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A Longitudinal Comparison of Sustainability Learning between Men and Women in Engineering and Nursing Programmes

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Abstract: For many years, Higher education institutions have been engaging with sustainability, many focussing on environmental ones. In this context, two phenomena have arisen that have, usually, been studied separately: (1) engineering schools have been at the forefront of sustainability efforts; and (2) women have tended to be more concerned about of environmental sustainability than men are. This paper is aimed at analysing the differences in perception between engineering students and nursing students at the University of Gävle, Sweden. Engineering and nursing programmes are practice-oriented with different foci on sustainability and usually being dominated by male and female students, respectively. The data for this article were based on two surveys carried out during 2010 and 2013, in which the same students answered the same questions at the beginning and at the end of their studies. Principal component analysis and regressions were carried out to analyse the survey answers. The results show that engineering programmes and gender affect actions positively. The results also show that engineering students increased their sustainability performance significantly more than nursing students. To improve environmental sustainability, it is important to promote the presence of women in engineering schools, and at the same time, social science oriented programmes (such as nursing) could learn from the efforts and action taken by engineering schools, so that sustainability is taught and learnt in a more holistic way.

Keywords: student attitudes; engineering programmes; nursing programmes; environmental sustainability; University of Gavle; student survey; higher education; gender; longitudinal study

1. Introduction

Higher education institutions (HEIs) have been engaging with sustainability issues, many focussing on environmental ones, during the last two decades [1]. A key element in this process has been has been the incorporation of sustainability goals in programme descriptions and course syllabuses [2,3], which is dependent on the school, or faculty, discipline (as discussed by Lozano [3]).

The way that sustainability is being incorporated into curricula has a direct effect on students' attitudes during their courses, in everyday life and, potentially, in their professional life [4]. Attitudes can be categorised as: informational or knowledge (beliefs and information); emotional or awareness (such as feelings and affections); and behavioural (i.e., actions) (as discussed by Luthans [5]). For an individual to change, there needs to be congruence between the informational, the emotional, and behavioural attitudes [6].

Within the incorporation of sustainability into curricula and teaching, two phenomena have been observed that have, usually, been studied separated. Firstly, engineering schools have been at the forefront of sustainability efforts, focussing mainly on environmental issues, for example the convergence of students' sustainability perception and the inclusion of sustainability in course

objectives [7]. In the Watson et al. study [7], environmental sustainability was more prominent in the curriculum and the students' behaviour, while social and economic sustainability were much less. It should be noted that, in general, there have been more men enrolling and finishing engineering degrees than women [8,9].

Secondly, women have tended to be more concerned about of environmental sustainability than men [10,11]. For example, women generally are more "environmentally aware" than men [11]. Other studies show that a difference between the genders regarding attitudes towards sustainable development is already displayed in the elementary school [10]. A discipline that has, traditionally, been female dominated is nursing.

Engineering and nursing tend to be practice-oriented and both emphasize professional ethical guidelines [12]. This makes the two disciplines suitable for comparing changes in attitudes towards sustainability.

Although there have been some studies comparing the content of sustainability in curricula [10,11], they have not controlled for gender. This paper is aimed at analysing the differences in perception between how an engineering students and nursing students change their knowledge, awareness, and action on sustainable development during their studies, while controlling for the effects of gender.

2. Methods

The paper is based on two surveys at the University of Gävle, Gävle, Sweden. The University of Gävle was the second Swedish university to obtain the ISO 14001 certification [13]. The university's vision is to have a leading position in education and research for a sustainable human living environment [14]. The university is a middle-sized institution with around 17,000 students and 700 staff. It is divided into three faculties: (1) engineering; (2) health and social work; and (3) business and education. This study focusses on the first two, since they have been engaged with the environmental and social dimensions of sustainability, respectively. Traditionally, engineering has been male dominated, while nursing has been female dominated.

In 2013 for all Swedish universities, women were awarded 28 per cent of the degrees in Engineering, and 86 per cent of the degrees of the nursing degrees [15]. The skewed balance between the genders is reflected in the sample of this study (see Table 1).

Table 1. Description of the sample.

Programme	Reg. 2010	Replies 2010	Replies 2013	% of Replies 2010	% of Reg. 2010	Same Students as in 2010	Compl. Replies	Fem.	Male
Computer eng. (Sw)	12	12	7	58	58	2	2	0	2
Computer eng. (Intl)	22	15	17	113	77	7	4	3	1
Electronics eng. (Sw)	9	9	7	78	78	4	4	0	4
Ind.eng and mgm. (Sw)	14	13	12	92	86	9	7	5	2
Mechanical eng. (Sw)	13	11	9	82	69	6	6	1	5
Nursing (Sw)	81	62	70	113	86	39	38	31	7
Ind. Mgm. and logistics (Sw)	24	22	12	55	50	12	10	3	7
Ind. Mgm. and logistics (Intl)	35	30	19	63	54	16	15	13	2
Building eng. (Sw)	35	27	19	70	54	14	14	5	9
Energy syst. eng. (Intl)	28	15	16	107	57	10	8	6	2
Total	273	216	188	87	69	119	108	67	41
With sustainability courses							47	27	20
Without sustainability courses							61	40	21
With sustainability courses (%)							47	57	43
Without sustainability courses (%)							61	66	34

In Sweden, the Higher Education Ordinance is a national policy document that links the Higher Education Act and the demands educational institutions must follow. The Higher Education Ordinance is subordinate to the Higher Education Act, which governs all universities in Sweden. For examination in a degree programme, the students must meet all the objectives specified in the Higher Education Ordinance [16].

In the Higher Education Ordinance, there are two objectives for the degree of Bachelor of Engineering which are directly related to sustainable development:

(1) Competence and skills: The student must demonstrate the ability to design and manage products, processes and systems regarding human conditions and needs and society's objectives for economically, socially, and ecologically sustainable development; and
(2) Judgement and approach: The student must demonstrate insight into the possibilities and limitations of technology, its role in society and the responsibility for its use, including social and economic aspects, as well as environmental and safety aspects.

For nursing degrees, the Higher Education Ordinance does not specify any objective that is directly related to environmental sustainability, although several objectives are related to social sustainability [16].

The empirical data for this article was based on two surveys at the University of Gävle, carried out during 2010 and 2013. The same students answered the same questions at the beginning of their studies and at the end of their studies. The complete results from the two surveys can be found in Sammalisto et al. [4]. The survey was tested in a small group of students before it was distributed to the selected programmes. Anonymity was guaranteed to all students, even though individual answers were needed to be identified in order to allow comparison with the other survey. The students were also informed that by answering the survey they would be included in a research study. The students were selected from engineering programmes at the school of engineering and from the nursing programme at the School of Health and Social Work. The programmes were originally selected to allow comparison with equivalent programmes at another university [4]. The survey was distributed during a lecture to obtain as high a response rate as possible. Although the response rate was high for the surveys (see Table 1), there was some loss of usable responses since some students did not respond to both questionnaires, due to as absenteeism, quitting their studies, or not answering all the questions. Overall, there were 108 complete responses obtained from engineering and nursing students who responded to both surveys. Table 1 shows the composition of students, response rates, credits in sustainable development, and gender of the respondents.

The surveys had two background questions (programme and gender), and three groups of questions concerning sustainable development: knowledge (with three questions), awareness (with five questions), and action (with eight questions). In all sixteen questions, students were asked to choose an option on a five-point Likert scale from "strongly disagree" to "strongly agree". The questionnaire was developed by two students as part of their master thesis [17]. The questionnaire can be found in the Appendix A.

The data were analysed using IBM SPSS 22 [18] statistics software, and the following statistical analysis methods were used: principal component analysis, correlations, and linear multiple regression.

Principal Component Analysis

Since it would have been impractical to use all sixteen variables in the analysis, the number needed to be reduced. This was done by using principal component analysis. Principal component analysis is based on the correlations between the variables and the analyses of the variables can be reduced to one or more variables, or so-called principal components [19]. The principal component analysis was done individually on the three knowledge items (see Table 2), the five awareness items (see Table 3), and the eight actions items (see Table 4). The reason for carrying out individual principal component analyses for the three sets of items, instead of one with all items in the same analysis, was that the three dimensions are theoretically distinct, yet highly related [6]. The aim was, thus, not to prove the discriminant validity between the dimensions. The items are presented in the questions in the Appendix A.

The analyses were first done for 2010 and then for 2013, i.e., a total of six principal component analysis. For the actions variables, two questions were removed from the analysis because they did not

meet the requirement of convergence with the other items. For the awareness variables, one question was removed for the same reason. As a criterion for selecting the number of components in the solution, an eigenvalue over 1 was required for the year 2013, which resulted in one component for each dimension (i.e., knowledge, awareness and action). The results of principal component analysis are shown in Tables 2–4.

Table 2. Principal component analyses of knowledge.

Items	2010 Loading	2013 Loading
I know a lot about sustainable development	0.85	0.82
The three dimensions of sustainable development are environmental, economic and social	0.72	0.54
I know some documents that deal with sustainable development	0.81	0.81
Total variance explained	63%	63%
Cronbach alpha	0.70	0.70

Table 3. Principal component analyses of awareness.

Items	2010 Loading	2013 Loading
A huge population puts a lot of pressure on the earth's resources	0.53	0.79
It is urgent to protect fresh water resources from pollution	0.59	0.76
The choice of personal lifestyle (e.g., saving water and electrical energy. waste recycling etc.) can make a contribution to sustainable development	0.79	0.89
Studying about sustainable development can promote sustainability	0.68	0.79
Total variance explained	43%	65%
Cronbach alpha	0.51	0.81

Table 4. Principal component analyses of action.

Items	2010 Loading	2013 Loading
I sort my waste	0.48	0.61
I buy second hand (e.g., clothes. furniture. etc.)	0.70	0.57
I talk with my family or friends about the current environmental situation	0.59	0.69
I try to save water, for example, when I take a shower	0.74	0.72
I attend activities about sustainable development (e.g., lectures about sustainable development)	0.72	0.80
I use public transportation	0.54	0.49
Total variance explained	40%	43%
Cronbach alpha	0.70	0.72

Although some individual values (such as waste sorting in 2010, public transport in 2013, and the Cronbach alpha for awareness in 2010) were lower than desired, the principal component analysis showed that there was a clear convergence between the different variables for each category, and that it was, therefore, possible to reduce the number of variables to three: knowledge; awareness; and action.

To ensure that all input variables are given equal weight in the composite variable for both years, an index was used instead of the principal components. The index was developed as the sum of input variables divided by the number of input variables, where the changes in the three indices are key for understanding the effects of education. Three change variables were constructed so the change in knowledge was equal to the knowledge index 2013 minus the knowledge index in 2010, and the equivalent for awareness and action. Three extreme values (student outliers) in sustainability awareness were replaced with the average value. These three students showed extremely low levels

of awareness in 2013 for all five questions in the category although they indicated in line with the mean value (that is, high, 4–5) 2010. Table 5 summarises all variables used in the correlation and regression analyses.

Table 5. Survey variables.

Interval Scale Variables	Min	Max	Mean	Std. Dev.
SD knowledge 2010 index	1	4.33	2.96	0.71
SD knowledge 2013 index	1	5	3.39	0.76
Change in SD knowledge	−2.67	3.33	0.42	0.92
SD awareness 2010 index	3.25	5	4.56	0.42
SD awareness *t* 2013 index	3.75	5	4.69	0.36
Change in SD awareness	−1.75	1	0.14	0.45
SD actions 2010 index	1.5	4.5	2.83	0.67
SD actions 2013 index	1.17	4.5	2.86	0.70
Change in SD actions	−3.59	3.31	0.00	1.08
Categorical Variables				
Percentage of engineering students	65%			
Percentage of women in all programmes	62%			

The correlation between the variables is shown in Table 6. There were strong correlations between: (1) how students responded in 2013 and 2010, which shows that it is important to be able to control for the input values when the effects of an education is evaluated; (2) the changes in knowledge, awareness and behaviour, as well as a strong correlation between engineering education and gender (the latter is mainly due to nursing education having a larger proportion of women); and (3) gender and engineering education, and the three types of knowledge/skills in sustainable development. The correlation analysis did not include control variables, thus major conclusions on their relationships cannot be confirmed. In this case, it is almost impossible to determine whether engineering education more often correlates with sustainability depends on the programme as such, or if that there were fewer women in the group.

Table 6. Variables correlations.

Variable	1	2	3	4	5	6	7	8	9	10 [1]
1. SD knowledge 2010 index	-									
2. SD knowledge 2013 index	0.29 **	-								
3. Change in SD knowledge	−0.56 **	0.61 **	-							
4. SD awareness 2010 index	0.24 *	0.20 *	−0.03							
5. SD awareness *t* 2013 index	0.24 *	0.30 **	0.06	0.36 **	-					
6. Change in SD awareness	−0.03	0.05	0.08	−0.66 **	0.46 **	-				
7. SD actions 2010 index	0.54 **	0.28 **	−0.19	0.38 **	0.17	−0.22 *	-			
8. SD actions 2013 index	0.34 **	0.54 **	0.19	0.12	0.21 *	0.06	0.44 **	-		
9. Change in SD actions	−0.23 *	0.23 *	0.42 **	−0.25 *	0.03	0.26 **	−0.54 **	−0.49 **	-	
10. Percentage of engineering students	0.22 *	0.40 **	0.14	0.32 **	0.04	−0.29 **	0.16	0.14	−0.01	-
11. Percentage of women in all programmes	0.09	−0.05	−0.15	0.06	0.21 *	0.06	0.21 *	0.37 **	0.16	−0.30 **

* $p < 0.05$, ** $p < 0.01$, Pearson correlation, except [1] which is Spearman correlation since they are categorical variables.

3. Results

A multiple linear regression analysis was done to compare the differences in perceptions for the programmes and gender, where the independent variables of main interest (the programme the students attended and gender) were measured by a one or a zero. A value of one meant that the students attended an engineering programme, while a value of zero meant the nursing programme. For gender, a value of one indicated a female student, and a value of zero indicated a male student. As dependent variables, the following variables were used: change in knowledge (columns 1 and 2 in Table 7), change in awareness (columns 3 and 4 in Table 7) and change in actions (columns 5 and 6 in Table 7). The changes in the variables, rather than their absolute level, were measured in order to evaluate the effects of the education.

The analysis controlled for the correlation between knowledge, awareness, and behaviour. When the effects on change in knowledge was tested (columns 1 and 2 of Table 7), the level of awareness and actions at the beginning of the studies (i.e., in 2010) was controlled for. The level of knowledge at the beginning of the studies was already included as the dependent variable the change in knowledge (2013 value minus the value 2010) and, therefore, needed no control variable. The results of the regression analysis are shown in Table 7.

The results in Table 7 shows the effects on sustainability knowledge, awareness, and actions. In terms of knowledge, the F value of the model was not significant and, therefore, no definitive conclusions from the model can be drawn. For the change in sustainability awareness, engineering students performs correspondingly 23 percent lower than nursing students. F value for this model is significant at the five percent level, and R^2 increases significantly when the "engineering" variable is included. For change in action, the F value is significant at the one percent level, and the explanatory power of the model also increases significantly (change in R^2) when the variable "engineering" is included. An average student of engineering education programmes increases their actions by 22% more compared to an average student in the nursing programme.

Table 7. Results of the models.

Dependent (to the Right)	Change in Knowledge		Change in Awareness		Change in Actions	
Independents (below)	Model 1	Model 2	Model 1	Model 2	Model 1	Model 2
Control variables						
Gender (women = 1)	−0.01	0.07	0.14	0.06	0.22 *	0.29 **
Knowledge 2010	-	-	0.13	0.16	−0.19 *	−0.22 *
Awareness 2010	0.05	−0.02	-	-	−0.22 *	−0.28 **
Actions 2010	−0.21 †	−0.24 *	−0.31 **	−0.23 *	-	-
Engineering		0.24 *		−0.23 *		0.22 *
Model statistics						
R^2	0.04	0.08	0.08	0.12	0.14	0.18
Adjusted R^2	0.01	0.05	0.05	0.09	0.11	0.14
Change in R^2		0.05 *		0.04 *		0.04 *
F value	1.38	2.32 †	2.85 *	3.47 *	5.61 **	5.46 **

** $p < 0.01$; * $p < 0.05$; † $p < 0.1$; $N = 108$.

The explanatory power of the models was not high, as R^2 peaked at 0.18 for the second model in the action variable. This means that most of the variation in the outcome depends on factors other than those included in the models. This was due to other elements that may affect change in students' actions over three years than any knowledge or skills they had when they started the programme and the application and gender they have. To ensure the validity of the analysis, the distribution of the residuals it (i.e., what remains and is not explained by the model) were checked for randomness. The residuals for all models met this criterion. Multi-collinearity was checked by measuring the "variance inflation factor", which was constantly below two. A level over ten is usually considered to

indicate problems [20]. The results show that engineering education is associated with an increase in the action of sustainability actions, while nursing is associated with an increase in awareness of sustainability.

With regards to gender, there was a strong positive relationship to changes in actions, which means that women perform significantly higher on this variable, as shown in the regression, but not in the correlation in Table 6. The discrepancy was due to women being overrepresented in nursing programmes, which in turn has significantly lower degree of change in actions than engineering programmes (Table 7). These two effects cancelled each other, and thus, in the correlation table there was no significant relationships between changes in actions and whether gender or engineering degrees. From this, two conclusions can be drawn: (1) it is important to have adequate control variables and not to rely on correlation analyses; and (2) a female student in an engineering programme would, statistically, most likely increase her sustainability performance.

4. Discussion

This study assessed how student attitudes towards sustainable development in terms of how knowledge, awareness, and actions changed in the three years between engineering and nursing students. The results showed that engineering students increased their environmental sustainability actions significantly more than nursing students, while the opposite applies for awareness of environmental sustainability. Engineering and nursing programmes are practice-oriented and, thus, can lead to behavioural changes, since it would be expected that a degree's objectives would have an impact on results. Environmental considerations were strongly emphasised in engineering education and engineering students changed their sustainability actions significantly more than nursing students. Nursing students, on the other hand, changed their sustainability awareness more than engineers. The explanation for this is not clear, but the results could be an effect of the scales in the survey. Engineering and nursing students, on average, showed extremely high levels of sustainability awareness with mean values above 4.5, on a scale from 1 to 5, and very low standard deviations (Table 6). Knowledge and actions has mean values closer to the centre of the scale.

Previous research has shown that there are considerable differences between the different programs when measuring individual dimensions of sustainability [3]; however, the differences tend to disappear if sustainability is assessed in all three dimensions: social, environmental, and economic. Since only environmental sustainability was assessed, then the results are in line with the first part of Lozano's study [3]. Environmental sustainability was the dimension that objectives in engineering programmes mainly emphasised, which is also in line with the study by Watson et al. [7], since these authors reported a clear link between the programme objectives and how the students looked at sustainability, which our study confirms.

Previous studies [10,11,21] showed that gender plays a role in attitudes towards sustainable development, where women tend to perform better than men do. This paper confirms this and demonstrates the need to check for gender when comparing programmes where one gender is significantly over- or under-represented. A comparison between the two programmes may miss vital information if gender is not considered.

5. Conclusions

Higher education institutions have been incorporating sustainability into their programmes for the last two decades. Most of the efforts have focussed on environmental sustainability, where two phenomena that have appeared have been studied separated: (1) engineering schools have been at the forefront of the efforts; and (2) female students have tended to be more environmentally focussed.

This research investigated the change in sustainability attitudes (knowledge, awareness, and actions) between engineering and nursing students at the University of Gävle. The study assessed student attitudes in the beginning and at the end of the studies. The study controlled for gender when comparing education programmes. The results showed that engineering students have increased their

sustainability actions significantly more than nursing students. The study also showed that women increase their actions significantly more during their studies than men. Other factors, such as education and culture, may also affect the outcome of sustainability learning.

Traditionally, engineering and nursing have been practice oriented and have been dominated by one gender (in the case of the former by males, and for the latter by females). Each discipline has had, given their context, different foci on sustainability; engineering has been more environmentally focussed, while nursing has focussed on social issues. This presents a paradox, where female students tend to be more environmentally focussed but do not choose disciplines that have been at the forefront of environmental sustainability (such as engineering).

To improve environmental sustainability, it is important to promote the presence of women in engineering schools, and at the same time, social science oriented programmes (such as nursing) could learn from the efforts and action taken by engineering schools. Nursing schools can learn how to address environmental issues from engineering schools, and at the same time, engineering schools could learn how to address social issues from nursing schools.

Further studies can give examples of how social sustainable development can be better implemented in engineering or nursing programmes.

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Author Contributions: Robin von Haartman and Per Blomqvist conceived the idea for the paper and wrote an early version of the paper. Robin von Haartman conducted the statistical analysis and wrote the methodology and results sections. Kaisu Sammalisto designed, supervised, and managed the questionnaire and data collection, as well as provided feedback for the manuscript. Rodrigo Lozano structured the paper and co-wrote large parts of the introduction, discussion, and conclusions.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Sustainable Development Questionnaire

The University of Gävle educates leaders for the future who can include sustainable development in their activities. We are interested in your opinions so please fill in the following questionnaire. We asked you to complete the questionnaire at the beginning of your studies.

Name:
E-mail:
Bachelor program:
You are A. Female B. Male

1. **Do you agree with the below statements?** Grade them on a scale from 1 to 5.
1. Strongly disagree; 2. Disagree; 3. Undecided; 4. Agree; 5. Strongly agree

(a) I know a lot about sustainable development.
(b) The three dimensions of sustainable development are environmental, economic and social.
(c) I know some documents that deal with sustainable development.

2. **Do you agree with the below statements?** Grade them on a scale from 1 to 5.
1. Strongly disagree; 2. Disagree; 3. Undecided; 4. Agree; 5. Strongly agree

(a) A huge population puts a lot of pressure on the Earth's resources.
(b) It is urgent to protect fresh water resources from pollution.
(c) The choice of personal lifestyle (e.g., saving water and electrical energy, waste recycling, etc.) can make a contribution to sustainable development.
(d) Reports of damage that people cause to the environment are exaggerated.

(e) Studying about sustainable development can promote sustainability.

3. **How often do you do the following to contribute to sustainable development?**
1. Never; 2. Seldom; 3. Sometimes; 4. Often; 5. Always

(a) I sort my waste.
(b) I buy second hand (e.g., clothes, furniture, etc.).
(c) I talk with my family or friends about the current environmental situation.
(d) I try to save water, for example, when I take a shower.
(e) I attend activities about sustainable development (e.g., lectures about sustainable development)?
(f) I print reading materials from my computer.
(g) I use disposable products.
(h) I use public transportation.

The results from the survey will be used in research.

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