What Good Is It for Me? The Development and Validation of the Science Usefulness Survey – the *SUS*

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Student engagement in science is likely relate to their perceptions of science usefulness. The lack of readily available tools to assess students' perceptions of science usefulness led us to develop the Science Usefulness Survey (SUS). The SUS is publicly available to those seeking to assess students' general perceptions of science usefulness. Our research and development resulted in a validated reliable instrument to assess student perceptions of a range of science issues. We found a number of unique relationships between science usefulness that are relevant for guiding instruction and curriculum choices. We discuss the implications, applications, and directions for future research.

INTRODUCTION

Student engagement and support for science is likely associated with the extent to which they find science to be useful (Burstein, 2003). However, the fact that members of the public (including students) often do not understand scientific processes, and instead some of them embrace pseudo-science (National Science Foundation [NSF], 2004) suggesting there may be issues related to perceived science usefulness that impact science learning and application (Bak, 2001). The extent to which the student find science to be useful may be contextual, depending on the situations in which they are involved both in and outside the classroom (Duckitt & Fisher, 2003; Kim, Choi, & Wang, 2013; Nisbet, 2005). Thus, evidence driven curriculum and instructional developers, particularly faculty members could benefit from access to assessments of students' perceptions of science usefulness that are domain general and yet can be applied to a multitude of science related learning and teaching contexts.

Of particular interest to us was how to effectively gather data to determine student perceptions of the usefulness of science, as their perceptions are often critical to science to teaching and learning (Jasanoff, 2011). We determined that the extent to which students perceive *science to be useful* is likely to be a proxy for their learning of science, potential engagement in scientific research or being thoughtful about science-related issues (Falk, Storksdiech, & Dierking, 2007). Our search of the literature revealed several items on larger surveys by no readily available existing instruments that could be used to assess student perception of science usefulness. Given the potential desire by teachers to use evidence to gauge student thoughts about science, we determined that many educators might benefit from a readily available tool that could be used to measure perceptions of science usefulness. Thus, we developed the *Science Usefulness Survey (SUS)*. The *SUS* (see Appendix) is a significant contribution to the field as it is the first validated, reliable instrument that could be used on a large scale to assess student perceptions of science usefulness.

WHY USEFULNESS OF SCIENCE?

Student and public perceptions of the usefulness of science can significantly impact engagement in and support of science (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008; George, 2003, 2006; Jasanoff, 2014; Wooden, 2006). If the students perceive a low utility of science then they are less likely to be motivated to learn more about scientific topics or to seek opportunities to inform themselves prior to engaging in decision-making regarding scientific issues (George, 2003, 2006). Thus, beyond learning about science, student perceptions of science usefulness may be manifested in their more broader decisions related to funding and support for scientific research (Dunlap & McCright, 2008; Elzinga, 2012; Frontiers in Innovation, Research, Science, and Technology, 2014; Lyall, Bruce, Marsden, & Meagher, 2013; McCright & Dunlap, 2010). For example, if students perceive that there is no benefit to using science to examine environmental consequences of economic development (e.g. climate change), then they may also be unlikely to support policy that would protect the environment based on scientific evidence that demonstrates the need for its protection (NSF 2004). On the other hand, if students find science useful for examining the consequences of situations such as growing and eating genetically modified foods, then they may be likely show motivation to learn more about and engage in the related food science (Wardle, Parmenter, & Waller, 2000). We embrace the notion that if the students perceive science to be useful they will support the added value of science in making meaning and decision and therefore may actively seek opportunities to learn more about science and provide support for scientific research (Tanner, 2013).

Student perceptions of the usefulness of science could also be an indicator of the level of engagement in societal issues that are science-related (Prpić, 2011). For example, engaging in discussions about climate change related policy may be more scientific evidence based – and therefore more likely to occur – if the students perceives science to be useful (Kahan et al., 2012; NSF, 2004). Further, students' perceptions of science usefulness may influence how they perceive the value of informal science education outlets such as public broadcasting of science programming, science museums, and science interpretative centers (Gauchat, 2010). Ultimately, perceptions of the usefulness of science are likely to impact students might provide support for funding for informal science education venues. However, if the students do not perceive science to be useful in explaining phenomena or influencing the quality of life they are less likely to endorse initiatives associated with funding or promotion of science (Blendon, Kim, & Benson, 2011).

Perceptions of the usefulness of science may be an important consideration when predicting the motivation and potential outcome of student engagement in science-related discussion forums, policy debates, and support for and engagement in science education (Gauchat, 2011). Of particular interest to us is the interplay among perceptions of science usefulness, engagement in science learning, world views, and the potential for support of science related policy (DeBoer, 2000). Thus, we anticipate that our measure of perceptions of science usefulness may act as a proxy for providing educators, scientists, and activists a means of gauging the potential support for science curriculum and science research, while providing data to guide the development of science agendas and programs.

Assessment of Personal Usefulness of Science

Aspects of assessments of student perceptions of science usefulness have been examined as part of other studies that assessed K-12 level student attitudes toward science (Abd-El-Khalick et al., 2012; George, 2003, 2006; NSF, 2004; Yager, Simmons, & Penick, 1989; Yager & Yager, 1985). The studies by Yager and colleagues (1985, 1989) used items from the National Assessment of Educational Progress (NAEP) to evaluate 9 year-old, 13 year-old, and 17 year-old students' attitudes toward the usefulness of science. The studies by George (2003, 2006) used four items from the Longitudinal Study of American Youth (LSAY). The four items included statements such as "Science helps in logical thinking" and "I will use science in many ways as an adult" which students responded to by rating their agreement on a five-point Likert scale. Similarly, the NSF (2004) survey of public understanding of science contains items implicitly associated with the engagement and perceptions of the usefulness of science. However, the items in the NSF survey are contextualized and require researchers to infer results to more general conditions. In all of these cases the items assessing science usefulness were embedded in a larger assessment or were inferred from responses to parallel items.

Our search of the literature failed to reveal any validated instruments suitable for explicitly assessing the perceptions of science usefulness among adults. We have built a case for the importance and utility of such an instrument to educators and scientists. Our study aims to fill the gap in the knowledge with the development and validation of a general assessment of adult perceptions of science usefulness.

METHOD

Research Goals

We created an instrument that could be used to assess adult students' perceptions of the usefulness of science that was informed by the literature (e.g. Prpić, 2011) and by our knowledge of working with adults as science educators. Specifically, the goals of our research were to:

- *Identify aspects of science that may relate to perceived usefulness;*
- *Create a set of items that assess adults' perceived level of the usefulness of science;*
- *Establish the validity of our instrument with experts, using their feedback to refine our items;*
- *Field-test our instrument to establish its reliability;*
- *Use our instrument and other measures to examine relationships between adult students' perceptions of the usefulness of science and their support for and engagement in science.*

INSTRUMENT DEVELOPMENT

Initial Item Formation

We began our instrument development with discussions of aspects of science and the work of scientists that the general public might find to be useful or useless. We also consulted the literature for evidence regarding how individuals currently perceive science as useful in giving meaning to phenomena. For example, from the literature it is apparent that there are a range of perceptions of how useful the science of evolution is for understanding species diversity and the associated implications (Nadelson & Sinatra, 2009). In addition, we used aspects of scientific issues that surface in public communication or in the news, such as climate change or genetically modified foods, to examine how people used or failed to use science to debate these developments and the associated policies.

As a team we discussed these aspects of usefulness to determine the possible root(s) of the issue of usefulness of science. Further, we maintained that an instrument to assess adult perceptions of the usefulness of science needs to contain items that allow individuals to reflect on the usefulness of science on a personal level. Based on our conversations and perceptions, we created forward phrased items such as: *I can use science as a way of discovering new things* – and reverse phrased items such as – *I cannot use science to explore areas of interest*. We generated a list of 20 forward- and reversed-phrased personal usefulness items that we used to create the *Science Usefulness Survey*. The items are presented as a five-point Likert scale with "1" representing "Strongly Disagree" to "5" representing "Strongly Agree."

Establishing Validity

Our interdisciplinary research team (composed of STEM discipline researchers and STEM education researchers) critically examined each of the instrument items for consistency in maintaining a primary focus on usefulness of science, were domain general (e.g. could be applied to a range of contexts), and to ensure we minimized the emphasis on the process and tenets of science, except for certain situations that we deemed were essential for examining usefulness. We then shared our instrument with five researchers, external to our study, with expertise in science education, assessment, and policy, and asked them to provide feedback regarding the items of the instrument. Based on their feedback we made adjustments to the language of our items to further emphasize the focus on perceptions of the usefulness of science. All of the five external reviewers thought our items were reflective of various aspects of how individuals were likely to perceive science as useful, and that our items were phrased in ways that older adolescents and adults could respond to without the need for further information or clarification. Therefore, we feel that we adequately established the construct and content validity of the items in our instrument. Based on our assessment, we determined that the validity of the survey was sufficient to proceed with field testing the instrument.

RESULTS

Field Testing - Round One

We began field testing our instrument by administering it to 75 undergraduate college students (primarily young adults as well as some older non-traditional students) enrolled in an introductory geoscience course. The course is designed for non-science majors to allow them to fulfill a university core course requirement in the natural sciences. Of the 60 students who completed the demographics and survey instruments, 75% were non-science majors, 10% were natural science majors, 7% were engineering majors, 5% were health profession majors, and the remaining 3% were undeclared. The students had previously taken an average of 2.22 college level science courses (SD = 1.36), an average of .28 college level mathematics courses (SD = .83), and an average of 2.13 college level English courses (SD = 1.10). The sample was on average 22.81 years old (SD = 4.98) and was composed of 57% females and 43% males. We administered a paper version of our instrument along with a general demographic survey at the beginning of one of the course meetings. We gave the students approximately ten minutes to complete the survey. Following data collection, we entered the responses into a statistical software program for conditioning (reverse coding answers) and analysis.

A reliability analysis of the results revealed a Cronbach's alpha of .90, which we interpreted as a "very good" to "excellent" level of internal reliability. The 60 participants who completed the survey had an overall average perceived usefulness of science of 3.64 (SD = .48) on a 5-point Likert scale, which we interpreted to be slightly above an ambivalent perception of science as useful for explaining a phenomenon. The item analysis of the Cronbach's alpha calculation revealed the lowest levels of contributions to the reliability for the items stating: "*I find science useful for explaining natural disasters*" and "*I find the problem solving structure of science to be useless.*" Yet, even these two low scoring items significantly contributed to the overall reliability of the instrument. Therefore, we determined that no restructuring of items was needed.

Field Testing - Round Two

Once we completed our initial pilot testing we field tested our instrument with a larger and more diverse sample of undergraduate college students (again, primarily young adults with some non-traditional students) that included a combination of science and non-science majors. Of the 314 undergraduates who returned surveys, 301 completed all items (or nearly all – with a few participants having skipped one or two items). The surveyed group of students was on average 23.86 years old (*SD* = 7.11) and consisted of 53.8% females and 46.2% males. The students had an average of 3.06 years of college (*SD* = 1.91) and had previously taken an average of 4.46 science courses (*SD* = 4.96). The students held an average level of religiosity of 5.05 (*SD* = 3.36) on a 10 point scale with 1 being low commitment and 10 being high commitment. Similarly, on a 10 point scale of political orientation, with 1 being liberal and 10 being conservative, our participants had an average political orientation of 5.27 (*SD* = 2.56).

Our reliability analysis of the second round of field testing of the instrument revealed a Cronbach's alpha of .93– a "very good" to "excellent" level of reliability. The 301 participants had an overall average perception of science usefulness of 3.40 (SD = .43) on a 5-point Likert scale, which we again interpreted to be slightly above an ambivalent perception of science usefulness. The item means, standard deviations, and inter-item correlations are presented in Table 1.

As we examined the inter-item correlations, we determined that all of the items in our instrument contributed positively to the overall reliability of our instrument and should be retained. Further, the inter-item correlations were relatively moderate, indicating that there are no instances of over-correlation, which is a potential indicator of replication of measurement of the items. The moderate levels of inter-item correlation values also justify retention of all the items in the instrument.

TABLE 1
ITEM MEANS, STANDARD DEVIATIONS, AND INTER-ITEM CORRELATIONS FOR THE SCIENCE USEFULNESS SURVEY (SUS)

Item	M	SD.	Inter-Item Correlation
SUS_1	3.50	.94	.52
SUS_2	3.79	.99	.56
SUS_3	3.82	.88	.57
SUS_4	4.05	.77	.67
SUS_5	4.00	.80	.63
SUS_6	3.93	.86	.71
SUS_7	3.58	.98	.55
SUS_8	3.74	.88	.67
SUS_9	3.37	.94	.56
SUS_10	3.66	.88	.71
SUS_11	3.66	.86	.63
SUS_12	3.57	1.00	.47
SUS_13	3.81	.99	.45
SUS_14	3.33	.87	.61
SUS_15	3.80	1.03	.43
SUS_16	3.90	.84	.70
SUS_17	3.76	.85	.62
SUS_18	3.65	.89	.62
SUS_19	3.83	.73	.68
SUS_20	3.49	.92	.59

Usefulness and Engagement in Science

As part of our validation and reliability process we gathered a variety of additional data such as religious commitment, political orientation, trust in science, number of STEM courses, and sources of science information and trust in those sources. We examined the correlations between these measures to evaluate any relationship(s) among these measures of science engagement with our perceptions of science usefulness measure (see Table 2).

Our correlation analyses revealed a number of significant positive and negative relationships. We found science usefulness to be positively correlated with trust in science (r = .31, p < .01), the number of completed college level science courses (r = .24, p < .01), whether science information was sought from science television programs (r = .39, p < .01) and magazines (r = .26, p < .01), and how much trust was placed in science television programs (r = .13, p < .05) and magazines (r = .14, p < .05). These results indicate that as perceptions of science usefulness increase there is a corresponding increase in trust in science, number of college level science courses, reliance on science television programming and magazines for science knowledge, and trust in the sources of science television programming and magazines.

We found personal usefulness of science to be negatively correlated with religious commitment (r = -.22, p < .01), reliance on social media for science information (r = -.13, p < .05), and trust in social media as a source for science information (r = -.15, p < .01). The negative correlations suggest as perceptions of science usefulness decrease, reliance on social media for science information, trust in social media for science information, and religious commitment increases.

TABLE 2
ELEMENTS CORRELATED WITH THE SCIENCE USEFULNESS SURVEY

	SUS	Trust in Science	Source: Social Media	Trust: Social Media	Religious Commit-ment	Number College Level Science Courses	Source: TV Science Program	Trust: TV Science Program	Source: Magazines	Trust: Magazines
SUS	--	.31**	-.13*	-.15**	-.22**	.24**	.39**	.13*	.26**	.14**
Trust in Science		--	.04	.09	.12*	-.07	.12*	.16**	.02	.04
Source: Social Media			--	.59**	.12*	-.31**	-.23**	.07	-.29**	-.11*
Trust: Social Media				--	.22**	-.23**	-.15**	.06	-.19**	-.09
Religious Commit-ment					--	-.05	-.15**	-.05	-.09	-.04
Number College Level Science Courses						--	.22**	.02	.21**	.20**
Source: TV Science Program							--	.38**	.42**	.23**
Trust: TV Science Program								--	.06	.50**
Source: Magazines									--	.32**
Trust: Magazines										--

* $p < .05$, ** $p < .01$

We conducted an analysis of variance (ANOVA) to determine if a relationship existed between academic major and perceptions of science usefulness. The ANOVA result was significant ($F = 4.45$, $p < .01$). Post-hoc analyses to identify pairwise differences in levels of personal usefulness of science and academic major revealed four significant relationships (Table 3). We found that students majoring in the Natural Sciences, Health Professions, and other science/science-related fields expressed a higher usefulness of science than students pursuing an education in the Arts and Humanities.

TABLE 3
POST –HOC PAIRWISE COMPARISONS OF USEFULNESS OF SCIENCE BY ACADEMIC MAJOR

Academic Major *(High Usefulness)*	**Academic Major** *(Low Usefulness)*	**Significance**
Natural Sciences	Humanities	p < .01
Natural Sciences	Art	p < .05
Health Professions	Humanities	p < .01
Other (Dominated by Environmental Science and Geosciences)	Humanities	p < .01

The survey revealed no significant relationship between personal usefulness of science and political orientation (liberal to conservative), number of mathematics or engineering courses taken, the seeking of science information from other sources such as newspapers, participant age, participant sex, socioeconomic status, or home community structure (rural, suburban, urban). We also found no significant relationship between knowing a scientist, mathematician, or engineer (outside of school) and perception of science usefulness.

SIGNIFICANCE AND IMPLICATIONS

The potential influence of usefulness of science on a student's motivation to learn science, engage in science-related activities, consider science-based decisions, and endorse or contest scientific policies related to funding or agendas, provides justification for assessing students' perceptions of science usefulness. The ability to effectively assess student perceptions of science usefulness can provide researchers, scientists, and educators insight into how courses, educational policies, research on science teaching and learning, request for science funding, or other education initiatives might be received and supported by the students.

Our research has resulted in a validity and reliability of an instrument which we have developed to assess adult students' perceptions of science usefulness. We argue that our instrument items were effective because they were based on both the experience of science faculty members working with the students and our consultation of the literature associated with students' perceptions and attitudes toward science. Our iterative development process provided several opportunities for vetting and examining the statistics of the items, which assured we selected items that were effective for assessing students' perceptions of science usefulness.

Our analysis of the relationship between perceptions of science usefulness and additional indictors of perceptions of science or engagement with science revealed several interesting and anticipated findings that may be of high interest to science educators and researchers. The association between trust in science and perceptions of the usefulness of science suggest that students who trust science and scientists perceive higher use for science. Similarly, the inverse relationship between religious commitment and perceptions of the usefulness of science suggest that students with high levels of religious commitment may rely more on other frameworks (e.g. faith) and less on science to explain phenomena. We maintain that these relationships triangulate the consideration of the effectiveness of our instrument to assess students perceptions of science usefulness, and the possibility for our instruments to be helpful for science educators and researchers to gather data useful for guiding curriculum development and conducting investigations. The implications for our findings reinforce the need for science educators to assure that their curriculum and instruction increases students' awareness and application of science to solve problems and explain natural phenomenon. Students' perceptions of the usefulness of science may also be increased when they are asked to compare and contrast the use of science to other ways of knowing to explain natural phenomenon. Further, students may experience increased perceptions of the usefulness of science if the benefits for using science to explain natural phenomenon are made explicit.

We found the relationship between trust in sources of information about science and perceptions of the usefulness of science to be intriguing. The greater reliance and trust in social media by those with low perceptions of science usefulness was surprising, and underscores the need to strive for accuracy in information presented through social media avenues or raise students' awareness of the possibility of bias and flaws in such sources of science information. Further, our finding provides support for the benefit of science educators and researchers for maintaining an awareness of the contents and uses of popular social media. We hypothesize that the information students are exposed to through these sources may be more consistent with their belief systems and more supportive of their perspectives of science, regardless of the accuracy of the information presented. It may be possible that certain groups of students are simply in favor of information that is consistent with their belief systems and are seeking general confirmation rather than objective science content.

Conversely, participants who indicated high perception of the usefulness of science indicated high reliance on television science programming and on magazines as sources of science information, which can potentially be more consistent and aligned with the philosophy and knowledge of the science community; a perspective inconsistent with those who indicated low perceived usefulness of science. What motivates students to select certain sources of science information, what they are seeking when they use those sources, and why they trust these sources are excellent directions for future research.

The associations between students' perceptions of science usefulness and other variables, such as preferred sources of science information, may be useful for science educators and researchers seeking funding and support for science, since these relationships could be leveraged as indicators of potential barriers or endorsements for educational and research agendas. We speculate that determining the relationship between perceptions of science usefulness and other variables are likely to be a very fruitful directions for future research.

Not surprisingly, we found students majoring in the natural and health sciences had higher level of perceived science usefulness than humanities and art majors. It is likely that students in the science domains selected those fields of study because of their views of science, including its usefulness for explaining natural phenomena. Similarly, students in humanities and the arts are more likely to rely on other philosophies or perspectives to explain natural phenomena and therefore perceive lower usefulness of science. The long-term implications of different academic foci and experience, perception of science usefulness, and influence on society are needed areas of research.

While public reactions to scientific developments (e.g. climate change and GMOs) and the overlapping student reactions motivated our research, our instrument may have wider applications. We maintain that our survey of the usefulness of science could be used by policy makers to examine public perceptions of science which may be helpful when drafting or seeking support for policies or programs. Further, the instrument could be used as part of larger studies of perceptions and attitudes toward science that might include influence of the media, specific current event topics or policy developments, or the influence of a particular intervention such as a museum exhibit, public event, or STEM related information campaign.

Limitations

There are several limitations to our study. The first limitation is the nature of the self-report instrument. However, with any measure of perceptions, self-report is likely to be the most effective way of determining what people perceive. Further, the alignments with trust and religious commitment suggest that the data we gathered using the SUS is consistent with societal expectation and practices.

The second limitation is the potential domain-specific and domain-general nature of personal perceptions of the usefulness of science, which may result in shifts in responses on our survey. However, combining our survey with indicators of a context may alleviate the potential issues associated with domain dependency. Again, further research in different contexts using the SUS may lead to greater understanding of how situations or conditions influence how much people find science to be useful.

The third limitation is the nature of our sample, which consisted entirely of undergraduate college students. While we maintain that the college students may be representative of the greater public, they are a rather specialized subset. Gathering data on other groups or subsets of the general public may reveal population differences in responses to the instrument that could be useful in future research.

CONCLUSION

We set out to address a gap in understanding science in society by developing an instrument that could be used to assess students' perceptions of science usefulness. The SUS appears to address this gap, and is a tool that may be useful for science educators, science education researchers, STEM scientists, and STEM policy makers, to explore and plan for perceptions of science usefulness in a wide range of contexts. We anticipate that our instrument could inform many different directions of education, policy preparation, research, and particularly to be used to gather data to empirically inform plans of action. We hope that as educator and research use the SUS they will provide us with feedback that we may use to refine our instrument and make it even more effective and useful for a wide range of applications.

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APPENDIX

Science Usefulness Survey – *SUS*

Directions: Answer each of the following based on your perceptions for the usefulness of science to YOU.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	1	**2**	**3**	**4**	**5**
1. I use science to figure out how the natural world works so that I can use nature to my benefit.					
2. I don't think science is useful for solving the problems I encounter in my life.*					
3. I like to use science to better understand nutrition.					
4. Science can help me understand nature better.					
5. I find science useful for explaining natural disasters.					
6. I use science to understand how organisms are related.					
7. Science is useful for bringing meaning to math.					
8. I look to science seek explanations about the natural world.					
9. When I solve problems I use a scientific approach.					
10. I use science to satisfy my curiosity about the natural world.					
11. I use science to figure out how the natural world works so that I can take better care of it.					
12. I don't think science can be used to explain a lot of my ideas about the natural world.*					
13. I cannot use science to explore areas of interest.*					
14. I use the scientific inquiry to gather evidence to explain ideas.					
15. I find the problem solving structure of science to be useless.*					
16. I can use science as a way of discovering new things.					
17. I find the accuracy and consistency of science to be useful.					
18. I can use science to predict the outcome of some events.					
19. Science is useful for understanding the relationships between variables.					
20. I can use science to forecast and plan for events in the future.					