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Teaching Sustainable Development and innovation in Engineering Education: Students' perception

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INTRODUCTION AND BACKGROUND

According to Fullan [1] (p. 6) "the education system was thought to be one of the major societal vehicles for reducing social inequality". The educational system has evolved, adapting to economic and technical requirements. The awareness of the physical and natural limits of the planet leads to a new evolution.

Wright [2] studied multiple international declarations that refer to the need to include Sustainable Development (SD) across the curriculum and to develop interdisciplinary and transdisciplinary research as well as public outreach. Sterling [3] (p. 806) argued that "the sustainability does not simply require an 'add-on' to existing structures and curricula, but implies a change of the fundamental epistemology in our culture and in our educational thinking and practice [...], sustainability is a gateway to a different view of curriculum, of pedagogy, of organizational change...".

We adopted the traditional definition of SD, from the Brundtland Report [4] that specifically emphasizes the requirement to "meet the needs of the present without compromising the ability of future generations to meet their own needs." SD is a challenge for the future for which the higher education institutions should contribute.

Two themes of education science are presented in this section: the first one is the integration of SD in higher education. The second one is about SD and educational innovation.

Lozano et al. [5] presented five main approaches for integrating SD into higher education curricula: i) coverage of some environmental issues in an existing course or courses; ii) a specific SD course; iii) SD intertwined as a concept in regular disciplinary courses; iv) SD as a possibility for specialization within the framework of each faculty; v) SD as an undergraduate or post-graduate program. So, integrating SD approaches differ from one institution to another.

Van Bellen [6] explained that the measure of sustainability must establish a connection from past to present and from present to future. Sustainability is a process of perpetual adaptation and actions should concern the three pillars. Moldavska and Welo [7] insist on the fact that the three pillars of SD should be addressed equally. Here, we focus our attention on how teaching could be transformed in order to be in adequacy with the global aim of SD.

There are tools for evaluating integration of academic SD initiatives in universities. Most studies are focused on the environmental pillar [8], [9]. Olszak [10], integrated economic and social pillars. Urbanski and Rowland [11] evaluated academic SD initiatives by using “STARS as a multi-purpose tool” in the campus sustainability movement. This tool was released by the Higher Education Associations Sustainability Consortium (HEASC) in 2006, and “would address all the dimensions of sustainability and all the sectors and functions of a university”. This type of tool evaluates the “sustainability performance” of colleges and universities, without understanding how different performances are achieved.

On the basis of this statement, our hypothesis is that the implementation of SD in a higher education engineering school, should lead to educational innovation, taking into account its relationship with research.

Since 2000, many studies have dealt with sustainable development and innovation, technological transitions, based on the idea that innovation is a key factor for SD [12]. Conceptual work has dealt with SD for engineers [13], [14], [15], [16]. The relationship between sustainable development and teaching innovation has been explored [17], [12].

It appeared necessary to think about the integration of SD in educational programs as well as innovation for a sustainable educational system [13], [18].

In education, the study of each stage of incremental transformation becomes a strategic priority for the integration of SD [16]. The change should begin with the educational leaders and then spread to the teaching staff. Our research question is: What are the students' perceptions about the value of integrating Sustainable Development and innovation into the curriculum?

Therefore, this communication presents previous SD research and a review context in Section 2; the research methodology is described in Section 3. The students' perceptions about the integration of SD and educational innovation in their academic field (UniLaSalle Beauvais) are presented in Section 4. Some conclusions are drawn in Section 5.

1 PREVIOUS SD RESEARCH AND REVIEW CONTEXT AT UNILASALLE

Since 2009, French institutions of higher education have engaged in the integration of SD in their strategies actions. The Conference of University Presidents (CPU) and the Conference of higher education (CGE) proposed the Green Plan (Article 55 of 3 August 2009 of the Grenelle 1 law) and the integration of sustainability in higher education.

We present a case study at “Institut Polytechnique UniLaSalle¹” focused on the education of engineers. UniLaSalle aims to train young engineers or managers in fields directly

¹ In January 2016, the « Institut Polytechnique LaSalle Beauvais », a French engineering school, merged with another higher education engineering school (ESITPA, Rouen). Both campuses (Beauvais and Rouen) have a common name: UniLaSalle (www.unilasalle.fr). This communication describes the students' perception of the Beauvais campus. It is an extension of a study released on the perception of the executive management and curricula manager's teams (2016-2017).

concerned by SD. The teaching of SD at UniLaSalle is adapted to the nature of each specialty² (Agriculture, Nutrition and Health, Geology and Environment). SD approach is integrated in UniLaSalle at three levels: campus life, teaching and research. UniLaSalle decided to be part of the pioneers to use the self-evaluation referential as a guide to build its action plan [19].

In recent years, the executive management team believed that “sustainable strategies within an engineering school is a holistic approach which links governance and strategy, teaching and research and campus life. It is a work at both individual and institutional levels concerning all dimensions of sustainability” [19] (p. 233).

In this context, as presented in a previous article [19], the question was: how to place an integrated approach of SD in the strategy of UniLaSalle? This article focused on the study of sustainability by using two perspectives: integration and evaluation by the executive management team.

Fourati-Jamoussi et al. [20] extended this idea of sustainability through the perception of the executive management and curricula managers' teams. A qualitative methodology [22] was chosen, based on the case study of UniLaSalle. Data were collected from 27 semi-structured interviews (during 45 min) with two groups: the executive management and the curricula management teams. The interview guide was built on six themes/questions: i) what is the definition of innovation in engineering education? ; ii) what are the different types of innovations? ; iii) what are the reasons to innovate at UniLaSalle? ; iv) what is the definition of SD? ; v) what are the reasons for integrating SD in the engineer training? ; vi) what is the link between SD and innovation in engineering education?

The results of this study are accepted for a publication [21] and can be summed up as follows:

- i) The reasons for integrating innovation in the engineering curriculum at UniLaSalle: The executive management team is more concerned by the issue of global environment and the evolution of education while the curricula management team looks for the best compromise between companies' needs and students' needs and wants.
- ii) The reasons for integrating SD in the engineering curriculum: According to the executive management team, the first reason for integrating SD is to train Responsible Engineers. The curricula management team, in charge of professional-qualification modules, precisely focusses on an ethical dimension. Regulatory and environmental issues are also important for this group.
- iii) The perceived pillars of SD: An important element of previous results is the emergence of a fourth pillar. Three respondents insisted on this fourth dimension and affirmed that the governance of energy and mineral resources is specific and different from environmental issues which are more connected to the natural living world. This fourth pillar was integrated during the elaboration of the survey submitted to the students. The three pillars, economic/ social and environmental, are well integrated by the executive and curricula management teams.
- iv) The link between SD and innovation in engineering education: SD is now perceived as a stimulus to innovation for the majority of respondents (both teams). SD is considered as a

² In Geology, Agriculture or Nutrition and Health curricula, the challenge of SD is integrated in specific pluridisciplinary courses which describe the challenges from SD requirements in their discipline.

constraint which induces innovation and sometimes as a factor which both promotes and restricts innovation.

The challenge of this work is to study the impact of integrating SD and innovation in the engineering curriculum on the students' perception at UniLasalle.

2 METHODOLOGY

A survey based on four themes was designed in order to compare the objectives of the executive and curricula management teams to the students' perceptions and experience: i) the reasons for integrating innovation in the engineering curriculum at UniLaSalle; ii) the reasons for integrating SD in the engineering curriculum; iii) the perceived pillars of SD; iv) and the link between SD and innovation in engineering education.

2.1 Subjects

291 engineering students (148 female and 143 male; mean age = 21.2, SD = 0.9 years) from three specialties (agriculture, nutrition and health sciences, and geology) participated in the study (Table 1). Data were collected in November 2017.

Table 1. Distribution of population by specialty and sex

		Sex		Total
		Female	Male	
Specialty	Agriculture	59	85	144
	Nutrition and health sciences	51	10	61
	Geology	38	48	86
Total		148	143	291

2.2. Measures

The questionnaire comprises 22 items. Three items concern sociodemographic data (age, sex) and the field of study (specialty). Ten items relate to innovation in the engineering curriculum. On a 5-point Likert scale (1 = not probable to 5 = very probable), students express their opinion about the reasons for integrating innovation in the engineering curriculum at UniLaSalle (eg, to satisfy companies' needs). Four items relate to the integration of SD in the curriculum. On a 5-point Likert scale (1 = not probable to 5 = very probable), students comment on UniLaSalle's reasons for integrating SD in the engineering curriculum (eg, to increase the level of responsibility of the future engineer). Students are then asked about the four pillars of SD (economic, environmental, social, energy & mineral resources). For each pillar, they indicate on a 5-point Likert scale (1 = very rarely addressed to 5 = very often addressed) to which extent each pillar is addressed in their curriculum. On the links between innovation and SD, students have finally to choose one of the following statements: i) SD promotes innovation in the engineering curriculum at UniLaSalle, ii) SD restricts innovation in the engineering curriculum at UniLaSalle or (iii) SD promotes and restricts innovation in the engineering curriculum at UniLaSalle.

3 RESULTS

Out of the ten reasons for integrating innovation in the engineering curriculum at UniLaSalle, the four main reasons put forward by students regardless of their specialty, are (Fig. 1):

- To satisfy the job market's needs
- To satisfy companies' needs
- To adapt training to the engineer's profile
- To improve teaching quality

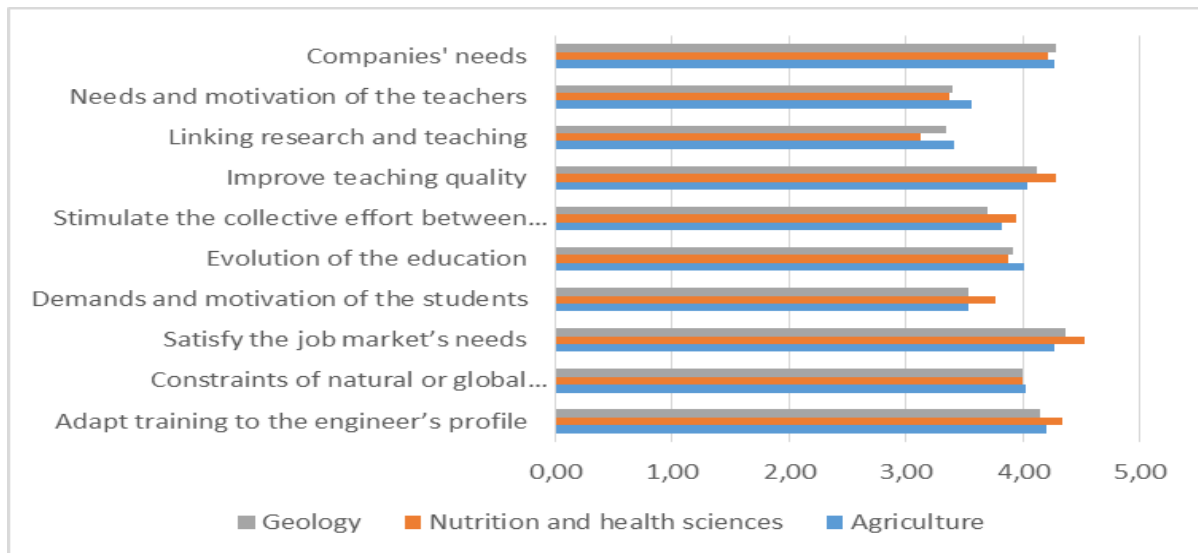


Fig. 1. Students' opinion about the reasons for integrating innovation in the engineering curriculum at UniLaSalle.

Regardless of their specialty students consider the reasons for integrating SD in the engineering curriculum in the following descending order of importance (Fig. 2):

- To allow students to understand environmental and regulatory issues,
- To increase the level of responsibility of the future engineer
- To satisfy European directives
- To take into account an ethical dimension

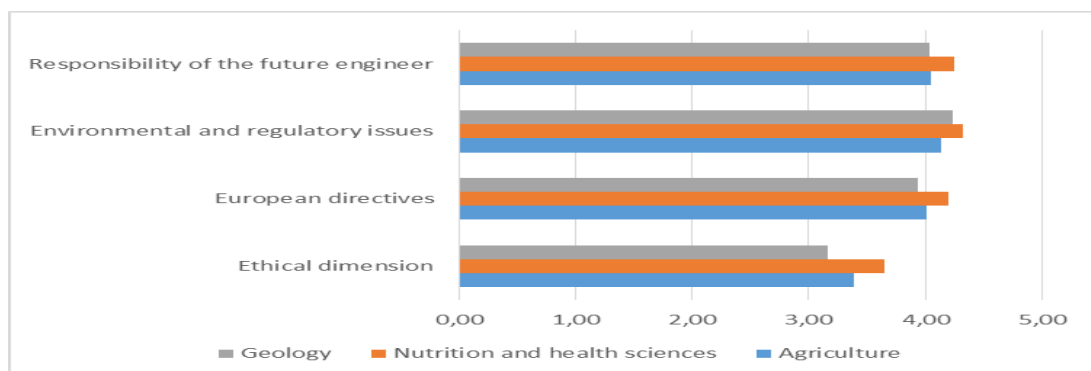


Fig. 2. Students' opinion about the reasons for integrating SD in the engineering curriculum at UniLaSalle.

Depending on their specialty, students consider that the pillars of SD are not addressed with the same intensity in their curriculum (Table 2). One-way analysis of variance (ANOVA) indicate that significant differences are observed by specialty on the environmental ($F(2, 284) = 12.58, p < .001$) and the energy pillars ($F(2, 284) = 92.16, p < .001$). Tukey's post hoc tests indicate that i) the environmental pillar is more addressed in the geology ($M = 3.85, SD = 1.08$) and agriculture ($M = 3.74, SD = 1.04$) specialties compared to the nutrition and health sciences specialty ($M = 3.00, SD = 1.10$) and that ii) the energy pillar is more addressed in the geology specialty ($M = 4.26, SD = 0.83$) compared to the agriculture specialty ($M = 2.78, SD = 1.18$); it is also more addressed in the agriculture specialty compared to the nutrition and health sciences specialty ($M = 1.96, SD = 0.98$).

Table 2. Student's opinion about the intensity (mean levels) to which each DD pillar is addressed in their curriculum depending on their specialty

	Agriculture (n = 144)		Nutrition and health sciences (n = 61)		Geology (n = 86)	
	M	SD	M	SD	M	SD
Economic pillar	3.73	1.08	3.46	1.20	3.65	1.08
Environmental pillar	3.74	1.04	3.00	1.10	3.85	1.08
Social pillar	3.17	1.10	3.47	.97	3.15	1.05
Governance energy and mineral resources pillar	2.78	1.18	1.96	.98	4.26	0.83

Finally, 66% of the students consider that SD promotes innovation in the engineering curriculum, 30% consider that SD promotes and restricts innovation in the curriculum. Only 4% assess that DD restricts innovation in the engineering curriculum at UniLaSalle. The result is the same for the three specialties.

4 DISCUSSION AND CONCLUSION

We can notice that the students' answers are converging with those of the curricula management team. Most of the students think that SD is a factor of innovation in their curricula. Depending on their specialty the different pillars of SD are not treated with the same intensity.

The speciality of our future engineers (Table 2) has a strong influence on their perception of the three pillars of SD and the fourth pillar on the governance of energy and mineral resources. Differences in the perception of the SD pillars integration between the specialties can be linked to their respective curricula [9] and corresponding work experience. The role of training and the need to balance the integration of the four pillars in the different curricula suggest differentiated actions according to the specialties. This study can help curricula management team and teachers to identify the dimensions of SD that need to be strengthened, as well as the implementation of specific resources and tools for teachers to innovate in training and to be aware of the reasons for innovation at the institutional level. It can be described according to different formalized situations and implies a change in the relationship between students, their involvement, and the teacher.

When a strategy for innovation and SD is implemented in training at all levels of the institution, from the executive management to curricula managers, this study shows that students also feel concerned by this visionary approach (eg. Figures 1 and 2).

The results of the link between SD and innovation showed that 66% of the students consider that SD promotes innovation in the engineering curriculum and 30% consider that SD promotes and restricts innovation in the curriculum, so we can confirm that the implementation of SD in a higher education engineering school is perceived as and should lead to educational innovation.

The internal variability of responses in each specialty appears surprisingly high. This may be due to an internal heterogeneity in the population for each specialty: eg. the different parents' level of education and socio-professional categories. A stratification approach (cluster analysis) could be set up and may show that the specialties are not the most important criteria.

This particular reflexivity, both from staff, curricula managers and students, can bring valuable insights in the support for any engineering institute that wishes to incorporate more social responsibility in its own development. It can also promote training and research as a vector for alignment of the job market's needs with the knowledge and skills acquired by future engineers.

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