# Is subjective knowledge the key to fostering Sustainable behavior? Mixed evidence from an education intervention in Mexico.

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**Abstract**

Educational interventions are a promising way to shift individual behaviors towards Sustainability. Yet as this research confirms, the standard fare of education, declarative knowledge, does not work. This study statistically analyzes the impact of an intervention designed and implemented in Mexico using the *Educating for Sustainability (EfS)* framework which focuses on imparting procedural and subjective knowledge about waste through innovative pedagogy. Using data from three different rounds of surveys we were able to confirm 1) the importance of subjective and procedural knowledge for Sustainable behavior in a new context, 2) the effectiveness of the *EfS* framework and 3) the importance of *changing* subjective knowledge for changing behavior. Yet, while the impact was significant in the short term, one year later most if not all of those gains had evaporated. Interventions targeted at subjective knowledge will work, but more research is needed on how to make behavior change for Sustainability durable.

**Keywords**

Behavior Change; Educating for Sustainability; Environmental Education; Knowledge Domains; Sustainability Science; Waste

# 1. Introduction

Achieving a Sustainable future requires that individuals around the world adopt different habits and behaviors. Psychologists as well as other scholars have proposed a diverse array models to explain why some people act more Sustainably than others do, but have had only limited success in reaching a professional consensus regarding the underlying drivers of Sustainable behaviors. The world's Sustainability challenges cannot await the development of a perfect theoretical model of Sustainable behavior. Rather what is urgently needed is to extract from psychological and behavior research the principals which can most effectively inform the development of the interventions which create meaningful and durable changes towards Sustainability in the participants' behaviors.

Much work has already been done in this direction. Of particular importance is that of psychologist McKenzie-Mohr who has distilled a host of research into a practical behavior change toolkit for community-level interventions (McKenzie-Mohr, 2011). Others have pointed to education as one of the best entry points for fostering Sustainable behavior change (Barth & Michelsen, 2013; Fischer & Barth, 2014; Hungerford & Volk, 1990; Tilbury, Nature, & Resources, 2002). Unfortunately, even education programs with explicit Sustainable behavior change goals are failing to integrate the most basic behavioral research into their curricular design and implementation (Larson & Redman, 2014). One practical framework for educational interventions which foster Sustainable behavior change, was proposed by one of us (Frisk & Larson, 2011); hereafter referred to as the *Educating for Sustainability* framework (*EfS*). Initial efforts have shown that this approach has promise (Redman, 2013),  but this paper is the first attempt to statistically evaluate the *EfS* framework's potential for changing behaviors.

## 1.1 Influence of Knowledge on Sustainable Behavior

The *Educating for Sustainability framework* is based on the integration of several strands of research including behavior change, Sustainability science and education pedagogy. The foundation of this framework is the well-studied result that knowledge of facts (which is the typical focus of education) does little to influence behavior (Kollmuss & Agyeman, 2002; McGuire, 2015). A wide array of theoretical frameworks have been proposed to explain what exactly does motivate Sustainable behaviors and "although many hundreds of studies have been undertaken, no definitive explanation has yet been found (Kollmuss & Agyeman, 2002)." The *Educating for Sustainability* framework integrates the insights of these researchers by using Kaiser and Fuhrer's (Kaiser & Fuhrer, 2003) concept of different domains of knowledge. The theory behind this approach has been fully fleshed out elsewhere (Frisk & Larson, 2011; Redman, 2013). In brief we propose that procedural knowledge and subjective knowledge are the keys to Sustainable behavior change, while declarative knowledge is far less so. A broad extensive survey previously conducted by the authors found exactly this relationship for both food and waste behaviors (Redman & Redman, 2013).

- *Declarative Knowledge*: This domain encompasses much of what is typically considered "knowledge"; facts about how long plastic persists in the environment or what happens to organics in the landfill. We don't argue that declarative knowledge is unnecessary just that it is insufficient to motivate Sustainable behavior change.
- *Procedural Knowledge*: This is the 'how-to' knowledge necessary to actually take Sustainable action. For example, this may encompass knowledge of what type of recyclables your local

community collects or how to manage a compost pile at home. Some types of procedural knowledge are highly situational while others are more universal.

- *Subjective Knowledge:* This domain encompasses a broad range including values, attitudes, and beliefs about consequences of personal action. Additionally, this domain includes information one has regarding these issues for family and friends as well as general social norms both descriptive and injunctive (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). Previously, we had divided subjective knowledge into two domains—effectiveness and social—but have decided that they are best unified into one domain. The specific reasons for this are elaborated fully in Appendix B3. Subjective knowledge includes for example beliefs about whether recycling will have an impact and if your friends would find composting at home gross or strange.

**1.2 Designing an Intervention with the *Educating for Sustainability framework***

While education interventions generally have been shown to be an effective avenue for promoting Sustainable behaviors (Zelezny, 1999), little has been done to evaluate outcomes for behavior in higher education (Vaughter, Wright, McKenzie, & Lidstone, 2013). For this research we are assessing the impact of a stand-alone Sustainability elective course for Mexican university students of all majors on knowledge and behaviors with regards to Sustainability and waste. In order to effectively target subjective and procedural domains of knowledge and thus promote Sustainable behavior, new approaches are needed in the classroom (Frisk & Larson, 2011; Redman, 2013). The intervention was therefore designed and implemented based on the *EfS* framework with an emphasis on developing the procedural and subjective knowledge of the participants. Some of the ways this was done included a focus on student choice, building social support and networks and an emphasis on systems thinking. For a full description of the education intervention itself see Appendix A.

**1.3 Research Questions and Hypothesis**

**1.3.1 Is the relationship between procedural and subjective knowledge and Sustainable behaviors cross-culturally robust?**

The broad applicability of much behavioral science research has been justifiably questioned (Henrich, Heine, & Norenzayan, 2010) given its narrow sampling base. Latin America is particularly poorly represented, one survey of the literature found that only 1% of the sampled publications included participants from Latin America (Arnett, 2008). Comparative surveys of environmental knowledge and behavior which have recently been undertaken in the region have found differences between countries (Geiger, Otto, & Diaz-Marin, 2014; Vicente-Molina, Fernández-Sáinz, & Izagirre-Olaizola, 2013), emphasizing the need for caution in extrapolating findings from studies undertaken in Europe or the United States to other parts of the world.

Our previous study, which found significant relationships between levels of procedural and subjective knowledge and Sustainable food and waste behaviors, was investigating a narrow population, K-12 teachers in the United States (Redman & Redman, 2013). We do not assume that our proposed knowledge-behavior relationship is cross-culturally robust and seek to confirm that it holds up as a necessary condition for answering the rest of the questions in this study.

*$H_1$: Higher levels of subjective and procedural knowledge correlates with more Sustainable behavior while higher levels of declarative knowledge does not.*

**1.3.2 Does using the *Educating for Sustainability framework* create an educational program which effectively targets procedural and subjective knowledge?**

If procedural and subjective knowledge are the keys to Sustainable behavior than it is essential to design interventions which effectively target those knowledge domains. The *EfS* framework proposes that the key output of an effective educational intervention is increased procedural and subjective knowledge relevant to the targeted behavior (Redman, 2013). Increases in these types of knowledge should lead to the desired outcome of more Sustainable behavior. We designed an educational intervention using the *EfS* framework (as described in Appendix A) and collected data before and after to evaluate whether this intervention resulted in the desired impact on the participants.

*$H_2$: Participating students will show an increase in their procedural and subjective knowledge as well as Sustainable behaviors after the educational program.*

**1.3.3 Does increasing procedural and subjective knowledge in an individual increase their likelihood of behaving more Sustainably?**

Much of the research on links between knowledge and human behaviors only looks at relationships for a snapshot in time (Osbaldiston & Schott, 2012). We identified this as one of the key weaknesses in our extensive survey, writing: "from this data alone we cannot conclude that an intervention (such as an education program) which increases an individual's knowledge in the different domains will correspondingly increase their participation in Sustainable behaviors (Redman & Redman, 2013)." Demonstrating a correlation between procedural and subjective knowledge and behavior is insufficient evidence that changing these types of knowledge will lead to *changes* in behavior. We therefore must look at the relationship between changes in knowledge and changes in behavior among the study's participants.

*$H_3$: Changes in procedural and subjective knowledge will predict changes in Sustainable behavior while changes in declarative knowledge will not.*

**1.3.4 Do changes in the knowledge domains and Sustainable behavior endure over the long run for participants in education programs such as this?**

To effectively contribute to Sustainability an educational intervention needs to create long-term behavior change. Unfortunately, education programs have been relatively unsuccessful at creating this type of enduring change in participants' behaviors (Glasgow, Klesges, Dzewaltowski, Bull, & Estabrooks, 2004; Hungerford & Volk, 1990). Indeed, Redman (2013) found that over the course of the year after a summer education program the participants' level of Sustainable behaviors slowly declined (though still ended up more Sustainable than before the intervention). Unfortunately, most studies only report on results from immediately after an education program or a follow-up of mere weeks (Nussbaum et al., 2015). We contend that in the long run there is a significant drop-off in impact of education interventions, but how much is too little studied. The important question for determining if education programs generally and the *EfS* framework specifically can foster the necessary changes towards more Sustainable behavior is the scale of the decline. To be a useful tool for Sustainability there must still be significant increases in behavior a year or more out.

*$H_4$: After one year participating students will still have increased knowledge (in all domains) and Sustainable behaviors relative to before the education program.*

## 2. Methods

In this section we provide only a brief overview of the methods applied in this study. A full and detailed description of the methods is included in the Appendix B, C & D as well as the R analysis scrip in Appendix E, while the raw survey data is available online.

### 2.1 Instrument Design

Many environmental/Sustainability knowledge/behavior surveys attempt to cover the full range of topics (e.g. food, waste, energy, water, etc.) but this leads to little information about each one and overly long surveys (Barr, 2003; Bogner, 1998; Finger, 1994). More importantly, there is evidence that individuals' knowledge and actions vary from area to area and a general survey washes that out (Thøgersen, 2004). We chose to focus our survey instrument on assessing knowledge and behavior with regards only to household waste for several reasons: (1) To build on the work we have previously done which focused specifically on food and waste behaviors; (2) Waste was one of the focal subjects of our educational intervention whose impact we are studying; (3) Sustainable waste strategies are relatively well accepted by experts and known about even by those who don't participate in them (e.g., recycling).

Beginning with our previously developed survey (Redman & Redman, 2013), we translated the questions and made changes to better reflect the local context. We used a four point Likert scale and categorized the questions into four groups: declarative knowledge, procedural knowledge, subjective knowledge and behaviors (for more information see Appendix B4). A sample of questions are show in Table 1 while the full survey instrument is provided in the Appendix C in the original Spanish as well as a back-translation into English.

**Table 1. Example Questions from Survey Instrument**

| Question | Knowledge Domain |
|---|---|
| Does plastic create serious environmental problems? | Declarative |
| Do you know how to compost organic waste? | Procedural |
| I know people who are committed to living Sustainably | Subjective |
| I bring my reusable bag to the store to avoid using a disposable bag. | Behavior |

### 2.2 Participant Population

This research was conducted with students at a newly opened branch of Mexico's National University (UNAM) in Leon, Guanajuato. The only Sustainability or environmental curriculum that the students were exposed to was imparted in our classes. The baseline data was collected in the first week of our classes and included students from all five degree programs (then existing). This baseline data is divided into two groups an intervention sample and a non-intervention sample. The intervention sample was surveyed again in full after the intervention was over. One year later we were able to get follow-up responses from a sub-sample of the intervention sample. Descriptive information about these samples can be seen in Table 2.

**Table 2. Descriptive Statistics of the Surveyed Samples**

|  | All | Intervention | Follow-up |
|---|---|---|---|
| Number | 119 | 82 | 28 |
| Male | 43.7% | 43.9% | 28.6% |
| Female | 56.3% | 56.1% | 71.4% |
| Elsewhere | 20.2% | 19.5% | 17.9% |
| Leon | 48.7% | 45.1% | 42.9% |
| Guanajuato State | 19.3% | 23.2% | 25.0% |
| Mexico City | 11.8% | 12.2% | 14.3% |
| Agricultural Administration | 16.0% | 11.0% | 7.1% |
| Intercultural Development and Management | 10.9% | 1.2% | 0 |
| Industrial Economics | 12.6% | 0 | 0 |
| Physical Therapy | 35.3% | 51.2% | 57.1% |
| Dentistry | 25.2% | 36.6% | 35.7% |
| Age(mean) | 21.5 | 21.8 | 22.4 |
| Grade(mean) | 8.1 | 7.8 | 8.1 |

Although the sampling methodology was not random we contend that our samples are sufficiently representative. We provide a fuller justification in Appendix D5 including the results of the Kolmogorov-Smirnov (KS) test we used to compare the samples.

This population of Mexican students was great for answering the research questions of the present study for a couple reasons. First, they are a very different group than those surveyed previously, providing a serious check on the broad applicability of the knowledge-behavior link for Sustainability. Secondly, higher education institutions everywhere are committing to creating Sustainable citizens but there is as yet little evidence whether the courses and curriculum offered are achieving this laudable goal (Vaughter et al., 2013). Ultimately, the university students of our sample, while not representative of the general population, are exactly the population that educational interventions of this type are targeted at.

**2.3 Implementation and Analysis**

The instrument was delivered via a web-based form and for all cases the identical form was used (see Appendix B5 for more detail). After anonymizing the data and removing duplicate and incomplete entries we have shared online the raw survey results in CSV format. All data manipulation and analysis was completed in R, an open-source statistical package and all the R script necessary to reproduce the results is also included. In Appendix D we describe in detail all the steps we took including removal of outliers, multicollinearity checks, the complete statistical outputs and more. Since the scales we use are both specific to this study and effectively arbitrary we report standardized results in the body of the paper. In Appendix B6 we describe how we created the standardized coefficient of the regressions and calculated Cohen's d (or effect size) for the T-tests. Appendix D includes both the standardized and unstandardized results.

# 3. Results

In this section we will discuss the specific analysis done to test each of the hypothesis and briefly present the results. The full results with additional analysis and tables can be found in Appendix D.

*H₁: Higher levels of subjective and procedural knowledge correlates with more Sustainable behavior while higher levels of declarative knowledge does not.*

In order to assess this hypothesis we looked at the 'all student' sample which after cleaning and outlier removal had 119 observations. In general for this study we will measure the levels of knowledge in the three domains and behavior using indices whose composition is detailed in Appendix D2. Table 3 reports basic

**Table 3. Descriptive Statistics of Indices**

|  | **Mean** | **Standard Deviation** | **Standardized Alpha** |
|---|---|---|---|
| **Declarative** | 3.06 | 0.43 | 0.65 |
| **Procedural** | 2.82 | 0.50 | 0.60 |
| **Subjective** | 3.15 | 0.43 | 0.70 |
| **Behavior** | 2.52 | 0.49 | 0.46 |

information about the indices for the all student sample including Cronbach's Alpha--a measure of how related the individual items of the index are. These standardized Alpha's are sufficiently high as the indices are attempting to capture broad domains and incorporate diverse concepts (Bland & Altman, 1997). However, the behavior index does not have a satisfactory alpha value due the multitude of behaviors it encompasses, which includes questions ranging from water bottle use to recycling. Interestingly, the correlation of the items dramatically increased after the intervention (to 0.70), presumably as the students now linked these behaviors more closely together.

**Table 4. Hypothesis 1: Regression Examining Relationship between Knowledge and Behavior**

|  | *Dependent variable:* |
|---|---|
|  | Behavior |
| Female | 0.165** |
|  | (0.080) |
| Degree: IDM | 0.257* |
|  | (0.153) |
| Declarative | 0.106 |
|  | (0.087) |
| Procedural | 0.305*** |
|  | (0.099) |
| Subjective | 0.324*** |
|  | (0.087) |
| Constant | 2.315*** |
|  | (0.134) |
| Observations | 119 |
| $R^2$ | 0.466 |
| Adjusted $R^2$ | 0.395 |
| Residual Std. Error | 0.379 (df = 104) |
| F Statistic | 6.493*** (df = 14; 104) |
| *Note:* | *p<0.1; **p<0.05; ***p<0.01 |

For all of the regressions in this study we used ordinary least squares (OLS) and controlled for sex, age, origin, degree program and final grade and checked for multicollinearity among the variables. We standardized the coefficients using the method suggested by Gelman (2008). In the body of the paper we will report only the standardized results for the knowledge domains and significant control variables. The full results and details of the regressions can be found in Appendix D.

The regression results support the hypothesis that procedural and subjective knowledge correlate with Sustainable behavior. The very low p-value (p<0.01) and high estimate for the coefficient suggest a very robust relationship. Meanwhile, declarative knowledge does not correlate (as hypothesized).

*H₂: Participating students will show an increase in their procedural and subjective knowledge as well as Sustainable behaviors after the educational program.*
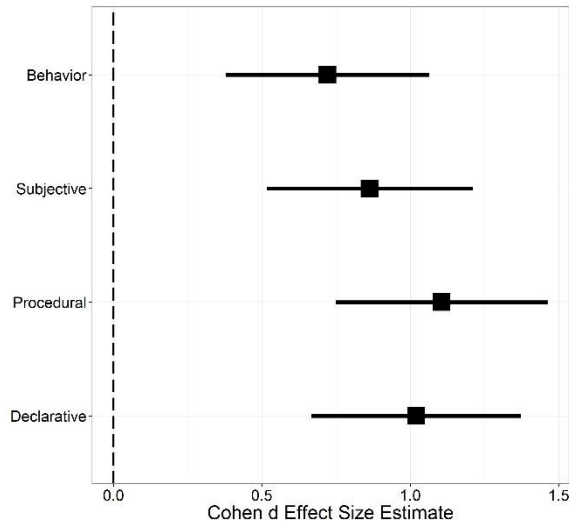
*Figure 1. Graph of T-test Result for Indices for the change from Pre to Post Surveys*

We ran a paired t-test comparing the pre- and post-survey answers for the intervention participants and calculated an effect size of the intervention using Cohen's d. Across the board there were statistically significant improvements on all but two of the survey questions (even after adjusting the p-values for multiple comparisons, see Appendix D10). Our focus is as always on the indices where we can be extremely confident of significant change ($p<0.01$) for all four. The graph in Figure 1 shows the estimated change along with the 95% confidence intervals. The intervention clearly had an impact on the participating students confirming hypothesis two.

*$H_3$: Changes in procedural and subjective knowledge will predict changes in Sustainable behavior while changes in declarative knowledge will not.*

We calculated the change in knowledge and behavior by subtracting each individual students' post-survey results from their pre-survey results. We could then run a regression to see whether *changes* in index scores predicted changes in Sustainable behavior. Table 5 displays the regression results for this analysis. Only subjective knowledge is significant and its effect size is quite large. Therefore hypothesis three is only partially upheld as increases in procedural knowledge did not contribute at all to predicting increases in behavior (neither did declarative knowledge as we expected it wouldn't).

**Table 5. Hypothesis 3: Relationship Between the Change in Knowledge and Change in Behavior**

|  | *Dependent variable:* |
| --- | --- |
|  | Behavior |
| Declarative | 0.168 |
|  | (0.157) |
| Procedural | 0.117 |
|  | (0.164) |
| Subjective | 0.455[**] |
|  | (0.177) |
| Constant | 0.636[**] |
|  | (0.254) |
| Observations | 72 |
| $R^2$ | 0.362 |
| Adjusted $R^2$ | 0.233 |
| Residual Std. Error | 0.500 (df = 59) |
| F Statistic | 2.794[***] (df = 12; 59) |
| *Note:* | [*]$p<0.1$; [**]$p<0.05$; [***]$p<0.01$ |

*H₄: After one year participating students will still have increased knowledge (in all domains) and Sustainable behaviors relative to before the education program.*
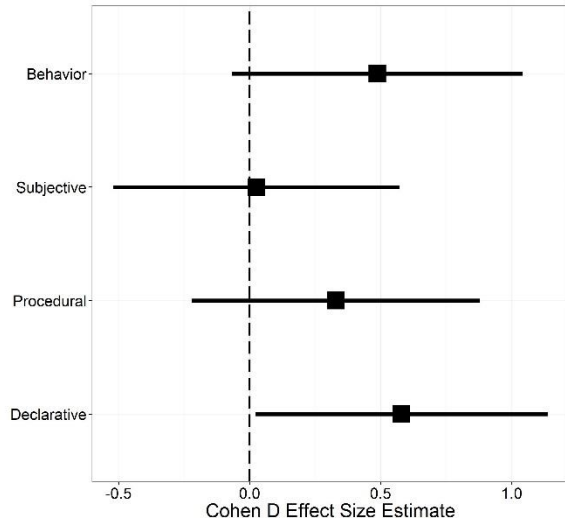


From the subset of students who responded to the follow-up survey one year later we can get an idea of the long term impact of the intervention. There was a large reversion by the participants back to their pre-scores across the board (see Appendix D13). For the indices, the graph in figure 2 shows the change between the pre- and follow-up surveys, nearly all the change we saw in figure 1 having been wiped out. While there is strong evidence for large changes in procedural and social knowledge immediately following the intervention after a year the reversion was so large that we cannot statistically say whether procedural or social knowledge changed over the long run.

*Figure 2. Graph of Cohen d Effect Sizes for changes from Pre to the Follow-up survey*

We also ran regressions on the follow-up results and the difference between the follow-up and pre-survey scores and found subjective knowledge to be predictive of behavior again and with a large coefficient. Unfortunately, the indices are highly correlated with each other which when combined with the much reduced sample size means that this result should be taken much more provisionally than the other evidence for subjective knowledge.

## 4. Discussion

### 4.1 Robustness of Knowledge Domains and their Links to Sustainable Behavior

Our previous study found a strong relationship between procedural and subjective knowledge and Sustainable waste behaviors among US K-12 teachers and this research found the same relationship among a very different population, Mexican university students. In fact, the standardized coefficients are very similar for the US (procedural: 0.313, subjective: 0.302/0.404—was split into two indices) and Mexico (procedural: 0.305, subjective: 0.324). This finding bolsters the case for the broad relevance of procedural and subjective knowledge domains for predicting the participation of individuals in Sustainable behaviors.

One area of concern is that the adjusted $R^2$ in this study is quite a bit lower than we found previously in Redman & Redman (2013), 0.787 vs. 0.395. That suggests that this model is less predictive overall. This could be due to change in the survey instrument, including its much shorter length or differences between the two studied populations.

### 4.2 The course made a big impact but that largely dissipated

The intervention we designed based on the *EfS* framework had a big impact on the participants' survey responses. There were large and significant increases in all four indices. In their meta-analysis Osbaldiston and Scott (Osbaldiston & Schott, 2012) found that the vast majority of experiments on Sustainable behavior change only measure the impact two to eight weeks out at best. What has been

done has produced warning flags about the true long term impact of our current efforts. Touching base with eco-tourism participants four months later Ballantyne, Packer and Falk (2011) found that "in general there was a low level of long-term impact (p. 1249)." Our own follow up a year later showed exactly why the predominance of short term analysis in Sustainable behavior change and Sustainability education research is insufficient to evaluate the efficacy of behavior interventions.

The results from a year later showed that most of the gains in knowledge and behavior have dissipated. Procedural and subjective knowledge, the focus of our intervention suffered most, with the gains of the intervention possibly being completely wiped out. There was however a statistically significant improvement in behaviors which was after all the overall goal of the intervention. If these gains in Sustainable behavior continue to endure the intervention will have been successful, if more modestly so than hoped. Density plot histograms in Figure 3 clearly show how the intervention changed the participants and how the responses mostly reverted for behavior but less so for declarative.
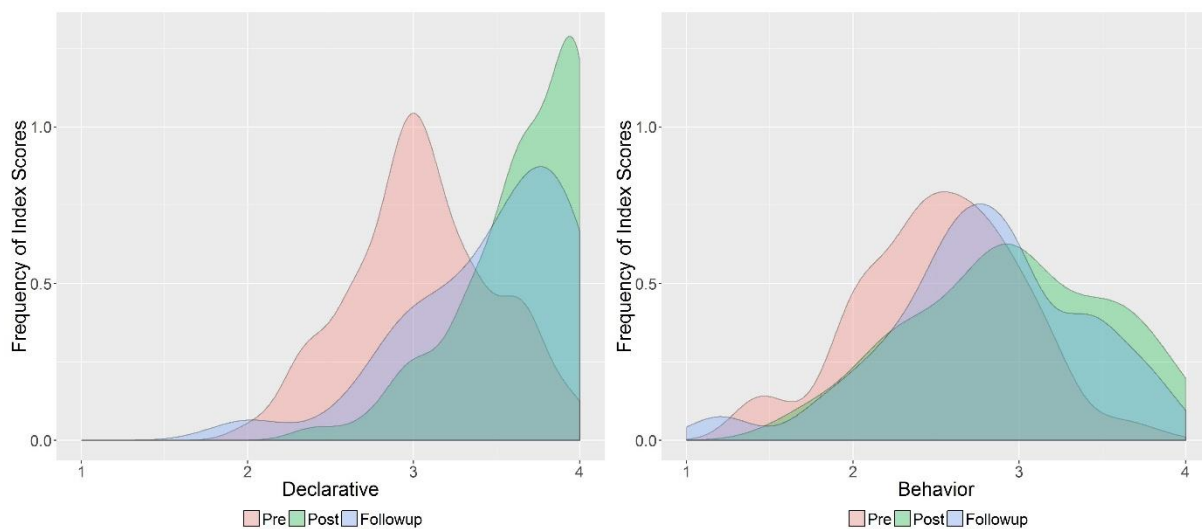


*Figure 3. Density plot histograms of the distribution of scores for declarative and behavior index for All, Post and Follow-up surveys (the rest can be found in Appendix D14)*

### 4.3 There were significant differences between the sexes

Other researchers have found that women have more positive attitudes towards Sustainability (Sahin, Ertepinar, & Teksoz, 2012) and the environment (Christensen & Knezek, 2015) and are more likely to participate in more Sustainable behaviors (Gossard & York, 2003). In our initial analysis of the 'all student' sample we found that to be the case, as can be seen in Table 4, where being female was a significant predictor of Sustainable behavior. An unpaired T-test comparing the male and female respondents found a statistically significant difference (p=0.024) between the means of their Sustainable behaviors (see Appendix D15 for full results of this and subsequent analysis related to sex differences).

To investigate this further we divided our 'all student' survey sample by sex and found some very intriguing differences. For females, procedural knowledge had a large effect size 0.490 (p<0.01) but subjective knowledge was not a significant predictor at all. For males it was the reverse with subjective knowledge being key, effect size 0.792 (p<0.01) and procedural knowledge not being significant.

Yet further investigations did cast some doubt as to whether this difference was just statistical noise. Firstly, the effect disappeared in the post and follow-up survey as the differences between the sexes for Sustainable behavior became statistically indistinguishable according to t-tests (as well as sex no longer being a significant predictor in the regressions). It is possible that the intervention had a differential impact on male and female students, thus closing the sex gap. Treating the males and females of the all student sample as separate samples we used the Kolmogorov-Smirnov (KS) test to ask if these samples represented different populations. For none of the indices were we able to say that males and females were different populations. It is outside the scope of this research project to investigate this further sex-based differences further but this potential finding has important implications which needs to be taken up in future research.

**4.4 Changing subjective knowledge predicted an increase in Sustainable behavior**

One of the main caveats from our previous research into the relationship between knowledge and waste behaviors was whether *changing* procedural and/or subjective knowledge would change behaviors. In this study we found evidence that increasing subjective knowledge does increase participation in Sustainable behaviors but increasing procedural knowledge (all else being equal) did not. This is especially interesting because procedural knowledge was still significant when we looked at the relationships in the post-survey, but not when looking at the changes.

It should be noted though that the adjusted $R^2$ is quite a bit smaller than in the regression for hypothesis one. The adjusted $R^2$ is also small for a regression of just the post survey data (0.264). It appears that our model is less effective in explaining Sustainable behaviors after participation in the course. Overall the results of this study bolster the case for a focus on subjective knowledge in education interventions though the reduced predictability of the model overall (as measured by the $R^2$) and the lack of the expected significance of changing procedural knowledge points to the need for further study and verification.

**4.5 Declarative knowledge is easily acquired and durable, yet its acquisition doesn't achieve the goal of behavior change**

While the *EfS* framework focuses on subjective (and procedural knowledge), students are expected to gain declarative knowledge as well (perhaps even more effectively than with traditional modes of teaching). We found that indeed the participating students significantly improved their declarative knowledge and more importantly that improvement endured through to the follow-up survey. Unfortunately, this research also further demonstrated the lack of a link between declarative knowledge and Sustainable behavior. This is not just a *static* non-relationship, the acquiring of more declarative knowledge did not predict any change in Sustainable behavior either.

# 5. Conclusion

The results of this study provide substantial support for the idea that the most effective way to encourage the adoption of Sustainable behaviors is to focus on subjective knowledge. This was in fact the only measured variable which was always statistically significant for predicting Sustainable behaviors. Researchers have previously focused on norms, on attitudes, on beliefs or on some other way of framing non-factual knowledge. We believe that a general conception of subjective knowledge which incorporates at least elements of all these concepts is more practical for implementation. However

subjective knowledge is framed, the relevant point for educators, policy-makers and others looking to foster more Sustainable behaviors is that factual, declarative knowledge is ineffective for achieving this end. Interventions, whether explicitly educational or not, must focus on subjective knowledge if behavior goals are to be achieved.

We are not the first to suggest that subjective knowledge is the key to fostering the Sustainable behaviors our world needs. This study makes an important contribution by confirming its importance in a new context, finding it to be changeable via a purposeful education intervention and that changes in subjective knowledge are impactful on behavior. Unfortunately, our follow-up survey found that the acquisition of subjective knowledge may be tenuous with average scores reverting to virtually where they were in the pre-survey after only a year. All interventions, particularly educational ones are time limited. This one was a full semester, many educational interventions are shorter. If subjective knowledge increases a lot during the intervention, as it did in this study, that is great, but ultimately meaningless if this gain dissipates completely over the long run. Is it simply impossible for a short intervention to durably change subjective knowledge? Could low cost and efficient methods like spot-check-ins or social media be sufficient to bolster subjective knowledge over the long run? Or is it necessary to foster university-wide (or community wide) social norms? Ultimately, researchers must show that subjective knowledge can be durably acquired if it is to be recommended as an essential tool for achieving Sustainability.

There are many possibilities beyond subjective knowledge for fostering Sustainable behavior but as long as researchers close out their studies with post-surveys and lack a long term follow-up, we will never really know what works. Our study found that the results of the post-survey were not indicative of the long term and that one year later knowledge of all kinds was reduced. Yet we did find a small but significant positive change in behavior, supporting the utility of the *Educating for Sustainability* framework. The logistical challenges are appreciable but long term check-backs are essential if research on behavior change is ultimately going to contribute to Sustainability.

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