A Case Study of the Development of Moral Sensitivity in Preservice Science Teachers as the Result of Exposure to Unintegrated and Integrated Socio-scientific Issues

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One goal of a science educator is to improve the scientific literacy of their students. By improving their scientific literacy, students have a better ability to interact and contribute to difficult issues that mix science with society. Fowler, Zeidler, & Sadler (2009) note that

> Scientific literacy must entail the ability to negotiate and make decisions regarding complex, social issues with theoretical and/or conceptual links to science. Issues such as global climate change, genetic engineering, alternative energy, stem cell research, and many modern health care options demand the attention of the entire populace and not just scientific specialists with particular areas of expertise

Social issues with scientific links are termed socioscientific issues (SSI; Fleming, 1986). A significant amount of research has been done on the connections between SSI and other aspects of science education, including nature of science (NOS; Eastwood et al., 2012; Khishfe, Alshaya, BouJaoude, Mansour, & Alrudiyan, 2017; Khishfe & Lederman, 2006), argumentation (Chang & Chiu, 2008; Khishfe et al., 2017; Robertshaw & Campbell, 2013; Sadler & Donnelly, 2006), informal reasoning (Fleming, 1986; Romine, Sadler, & Kinslow, 2017; Sadler & Zeidler, 2005; Topcu, Sadler, & Yilmaz-Tuzun, 2010) and the attainment of scientific knowledge (Dawson & Schibeci, 2003; Pedretti, 1999; Sadler & Donnelly, 2006). However, less work has been done to determine the connections between SSI and the moral development of students.

Moral development and morality are necessary for negotiations and solutions involving SSI. SSI are inherently moral/ethical problems, therefore for students to interact and help solve these issues, they must have education that promotes their moral development. Moral development can be described using a Four Component Model (Rest, Bebeau, & Volker, 1986)

including moral sensitivity, moral reason, moral commitment, and moral courage. These four components are scaffolded, meaning that in order to have moral courage and take action, the individual must have moral commitment to choose to do the moral action, which means that they have used moral reasoning to determine what the moral action is, and have therefore used moral sensitivity to realize there is a moral issue. Clarkeburn (2002) suggests,"Ethical sensitivity is the first step in real-life moral decision-making. Without recognising the ethical aspects of a situation, it is impossible to solve any moral/ethical problem, for without the initial recognition no problem exists." In other texts, as well as this one, moral sensitivity and ethical sensitivity are used interchangeably. Morality and ethics are considered similar, but different concepts. However, moral or ethical sensitivity are considered interchangeable as they are both a recognition of issues considered right or wrong by society and personally.

There have been a few studies demonstrating the connections between SSI and the development of moral sensitivity in college students (Clarkeburn, 2002) and high school students (Fowler et al., 2009). These studies used an ethics intervention in which many SSI were integrated with scientific concepts taught in the courses with the embedded moral concerns. It was demonstrated in both of these studies that these interventions significantly improved moral sensitivity in the test groups compared to the comparison groups.

In the aforementioned studies, the ethics interventions were given over the course of an academic year using multiple SSI that were directly related to the course curriculum. The purpose of this current study was twofold. What is the effect on the moral sensitivity of pre-service teachers resulting from: 1) A single, SSI unintegrated with course content, and 2) A second, SSI integrated with course content?

Theoretical Framework

The first test for development of moral sensitivity was the Dental Ethical Sensitivity Test (Bebeau, Rest, & Yamoor, 1985) which was intended to measure dentistry students' moral sensitivity to profession-relevant issues. The Test for Ethical Sensitivity in Science (TESS) was developed by Clarkeburn (2002) in order to measure the ethical sensitivity as it relates to scientific practices. The TESS requires students to respond to an unstructured scenario with their responses scored according to the level of recognition of the moral issues. The study found a statistically significant progression of the moral sensitivity in bioscience students after an ethics

intervention, when compared to a control group without the intervention. The ethics intervention, led by an ethicist, contained three structured group discussions around assigned scientific literature relevant to the science curriculum and containing socio-scientific issues. This study demonstrated that ethical sensitivity can be improved through ethics education, and furthermore, is unlikely to be improved simply through science content knowledge.

In order to determine how a science curriculum based on SSI affected the moral sensitivity of high school students, Fowler et al., (2009) created the TESSplus by including an additional unstructured scenario in their pre- and post-tests. In their study the treatment group was given activities designed to help students better understand scientific concepts and their applications to SSI, while the comparison group was given a traditional, textbook-driven curriculum. The treatment group students showed a significant progression in their moral sensitivity when using only the original TESS scenario, when compared to the comparison group. There was no significant difference found between the treatment group and the comparison group when the new TESSplus scenario was used. The researchers speculated that students demonstrate increased moral sensitivity for issues involving human beings (TESSplus scenario) over non-human beings (TESS scenario), as well as for scenarios in which students are more likely to have pre-formed emotions or beliefs. The study does provide evidence suggesting that regular interaction with SSI over the course of an academic year can progress moral sensitivity when students engage with scenarios without obvious human consequence or that are less well known. The researchers pose the need for further investigation into the contextual features of SSI used for instruction and the relationship with the development of moral sensitivity.

Methods

Overview

The purpose of this study was to answer the following research questions:

1. What is the impact of a single, unintegrated SSI on the development of moral sensitivity in preservice teachers?

2. What is the impact of a second, integrated SSI on the development of moral sensitivity in those preservice teachers?

The TESSplus pre-test/post-test model established by Clarkeburn (2002) and Fowler et al., (2009) was used to measure any statistically significant changes. The changes in moral sensitivity of the preservice teachers (treatment group) were compared to that of non-education majors (comparison group).

For the first research question, students examined an SSI based on the Italian earthquake of 2009 which resulted in over 300 deaths and criminal charges of manslaughter against six scientists and a government official for not properly predicting it. Students completed a pre- and post-test TESSplus. This unit was not integrated with content from the course.

In order to examine the second research question, students in the second semester course were given an integrated SSI. This SSI was based on the Flint Water Crisis and integrated with a unit on water treatment and purification. In order to determine any further development of the preservice teachers' moral sensitivity, the TESSplus was administered again at the conclusion of the unit. These post-post-test results were compared to the pre-tests and post-tests from the first semester.

Sample and Population

The treatment group had 84 preservice teachers (73 females and 11 males). The comparison group had 14 non-education majors (4 females and 10 males). The subset of the treatment group that took a post-post-test included 10 preservice teachers (7 females, 3 males, 5 of whom were special education majors, and 5 of whom middle school education majors).

Learning Conditions

The regular two-semester chemistry course was an inquiry-based chemistry course with a corresponding lab taught only in the first semester at a large Midwestern university. The lab included explicit NOS instruction. The treatment group, consisting of all of the preservice teachers, was enrolled in both courses, while the comparison group was only enrolled in the regular chemistry course. The entire sequence is required for middle childhood and special education majors.

SSI Interventions

The unintegrated SSI intervention, describing the Italian earthquake of 2009, was given to the treatment group as an out-of-class assignment, unrelated to any scientific concepts taught in the course other than the NOS. It consisted of three readings and the assignment page (Appendix 1). The first reading was a news article from *Nature News*, titled "Scientists on trial: At fault?" (Hall, 2011). It gave an overview of the events resulting in the trial of six scientists and one government official charged with manslaughter after the 2009 earthquake in the Italian city of L'Aquila, which killed more than 300 people. The article explained that the charges were related to the failure of government-appointed scientists to properly evaluate and communicate the potential risks to the public. The second reading was an open letter from a representative of the American Association for the Advancement of Science (AAAS) to the Italian President (Leshner, 2010) that voiced concerns over the charges due to the uncertainty in predicting earthquakes. The third reading was a news article from *Nature News*, titled "Italian court finds seismologists guilty of manslaughter" (Nosengo, 2012). This article explained the outcome of the trial against the scientists and government official, stating the verdict was based on negligence in the way the risks of the earthquake were assessed and communicated. Finally, the written assignment revisited NOS principles and asked the students to answer several questions about the roles of scientists and whether the people's expectations were reasonable.

The integrated SSI intervention was based on the Flint Water Crisis which started in 2014 when the drinking water source for the city of Flint, Michigan was changed in an attempt to create a cheaper system. Due to insufficient water treatment, lead leached from the water pipes into the drinking water, exposing over 100,000 residents to unsafe water. Subsequent measures to create cleaner water resulted in additional problems. This SSI was given to the treatment group students enrolled in the second semester of the inquiry-based chemistry course and involved both in-class discussion and out-of-class assignments and was linked to an in-class water purification unit. The out-of-class assignments consisted of three readings. The first reading was a news article titled, "The science behind the Flint water crisis: corrosion of pipes, erosion of trust" (Olson, 2016) which described the events and science behind the Flint Water Crisis. The second reading was a news article intended for science educators, titled "The Flint Water Crisis: What's Really Going On?" (Dingle, 2016). This article described the timeline of events, along with the chemistry behind the crisis. The third reading was a *Science* news article,

titled, "Was Flint's deadly Legionnaires' epidemic caused by low chlorine levels in the water supply?" (Shultz, 2018). The article described the connection between the Flint Water Crisis and the Legionnaires' epidemic in Flint. After the students had completed the readings, they participated in an open-ended, in-class discussion led by the course professor using a Think-Pair-Share approach which has been shown to improve students' critical thinking (Kaddoura, 2013) and results in positive effects on aspects of oral language use, thinking, metacognitive awareness, and the development of reading comprehension strategies (Carss, 2007).

Instrument and Scoring

The TESSplus (Clarkeburn, 2002; Fowler et al., 2009) was used as a pre-test and post-test before and after the first SSI and as a post-post-test after the second SSI to measure any changes in the moral sensitivity of the treatment and comparison groups. The TESSplus consists of two socioscientific issues given as unstructured scenarios. The original TESS scenario describes a research plan to genetically modify cows to produce pharmaceutical milk for the treatment of cystic fibrosis (denoted Genetic Modification), and the additional TESSplus scenario describes a research plan to provide cloning as a reproductive alternative for infertile parents (denoted Cloning). The students were asked to list five issues or questions that needed to be addressed before a decision should be made about the given research plan. The pre-test was given three weeks prior to the first SSI intervention and the post-test was given two weeks after it was completed. The post-post-test was given the week following the second SSI intervention or roughly 4 months after the post-test.

The completed instruments were assigned random numbers using an online randomizer and copies were made with only the number as an identifier for scoring. Scoring of the TESSplus was done similarly to Clarkeburn (2002) and Fowler et al. (2009) by rating each issue or question listed on a scale from 0 to 3 based on the level of its moral consideration. A score of 0 indicated no moral consideration, a score of 1 indicated some moral consideration, a score of 2 indicated moral consideration, and a score of 3 indicated strong moral consideration. The specific criteria with sample responses are provided in Table 1. The sum of the scores was used as the measure of moral sensitivity with a maximum value of 15.

Table 1

Scoring criteria and sample responses

Score	Criteria	Genetic Modification Response	Cloning Response
0	No moral consideration	How is the pharmaceutical cow created?	How would the procedure be performed?
1	Some moral consideration, but not completely apparent	I am opposed to cloning. How safe is this method?	Would there be side effects?
2	Clear moral consideration	Would the cows be harmed or negatively affected?	Would this be harmful to the mother or fetus?
3	Strong moral consideration, including decision-makers and statement of risk	Since humans are imperfect, are we responsible enough to create life, even for a good cause?	How will it be determined that couples want to use this for having a baby (good reason) and not a bad reason such as producing children to be workers, etc.?

Two researchers scored the TESSplus instruments. Inter-rater reliability was established by independently assigning scores to TESSplus results not used in the data analysis due to the absence of matching pre- and post-tests. The researchers then independently assigned scores to the TESSplus used for data analysis and met at regular intervals to discuss and reach consensus over discrepancies. The agreement between independently rated TESSplus reached 95% after four regular meetings.

Data Analysis

The treatment and control groups were compared using two-sample t-tests employing the mean change (average of the difference between tests) for each group. Paired t-tests were used for direct comparison of results from the same group on two different tests. Results were determined statistically significant if a p-value of less than 0.05 was obtained.

Results

First Research Question

The mean changes (differences) between post-tests and pre-tests and standard deviations for the comparison and treatment groups are shown in the first row of Table 2. These values were determined not to be significantly different in both individual scenarios as well as the overall average of both scenarios, based on two-sample t tests ($p > 0.05$). However, significant differences were found when the mean changes were analyzed based on gender. These results are also shown in the following rows of Table 2. Statistical analysis was performed on groups within outlined rows, as well as between groups of similar shading. Statistically significant differences are indicated with number or letter superscripts.

Table 2

TESSplus scenario results after the first SSI

	Genetic Modification	Cloning	Overall
Groups Examined	mean change ± SD		
Comparison Group (n = 14)	-0.50 ± 2.07	-0.57 ± 2.03	-0.54 ± 1.45
Treatment Group (n = 84)	-0.42 ± 1.93	0.18 ± 2.03	-0.12 ± 1.53
Comparison Group Females (n = 4)	-2.00 ± 2.16	-0.75 ± 2.06	-1.38 ± 1.38
Comparison Group Males (n = 10)	0.10 ± 1.79	-0.50 ± 2.12 [3]	-0.20 ± 1.40 [5]
Treatment Group Females (n = 73)	-0.59 ± 1.85 [1, A]	-0.01 ± 1.99 [4]	-0.30 ± 1.49 [6]
Treatment Group Males (n = 11)	0.73 ± 2.10 [1]	1.45 ± 1.92 [3, 4, B]	1.09 ± 1.22 [5, 6, C]
All Females (n = 77)	-0.66 ± 1.88 [2]	-0.05 ± 1.99	-0.36 ± 1.50 [7, D]
All Males (n = 21)	0.43 ± 1.94 [2]	0.52 ± 2.20	0.48 ± 1.44 [7]

[1-7] statistically significant difference (two-sample t-Test, $p < 0.05$)
[A-D] statistically significant difference (paired t-Test, pre and post, $p < 0.05$)

The treatment group males demonstrated significant progression compared with the treatment group females, as determined by two-sample t tests ($p < 0.05$). A similar trend was discussed in Clarkeburn (2002), indicating that male students from the treatment group were more likely to progress compared to the female students from the treatment group. In general, the male students demonstrated significant progression in their moral sensitivity, while the

female students demonstrated significant regression. Additionally, the treatment group males demonstrated significant progression compared to the comparison group males in both the Cloning scenario and overall (two-sample t-test, $p < 0.05$).

Paired t-tests were used to compare pre- and post-test results in each group, so the source of significant change in the two-sample t-tests could be determined. Treatment group females had significantly lower post-test scores than pre-test scores in the Genetic Modification scenario, indicating significant regression. The other groups had no significant change in their post-test scores and pre-test scores for that scenario. The significant regression observed in the treatment group females in this scenario accounts for the difference between the treatment group females and treatment group males, and for the difference observed between all males and all females overall. The significant regression of females in the Genetic Modification scenario also accounts for the statistical difference observed between all males and females when considering both scenarios. The sample size for the comparison group females was the smallest of all the groups analyzed, with only four participants. Therefore, the results from the comparison group females, although showing regression, would not have contributed strongly to the results obtained from the treatment group females.

Treatment group males had significantly higher post-test scores than pre-test scores in the Cloning scenario. The other groups had no significant change in their post-test scores and pre-test scores for that scenario. This led to the statistical progression of the treatment group males compared to the comparison group males and the treatment group females. As observed in Fowler et al., (2009), there were generally higher mean changes for every group in response to the Cloning scenario as compared to the Genetic Modification scenario, with the exception of the comparison group males. The higher scores in this scenario likely resulted in a non-significant regression for the other groups. However, this does not explain why the treatment group males had significant progression in this scenario.

Overall, the treatment group males showed significant progression and all of the female students had significant regression. The significant progression of the treatment groups males on the Cloning scenario likely accounted for the statistically significant increases in moral sensitivity seen relative to the other groups overall. Specifically, the increases seen when compared to the comparison group males in the Cloning scenario, the treatment group males and

the treatment group females when comparing both scenarios, and to the overall differences between all females and males.

The changes in pre- and post-test results are further reflected in Table 3. While not statistically significant, the percentage of the treatment group progressing is 14.3% higher than the comparison group. Additionally, the percentage of regressing scores in the treatment group is more than 10% lower than in the comparison group.

Table 3

Percentages of each group progressing, regressing or showing no change for both scenarios

Groups Examined	Direction of change (% of group)		
	Progressing	Regressing	No change
Comparison Group	28.6	57.1	14.3
Treatment Group	42.9	46.4	10.7
Comparison Group Females	0	75.0	25.0
Comparison Group Males	50.0	40.0	10.0
Treatment Group Females	37.0	52.0	11.0
Treatment Group Males	81.8	9.1	9.1
All Females	35.1	53.2	11.7
All Males	61.9	28.6	9.5

When analyzed based on gender, the general trend was progression for males and regression for females. However, each gender shows greater progression in the treatment groups compared to the comparison groups, with both the treatment group males and the treatment group females' progression scores over 30% higher contrasted to their respective comparison groups. The increased percentage of progressing scores and decreased percentage of regressing scores in the treatment group suggests a general trend of improvement in moral sensitivity among the treatment groups.

Second Research Question

After the second SSI, a post-post-test was administered with the results presented in Table 4. While there was not a statistically significant difference between the pre-test and post-

test scores, as well as the post-test and post-post-test scores for these students, there was a statistically significant difference between the pre-test scores and the post-post-test scores in the Genetic Modification scenario and overall (paired t-test, $p < 0.05$). This finding is similar to that found by Fowler et al., (2009), suggesting that the Cloning scenario is too personal for students and does not allow for significant change to be seen. In addition, there were no statistically significant differences between genders, however, there were some differences when the two types of education majors were compared.

Table 4

TESSplus scenario results after the second SSI

	Genetic Modification	Cloning	Overall
Factors Examined	mean change ± SD		
Pre vs post (n = 10)	0.10 ± 2.18	0.40 ± 2.22	0.25 ± 2.15
Post vs post-post (n = 10)	1.20 ± 1.81	0.20 ± 2.15	0.70 ± 2.00
Pre vs post-post (n = 10)	1.30 ± 1.42 [1]	0.60 ± 1.58	0.95 ± 1.50 [2]
Females (n = 7)	1.14 ± 1.46	0.57 ± 1.72	0.86 ± 1.56
Males (n = 3)	1.67 ± 1.53	0.67 ± 1.53	1.17 ± 1.47
Special Education Majors (n = 5)	0.60 ± 1.34	1.20 ± 0.84 [4]	0.90 ± 1.10 [5]
Middle School Education Majors (n = 5)	2.00 ± 1.22 [3]	0.00 ± 2.00	1.00 ± 1.89

[1-5] statistically significant difference (paired t-Test, $p < 0.05$)

The Special Education majors had significantly higher post-post-test scores than pre-test scores for both the Cloning scenario and overall. The Middle School Education majors had significantly higher post-post-test scores than pre-test scores for the Genetic Modification scenario. Both of these findings were based on paired t-tests ($p < 0.05$). This may be a reflection of the common personalities for these chosen fields. Special Education majors likely need to be more empathetic and may respond more strongly to a scenario involving human life. Middle School Education majors reflected growth in moral sensitivity through the Genetic Modification scenario paralleled what was seen previously by Fowler et al., (2009).

Discussion and Implications

The smaller number of participants in this study limits the generalizations that can be drawn, but some results were notable. A single, unintegrated SSI resulted in an increase in the moral sensitivity scores of preservice teachers compared to non-education majors. Furthermore, male preservice teachers in the treatment group showed significant improvement in their moral sensitivity, compared to their female counterparts and comparison males. Overall, female preservice teachers showed significant regression in their moral sensitivity, compared to their male counterparts, but less regression and a greater percentage of progression than their female comparison group. These results suggest that a single SSI has the potential to positively affect the moral sensitivity of preservice teachers, with more profound changes seen in males. A greater sample set with results obtained from more than two semesters would help to support and generalize this conclusion. Additionally, it is reasonable to assume that the preservice teachers' exposure to NOS could account for some of the positive changes observed.

While it has been demonstrated previously that the treatment group males demonstrated greater progression compared to the treatment group females (Clarkeburn, 2002), no reasoning was provided. We hypothesize that the gender differences arose from a combination of testing fatigue and inherent gender differences in empathy (Christov-Moore et al., 2014). All of the students potentially remembered the test scenarios, and determined that their initial answers were not sufficient. This may have resulted in the regression observed in the treatment group females, compared to the progression observed in the treatment group males. Due to inherently greater empathy, the female students initially provided more moral consideration, and when given the post-test, may have decided they needed to provide more matter-of-fact considerations. While the male students initially provided few moral considerations, when given the post-test, they may have decided they needed to provide more moral consideration. Future studies should include an interview component in order to determine if testing fatigue contributes to these findings.

For the 10 preservice teachers exposed to the second integrated SSI based on the Flint Water Crisis, they showed clear gains in moral sensitivity after the exposure, although it is not clear whether the significant improvement in the moral sensitivity is due to the second SSI, the integrated nature of the SSI, the continued exposure to NOS, or some combination. Further studies could be done to separate these variables in order to measure their impact.

It has been shown previously that several SSI integrated throughout a science course, with discussions and assignments linking the ethical concerns, significantly improved the moral sensitivity of college students (Clarkeburn, 2002) and high school students (Fowler et al., 2009). However, it was not clear from those previous studies at what point in the ethics intervention the change was affected. This study provides some insight into the effectiveness of even one SSI, regardless of context, on development of moral sensitivity for preservice teachers. Although, the improvement from the first, unintegrated SSI was not significant, it was clear that the second, integrated SSI did have a significantly positive effect on the development of moral sensitivity in preservice teachers. While these findings cannot be generalized for all students, it seems possible that even one SSI can help develop moral sensitivity of students in science-based courses.

Conclusions

The development of scientific literacy is an important factor allowing people to interact with and contribute to difficult issues that mix science with society. Developing students' moral sensitivity increases their ability to negotiate solutions involving SSI. This study demonstrated the effect on the moral sensitivity of preservice teachers of one unintegrated SSI followed by a second, integrated SSI. The measure of change in moral sensitivity was obtained using a pre-test, post-test model, using the TESSplus. In response to the first SSI, the test group of preservice teachers had greater progression of moral sensitivity compared to the comparison group, with significant progression observed in the male test group participants. In response to the second SSI, the preservice teachers saw a significant progression of moral sensitivity compared to their original scores. These results suggest that student exposure to even one SSI in a science course can help develop their moral sensitivity.

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Appendix 1: *Italian earthquake SSI assignment*

Name _____

Thoroughly answer (at least 1-2 paragraphs each) the questions that follow after reviewing some of the tenets of the Nature of Science from Lab 1. From http://www.project2061.org/publications/sfaa/online/chap1.htm

THE SCIENTIFIC WORLD VIEW

Scientists share certain basic beliefs and attitudes about what they do and how they view their work. These have to do with the nature of the world and what can be learned about it.

- The World Is Understandable
- Scientific Ideas Are Subject To Change
- Scientific Knowledge Is Durable
- Science Cannot Provide Complete Answers to All Questions

SCIENTIFIC INQUIRY

- Science Demands Evidence
- Science Is a Blend of Logic and Imagination
- Science Explains and Predicts
- Scientists Try to Identify and Avoid Bias
- Science Is Not Authoritarian

THE SCIENTIFIC ENTERPRISE

- Science Is a Complex Social Activity
- Science Is Organized Into Content Disciplines and Is Conducted in Various Institutions
- There Are Generally Accepted Ethical Principles in the Conduct of Science
- Scientists Participate in Public Affairs Both as Specialists and as Citizens

Questions:

1. What is the job of a scientist? Try to answer in a general way, but then provide details to explain further.
2. Did the scientists in this overall story perform their job? Explain.
3. Assume that the people's expectations of the scientists were reasonable. Try to find 3 points to support this view.
4. Assume that the people's expectations of the scientists were unreasonable. Try to find 3 points to support this view.
5. Were the people's expectations of the scientists reasonable? Why or why not and how or how so?
6. If the conviction stands upon appeal would this be good or bad for science? Attempt to explain using your understanding of science and other scientists like doctors or economists.
7. Why is it important for society to be scientifically literate (that is understand the tenets of the Nature of Science)?