What happened to the Industrial Ecologist alumni? A survey of occupations, activities, competences and skills

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Abstract

A number of think tanks in Europe states that there is a need for a new type of engineer that is able to assist industry to reroute linear economic and material flows to circular. These engineers should be systems thinkers for sustainable development, communicative and also be able to take on the leadership for holistic problem solving. In quite a few universities around Europe there are educations in Industrial Ecology that meet these demands. Based on a survey coordinated from Chalmers University of technology of what former Industrial Ecology students work with after they finished their education was conducted during the spring 2015. The survey went out to around 500 Industrial Ecology alumni in the world but mainly in Europe.

The aim of this contribution to the EESD16 is to present the results of the survey and further to contribute with a discussion on how different skills and competences are developed during the Industrial Ecology education which could inspire engineering education in general for future curriculum developments. The aim is also to reflect on the reasons why industry and alumni from Industrial ecology do not find each other.

The preliminary analysis of the survey shows that a large group alumni end up in various research activities rather than working in industry, despite the need in industry and educators hope. The results also indicate that the Industrial Ecology alumni is mainly a LCA practitioner, despite the number of .different Industrial Ecology tools in the toolbox. The results also indicate that a relatively large group is not completely satisfied with their work and the limited amount of systems thinking in their everyday work life.

1 Introduction

European Think tanks discuss the future of industry and stress the need of skills of the workforce for a New economy. In the New economy manufacturing processes are resource efficient and circular rather than linear. This calls for a new type of specialists that have broad generalist abilities based in systems thinking for sustainable development and the ability to link disciplines into whole systems design in creative and collaborative teams (Aldersgate group 2012, IEMA 2014).

1.1 Industrial Ecology and sustainability educations

Industrial Ecology is an interdisciplinary domain of knowledge and can be described as an

approach where energy and material flows in industry and society are put in the context of impact on nature. In the 1990 it was acknowledge that in such approach to industrial design needed an education that could "*bridge the traditional separation between the study of technology and society*" (Jeliniski, Graedle et al. 1992). An industrial ecologist is a profession with a competence to assess and bridge deficiency gaps in sustainable problem solving under pinned by systems thinking (Allenby 2006). The typical practitioner use tools such as LCA and MFA to approach the energy and material flows in society. Industrial ecology is taught at master's level at several universities around Europe since the mid 1990'ies for example Trondheim (N), Delft (NL), Graz (AU), Coimbra (P) and Gothenburg (S).

There are several higher education programs with an environmental and sustainability focus such as environmental programs with both social science and natural science profiles, engineering environmental profiles with focus on industrial processes and business administration programs with focus on CSR. Industrial ecology bridge the traditional environmental and business administration programs by applying systems analysis to environmental, technology, stakeholder and actor understanding. An industrial ecologist have the ability to manage transitions in technology and society towards sustainable development (Cockerill 2013)

The objective of this contribution is to improve the understanding on what constitutes the professional role(s) of Industrial Ecologists. An international survey was directed at Industrial Ecologists aiming to chart their jobs, skills and competences. The aim is further to discuss how IE educational programs match the needs of their professional lives with the ambition to discuss how the results can inspire engineering education in general for future curriculum development.

1.2 Skills and alumni surveys

In the literature on skills for sustainable development several concepts are used to describe skills such as, competencies, capabilities and key competencies. To differentiate between skills and competences a useful description from Wiek and Withcombe is "*a competence is a functionally linked complex of knowledge, skills and attitudes that enable successful task performance and problem solving*" (Wiek, Withcombe 2011).

Skills does not work in isolation but in connection to knowledge and experience. The interest in skills is often connected to alumni surveys and employability, relevance in industry and society and feedback to educational programs (Bootsma &Vermeulen 2011, Hansmann et al. 2010, Hesselbart & Schaltegger 2014). Skills that a change agent for sustainable development need to master are such as to be able to persuade, empower and entrepreneurial skills (Hesserbarth and Schaltegger 2014). They also conclude that educational programs need to balance subject specific, methodological issues, social and personal competences with more traditional and conventional based knowledge. In an alumni questionnaire (Bootsma &Vermeulen 2011) evaluated the alumni skills such as ability to translate theory into practice, debating skills, give and receive constructive critique and motivate collaborators. Argumenting, managing conflicts and negotiation and clear communication where among the skills evaluated in an alumni survey

of environmental professionals (Hansmann et al. 2010).

2 Method

The questionnaire was a web based questionnaire where the link was sent out via e-mail list through program directors and social networks such as Facebook gropes and LinkedIN. The platform used to host the questionnaire was SurveyMonkey. The questionnaire included 60 questions and took 25-30 minutes to complete. The questionnaire was open from mid May to mid June in 2015.

The skills evaluated were communication (oral, reading, writing, speaking and negotiation), academic (analysing, critical thinking, argumenting and change perspective), scientific skills (professional software, calculation, measurement and observation) and personal skills (cooperation, interpretation, self-management, self-learning, managing conflicts, persuade, inspire, empower and decision-making).

2.1 Design of the questionnaire and evaluation

The questionnaire was designed according to two main questions: occupation and important activities in their daily work in order for us to be able to evaluate essential competences and skills of a working Industrial Ecologist. The questionnaire was divided into 4 parts:

1. The first part described the educational background, i.e. year of degree, name of M.Sc. degree, and university. In this first part the respondents were also asked to list their weekly activities and how much time was spent on these.
2. The second parts mapped the extent various general skills they used. One part was identifying where different skills were applied in their working activities (*Activities at work*) i.e. with peer, within the company organisation where they work, the local community, nationally or internationally. The other part was mapping communication, academic, scientific and personal skills, and the respondent were to estimate time spent on each as part of their weekly activities, from <1, <5, <10, <15, <20 and >20 hours a week. For each set of skills, the respondents also rated their level of their comfort with each skill (from highly comfortable, quite comfortable, moderately comfortable, I'm doing fine, and not comfortable at all).
3. The third part of the questionnaire covered the engagement with typical Industrial ecology methods and the time spent using the IE toolbox, cross-disciplinary literacy and the type speciality the respondents perceived that their work required.
4. The fourth part covered the respondent's satisfaction with the amount of systems thinking and perception of whether or not they had an Industrial Ecology-type job.

2.2. Evaluation of the questionnaire

The resulting excel file was imported to Filemaker Pro were the results of the questionnaire were further evaluated by counting, grouping and characterising the respondents' answers. The

answers were in some cases further processed if necessary, i.e. translated histogram information into actual hours where it was useful.

The respondents were categorised based on their application of industrial ecology tools. This was motivated by curiosity and the hypothesis that different skills were important in different types of professional practice. It was also observed that there was a the great variation of tools in use.

3 Results and analysis

The questionnaire is estimated to have reached at least 472 Industrial Ecology alumni and 205 responded. The respondents were 52% male, 43% female and 5% would not state their gender. The respondents generally spoke three languages of which at least two were not their mother tongue. The respondents came from 39 countries all over the world from both industrialised and developing countries where the three most frequent countries were Sweden, Norway and the United States. Most of the respondents (66%) were at the time of the questionnaire employed, 2% was unemployed and 32% did not state any occupation. Among the respondents 25% were consultants, 20% PhD students and 12% were project coordinators or managers. Other occupations include eco-engineering, public servants and entrepreneurs.

3.1 The responses and identified groups

Out of the 205 respondents 156 respondents continued to fill in the questionnaire after the initial starting question. The respondents were grouped into 0, >5, >10, >15 and >20 years of graduation and the respondents in the groups were 19, 105, 43, 7, 6 respondents. In the 0-group the majority of the respondents were still students and didn't continue the survey after the first set of questions.

A large group, 40% of the respondents, where LCA specialists for example consultants, PhD students and industry researchers. The larger group of respondents were a mixed group of different type of industrial ecology practices such as communicating, coordinating, supporting and networking activities. The first job after graduation was often consultant, eco-engineer or PhD students and the second were often the same but the consultant has changed to be a PHD student and vice versa.

3.2 Activities at work

It is interesting to study how the Industrial Ecology professions applied different skills in relation to bridge deficiency gaps and translate between different disciplines and professions (figure 1). The respondents could choose more than one alternative in their answer. On a general level the alumni communicate, network and do interdisciplinary work preferably on an international level and to a lesser extent locally and nationally. Peers are generally important and those are found within the company. These peers are probably also international colleagues.

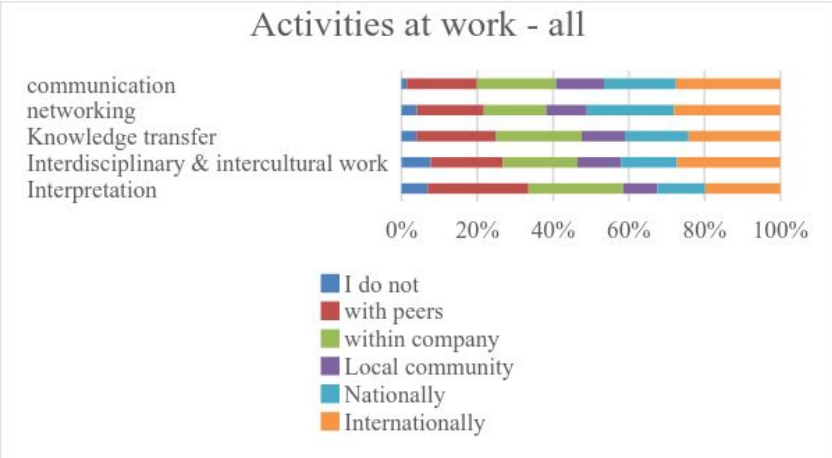


Figure 1. How different skills were applied in the alumni's activities at work.

In comparing the LCA specialist group and the larger more general Industrial ecology practitioners there are similarities and differences. In engaging in Interpretation activities both groups applied these mainly among peers and within the organisation where they are employed and Interdisciplinary communication activities occurred mainly on an international level. A LCA specialist acts more on a national and international level considering communication, networking and knowledge transfer. The other group of Industrial Ecology practitioners communicated and did more networking at the local community level and knowledge transfer appeared more within the company or organisation.

3.3 Skills

The general results For Academic skills show that analysing and critical thinking are skills that the respondents are comfortable with and spend time doing. Respondents spend less time and are quite comfortable Changing perspective and argumenting. In the LCA specialist the group were to a higher degree comfortable with analysing than group with Industrial Ecology practitioner who are slightly more comfortable and spend more time on changing perspective than the LCA specialist.

The results for scientific skills are shown in figure 2. The overall result shows that Professional software was most comfortable and much of the working hours was spent on the software. Looking into the LCA specialist group and the Industrial Ecology practitioner the amount of time and the comfort with the Professional software are perceived equal. Looking further into what type of industrial ecology tools that the practitioners use the group of Industrial ecology practitioners have interpreted this as Microsoft office tools which they spend time on using. The LCA specialist mention to a much higher degree different type of LCA software.

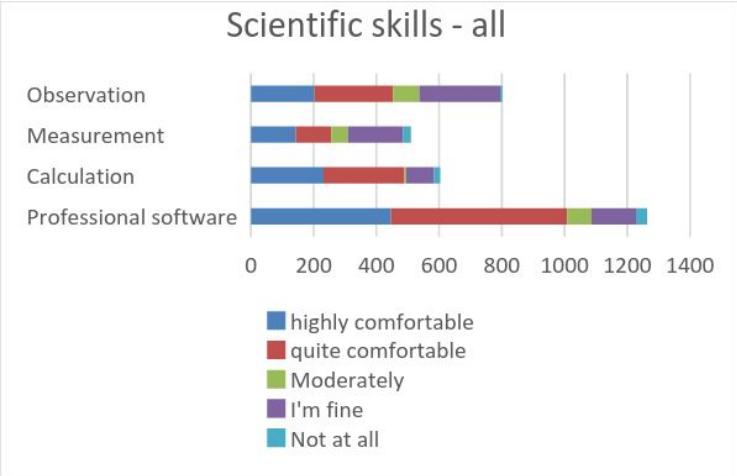


Figure 2. Scientific skills

The results for the whole group of communications skills show that an industrial ecologist is comfortable with reading, writing and speaking and much less comfortable with oral presentations and negotiations. In the LCA specialist group the general pattern was the same as with the respondents as a whole. The Industrial Ecology practitioner revealed slighter higher degree of comfort and time spent on oral presentations and negotiating. By looking into the occupations of the individuals who answered that they were highly and quite comfortable with negotiation and oral presentations showed that these professionals were project managers and coordinators, entrepreneurs and management consultants.

Skills such as cooperation, self-management, self-learning and interpretation are generally perceived as comfortable and decision-making, persuasion, inspire & empower and managing conflicts. The LCA specialists are comfortable with self-learning and less comfortable with Inspire and Empower, Persuade and Cooperation. Looking into the group with high comfort in self-learning you find PhD students, consultants and project coordinators. On the other hand the group of industrial Ecology practitioners are more comfortable with cooperation, inspire & empower and persuade. Looking into the individual answers the respondents with high comfort in persuading and inspire & empower are working as public servants, university teachers, project managers, entrepreneurs and consultants

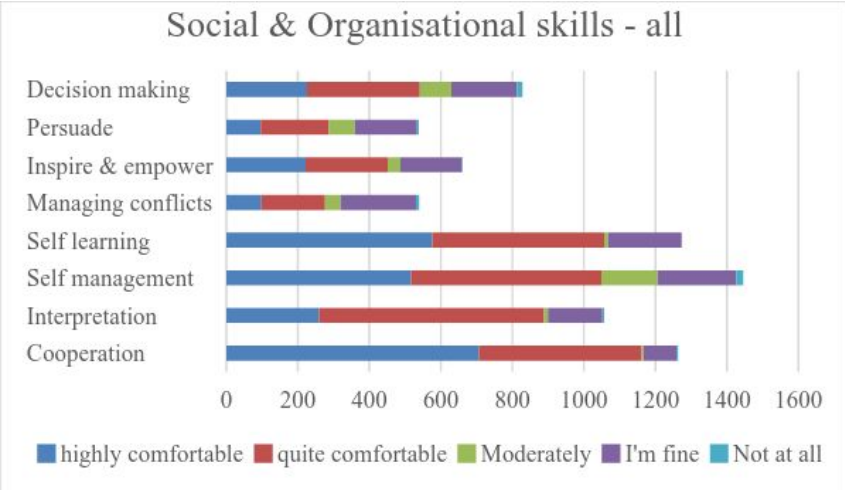
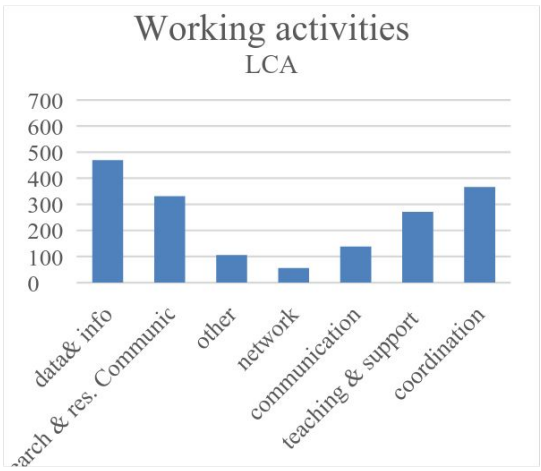


Figure 3. Personal skills and the skills less comfortable are persuade, managing conflicts and decision-making.

3.4 Activities at work

The respondents were asked to list the main 5 activities occupying their weekly work. The answers were free text answers that were analysed and grouped into different activities. The tasks that the professionals occupy their time with are finding information and data, research activities, networking, communicating, teaching and support and coordination. In figure 4 the outcome of the activities in the LCA specialist and the Industrial ecology practitioner are illustrated.

Although the group of practitioners are larger than the LCA specialists, the LCA specialist spend more time on data and information. The Industrial Ecology practitioner spend more time networking, communication and coordinating groups. In both groups they spend fairly equal amount of time on teaching and supporting activities.



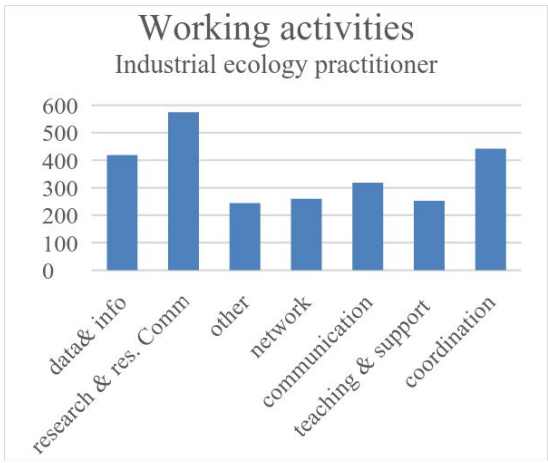


Figure 3. Working activities in the two groups of Industrial ecology professionals

4 Discussion

An industrial ecologist first job is often PhD students or a consultant and later on advisor or project leader. This is also found in other alumni surveys of environmental professionals as well as that employers often are consultancy firms, universities, companies and governmental organisations (Bootsma and Vermulen 2011).

From this study it can be shown that an Industrial ecology profile can be described in at least two different ways: the LCA specialist who is a traditional user of the industrial ecology toolbox and the Industrial Ecology practitioner that communicate, network and coordinate industrial ecology activities. These two groups have use of different sets of skills. The task for education it to provide students with the right kind of knowledge, skills and motivation which practitioners need to make difference in the world (Hesselbarth & Schaltegger 2014). At present the LCA specialist is well supported in the educational system.

The two types of Industrial ecology professionals also calls for reflection and review of the curricula in industrial ecology programs. A program that meets both types of professionals need to be truly interdisciplinary where skills are balance between specialist skills and traditional and conventional knowledge (Clark et al. 2011). At present the curricula supports the specific topic expertise i.e. the industrial ecology tool box but not to the same extent the specialisation in a generalist holistic thinking applied to enable the transition towards a more sustainable society. This can be explained by lack of recognition of the skills by the respondents or that the curriculum is taught by specialists as described in Clark et. al (Clark et al. 2011).

The result of this survey should be useful input to improvements in curricula of industrial ecology and other engineering programs to be able to identify islands of specialist knowledge that could be integrated into an interdisciplinary whole. There are educational programs that use alumni surveys to evaluate the education and to get inspired about direction to change (Hansmann et al. 2010). However alumni surveys cannot be the only tool, knowledge about general trends in society needs also to be taken into account. The general trend in industrial ecology and industry is to close energy and material loop in products, cities and industry.

5 Conclusion i

This study has identified at least two groups of industrial ecologists, one that has a specialisation in LCA and another group with a much more mixed professional practice. Skills a part of the educational curricula were in general more comfortable to the respondent such as cooperation in group work, analysing data and familiarity with professional Industrial Ecology software. Skills such as negotiation, persuade, managing conflicts get less attention in the educational curricula or rather more perceived as a skill taught by life.

The focus in industrial Ecology programs are in general on the industrial ecology tool box and

preferably LCA. Industrial Ecology is developing into new arenas where lifecycle thinking and systems thinking guide the practitioner in the day to day practice where daily activities focus on managing stakeholders, coordination of actors and managing networks. These new arenas of practice for Industrial ecology and engineering in general have potential for development in the industrial ecology curricula.

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