primary variables (utility condition only).

	Personal	Specific	Future	Agentic	Practical	Fun	Essay length
Personal							
Specific	0.09						
Future	−0.03	0.21*					
Agentic	−0.01	0.14	0.51*				
Practical	0.14	0.55*	0.00	−0.28*			
Fun	0.03	0.37*	0.00	0.13	0.11		
Essay length	0.26*	0.30*	0.11	0.02	0.21*	0.12	
Expectancies	0.01	0.10	0.21*	0.12	0.11	0.05	0.27*
Science grades (pre)	0.15	0.28*	0.03	0.11	0.21*	0.13	0.30*
Grade level	−0.25*	−0.03	0.26*	0.22*	−0.11	−0.04	−0.04
Gender	−0.13	−0.07	0.09	0.19*	−0.26*	0.02	−0.20*
Science interest (post)	−0.06	0.11	0.12	0.03	0.04	−0.01	0.06
Science grades (post)	0.19*	0.31*	−0.05	−0.03	0.29*	0.16	0.28*
M	1.73	1.57	0.18	0.13	0.49	0.13	46.87
SD	1.60	0.78	0.38	0.33	0.50	0.34	13.52

Note. *N* varies from 112 to 127 due to missing data. Expectancies and interest could range from 1 (low) to 7 (*high*). Essay length referred to the average number of words students wrote in their essays. Science grades could range from 0 (*F*) to 4 (A). Grade level was coded −1 (7th grade) and +1 (9th grade). Girls (−1) were compared with boys (+1). Personal pronouns ranged from 0 to 7, specificity of utility ranged from 0 (no utility) to 3 (specific utility), and future oriented utility ranged from 0 (immediate or near future) to 1 (next month or beyond). Essay content that was agentic, practical, or fun was coded depending on its absence (0) or presence (1).
* $p < 0.05$.

$p < 0.01$, but this might be a consequence of being linked to gender; boys wrote more about agentic goals, $r(125) = 0.19$, $p = 0.04$, and girls wrote more about practical goals, $r(125) = -0.26$, $p < 0.01$.

7. Discussion

The present study examined whether the effects of a self-generated utility intervention varied by age among a sample of socioeconomically disadvantaged Black and Hispanic students. The pattern of effects varied across grade level. Among ninth graders, the effect of the intervention was similar to that observed in prior research, suggesting a benefit to students with low expectancies, although not significant in the current study. Among seventh graders, the pattern was reversed, demonstrating a positive effect for those with high expectancies.

The effects of the intervention on science grades were subtle overall, and there was no effect on perceived utility. The absence of effects on these outcomes may be related to the context in which this study was conducted. The students in this sample not only belong to racial and ethnic groups that are historically underrepresented in STEM fields, but also attend school in a district where about half of students either do not finish high school or stop their education upon graduation. Together, these two factors might create barriers to students' recognition of the applicability of science to their lives that are too formidable to change with six self-generated utility essays. In populations where educational opportunities are limited and STEM careers seem unlikely, a multi-pronged or more sustained approach may be required to produce changes in beliefs about the utility of science and grades.

7.1. Black and Hispanic seventh-grade students

The effect of the intervention among the seventh graders diverged from that of the ninth graders in this study and is also different from that observed in prior research with older samples. Among seventh-graders, the self-generated utility intervention raised interest for students with initial high expectancies for success but did not affect interest among students with initial low expectations for success. The analyses of essay content indicated that even though seventh graders were referring to themselves in their essays (i.e., using first-person pronouns), and writing essays of similar length to the ninth graders, they were less likely to refer to the future and less likely to mention utility for an agentic purpose. It appears that, although seventh graders were able to think about themselves in the context of science, they did not demonstrate the capacity to connect science to goals that could move them forward in time toward agentic ends. Higher expectancies were associated with utility that was focused more on the future, suggesting that seventh graders may have the capacity to handle the abstract nature of self-generated utility, when prompted, but only in domains in which they have high expectancies for success. In other words, expecting to be able to perform well in science might help developing learners to connect what they are doing in school to their futures.

The intervention affected interest but it did not affect perceptions of utility. Although utility interventions do not always directly affect perceptions of utility, they have been found to be moderated by variables such as expectancies for success (e.g., Hulleman et al., 2010). The absence of an effect on perceptions of utility reveals that these effects did not occur as a consequence of increased perceptions of utility. The utility intervention may have helped students form a personal connection to the content in science class, which might have directly fostered interest, but did not move students to believe science content from class is necessarily useful to them at a personal level. Similarly, explicit statements of low utility were especially rare among 7th graders, consistent with the idea that utility (either high or low) was not a salient feature of science for them. This pattern of findings may also be consistent with young students' perceptions of interest. Younger students have been found to rely more on their emotional experience and less on perceptions of utility value when identifying interests (Frenzel et al., 2012). The intervention may have improved the emotional experience of science class without directly impacting beliefs about utility and meaning.

The pattern of results showing that the intervention was more effective at promoting interest among seventh grade students with high success expectancies is similar to research on utility interventions that directly communicate utility to learners during instruction (Durik & Harackiewicz, 2007; Durik, Shechter, Noh, Rozek, & Harackiewicz, 2015). Prior research has shown that learners with high expectancies of success reported higher interest and performed better when utility value was directly communicated to them (e.g., the instruction included an explanation of how the content to be learned is useful). The interpretation was that learners with higher expectancies for success may have perceived the directly-communicated utility as challenging and meaningful. Similarly, in the present study, seventh-graders with higher expectancies may have been able to make clearer connections between the content and their personal experiences when they were prompted to do so, which led to their higher interest. This may have added value to the situation by helping them think about themselves and their futures in a way that they would not have otherwise. In contrast, seventh graders with low success expectancies may have experienced the exercise of self-generating utility as overwhelming, irrelevant for them, or confusing, given that they do not believe they will succeed in science.

7.2. Black and Hispanic ninth-grade students

The effects of the intervention among this sample of Black and Hispanic ninth graders were limited. Although not significant, the pattern was in the same direction of that seen in prior research that focused on primarily Caucasian samples of similar age (Hulleman & Harackiewicz, 2009), or primarily Black and Hispanic samples at an elite university (Harackiewicz et al., 2016). On one hand, this pattern of results may suggest that the effects of self-generated utility interventions rest at least in part on the extent to which people have general knowledge about the world. These ninth-grade Black and Hispanic students with lower expectancies for success may have tapped into their knowledge of the world in general and fit their own personal goals and desires to learn within that context. In other words, utility for science was somewhat connected to the future for these students, even though they were not likely to refer to themselves with personal pronouns in their essays. Given that these ninth-graders had lower expectancies for success and few aspired to be scientists (Skells, 2014), it is somewhat remarkable that the intervention was even slightly effective for boosting their science interest.

On the other hand, the results with these ninth graders are subdued relative to those found with other samples and there was not an effect on science grades. These ninth graders were very unlikely to further their education by virtue of their enrollment in integrated science, so even when they were prompted to consider the utility of science, the effect may have been constrained by what they saw as possible for themselves. We selected students in Integrated Science as the sample with which to conduct this intervention because they were likely to have especially low expectancies for success, given that the course was designed to support students with reading scores that were below grade level. Given this, one might have expected that this sample could benefit the most from self-generated utility. However, these students' relatively underdeveloped skills in language arts may have had difficulty putting into words their beliefs about how science could be personally useful. Consistent with this, the utility essays revealed limited specificity with regard utility value, which may also be reflected in the absence of any effects on perceived utility value. The subtle pattern of effects might suggest that an intervention that does not rely on writing, for example one in which students are asked to evaluate peers' statements of utility (Gaspard et al., 2015), may be more effective for populations that struggle with language arts.

Finally the pattern of effects for ninth graders, although subtle, is similar to that observed with other samples of students who are socioeconomically more advantaged. Therefore, it is reasonable to conclude that the utility intervention did not lead students to activate negative stereotypes about their group within science. If the prompt to consider utility had activated negative stereotypes then one would have expected negative effects of the utility value intervention, but that did not happen. When students are asked to self-generate utility for science, they may first look outside of themselves to identify meaningful and relevant content in their environment, and then to connect it to science. The subtle effects of the intervention also suggests that the connections that students made between science content and the self were relatively weak, and had room for further growth.

7.3. Limitations and future directions

Although the results of this study are provocative and begin to test the effects of self-generated utility in a wider array of students, there are also several limitations. The classrooms selected for this study allowed for an analysis of the effects of self-generated utility for a sample of predominantly Black and Hispanic students, but these classrooms also prevented certain comparisons as well. First, the sample of predominantly White and/or Asian students was too small to conduct direct comparisons with the Black and Hispanic sample. Thus, differences based on race and ethnicity could not be directly tested. It is only possible to compare the pattern of results observed here to that reported in other studies involving students with backgrounds that were quite different from prior samples of ninth graders. Given the differences in backgrounds, the results are surprisingly similar to those from prior samples. In contrast, the seventh grade sample was more similar to prior samples of ninth graders, and they showed a different pattern than observed in prior research. Taken together, the age-related capacity for thinking about the future may be a necessary component in order to see positive effects of self-generated utility among students with low expectancies for success.

In addition, classes, not students, were randomly assigned to the intervention. Although the same teachers were represented in both the experimental and control classes and variance by classroom was modeled in the analyses, it is still possible that some unmeasured and unforeseen difference between the classes accounted for the findings. This is a question to be answered by research in which it is possible to use true random assignment to conditions rather than cluster random assignment, and to examine how classroom contexts may influence perceptions of utility and interest in science.

Despite these limitations and when viewed in light of prior research, these results suggest that self-generated utility interventions may be fairly robust to differences in student characteristics with regard to socioeconomic background, but sensitive to students' ages. Embedded in the utility construct are aspects of time, future, and potential, all of which tap adolescent students' developing sense of self, and come together when students respond to a prompt to self-generate utility. The data reported here suggest that age rather than background might be an important variable to consider when broadening the implementation of this intervention. Continued research among different age groups can help illuminate the relevant processes that are involved in the complex task of perceiving utility in learning content.

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