

Wicked problems: university research topic convergence despite divergence in local educational and innovation policies

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Abstract

Purpose – This study aims to determine how sustainable development (SD) demands (according to the United Nations Economic Commission for Europe's (UNECE) SD themes from 2005) are connected to the contents of education, research, development and innovation (RDI) in higher education institutions (HEI). Education and the RDI nexus may affect HEI's capability to handle SD-related wicked problems and enhance their societal impact.

Design/methodology/approach – This paper examined SD-oriented curricula contents of two universities (Brazil and Finland) and counted the number of SD-related research outcomes. In addition, conceptual modelling was used to analyse the mechanisms that may be directing HEIs' SD work in local innovation.

Findings – The data showed a convergence deviation in the RDI of SD-related subjects between the two HEIs. There was no correlation between SD-oriented education and RDI-work in either HEI. Education and RDI processes have different UNECE SD themes at the focal point, and the education-research nexus is lacking. This difference indicates that new SD-related knowledge produced through RDI was not effectively used in education. Modelling revealed that the convergence in RDI outcomes arose from the same kind of local business, industry and societal challenges, implementing effective stakeholder pressures into HEIs. The



results may indicate that stakeholder SD needs were not directly transferred into the competence qualification of the curriculum.

Originality/value – To the best of the authors' knowledge, this is the first quantitative study to reveal the independence of universities' SD-related RDI subjects on educational curricula.

Keywords Curriculum, Sustainable development goals, Stakeholder relationship, Innovation environment, HEI, Education-research nexus

Paper type Research paper

1. Introduction

Since the 1960s, the depletion of natural resources, increasing environmental pollution and social crises have been on the agenda of global environmental and social policies (Meadows *et al.*, 2004). On the other hand, sustainable development (SD) in business, industry and society tends to encounter various conflicts. Hence, the challenge of SD integration is a typical example of a wicked problem (Rittel and Webber, 1973; Brown *et al.*, 2010). This study used recommendations of the United Nations Economic Commission for Europe (UNECE) for SD-oriented themes for education (UNECE, 2005) as a framework for addressing sustainability-related global wicked problems. Typically, wicked problems in SD are related to environmental pollution, social cohesion, legality, cultural confrontation and human health issues (Brown *et al.*, 2010; Rittel and Webber, 1973). To challenge these threats, higher education institutes (HEIs) around the globe have invested efforts into the promotion of effective research and education on SD issues (Bettencourt and Kaur, 2011; Hoover and Harder, 2015; Clark *et al.*, 2016). The need for research and education is strong, and the typical features of new knowledge and competencies are applicability, practice orientation and rapidity. Currently, HEI's concrete response as a "third mission", as social impact, is considered natural and embedded in operations of research, development and innovation (RDI) and education (Mensah and Enu-Kwesi, 2018; Pinheiro *et al.*, 2015). The objective of this study was to develop HEI alignment in SD-related education and RDI, as well as their impact on society.

New regenerative procedural knowledge and operations seek to eliminate global environmental threats and social challenges (Ripple *et al.*, 2017; Lade *et al.*, 2017; IPCC, 2018). At the same time, university actors face trade-offs between the demands and pressures from their stakeholders (including financial ones) and their own academic prestige and autonomy (Mielke *et al.*, 2017). On the other hand, stakeholder boundary knowledge is thought to play a key role in solutions to SD challenges (Cash *et al.*, 2003). Together or independently, university research and education can lay the foundation for regenerative innovations for SD. The intellectual autonomy of academics still lies in the methods and research questions used in disciplinary research processes and produces scientifically solid answers to SD-related questions (Bentley *et al.*, 2015). However, there is a gap in the literature regarding how these external demands and pressures may actually shape the interconnection between SD-oriented education and RDI activities. Here, innovations are defined as new solutions for industry and society to cope with changing challenges in their operational environments (Chesbrough, 2006). From the perspective of HEIs, this is an interesting process as there should be a strong link between competence education, intensity to produce new research-based knowledge and creative potential to produce new innovations.

Acquiring SD knowledge and skills amongst groups of students may increase the sustainability of society both "outside-in" and "inside-out". Education itself is changing because of the societal goal to become more sustainable, and at the same time, educational institutions contribute to the SD actions of society (Barth and Michelsen, 2013). Hence, the

presumption is that effort (e.g. the volume of SD studies in a degree programme) and outcomes (skills and competencies) supporting more sustainable societies increase. In the “outside-inside” process, educational institutes internalise the demands and needs of industry and the public sector (Barth and Michelsen, 2013). University research and development activities support policy pressure and stakeholders’ (broadly defined) sustainable innovation activities (Blanco-Portela *et al.*, 2017; Wals, 2014).

In a sustainable innovation process, numerous external steering, interactive and selection processes may affect not only the innovation process itself but also the entire innovation landscape (Scout and Geels, 2008). According to this model, protected technology niches, innovation processes and cooperative networks are continuously evolving and changing (even social-technological regime shifts may occur). Divergence (at the level of diversity) between and within niches has both positive (e.g. new angles of ideas) and negative (e.g. overload of ideas) effects on the former development of that niche (Scout and Geels, 2008). Universities face different pressures regarding SD issues based on national traditions, current laws and policies (Holm *et al.*, 2015). On the other hand, internal struggles within universities regarding the importance of SD issues may be severe in terms of conflicting perspectives or in the sense of resource allocation (Hoover and Harder, 2015).

Recently, some differences in the supply level of integrated SD education have been revealed, which may originate from differences in national and local steering policies and actions and pedagogical traditions of universities (Friman *et al.*, 2018). The “supply” of such SD education may reflect the university’s efforts to increase its capacity to challenge the progress of global unsustainability. Reflected in the content of the curricula, these efforts significantly influence the learning process and are observable through their effect on a student’s learning outcome (Shallcross, 2016; Stough *et al.*, 2018). However, it is unclear whether an educational investment in SD (in terms of hours used) is related to research activities (broadly defined as RDI) of SD issues (quality or quantity). The education-research nexus is of vital importance when HEIs maximise their SD efforts in society (Annala *et al.*, 2016).

Data regarding SD-related content of curricula and SD-oriented research outcomes (i.e. the number of theses and publications) in two HEIs (Brazil and Finland) were composed and compared. The aim was to evaluate the transition intensity of the newest research-based SD knowledge into curricula as an up-to-date SD competence. Education of relevant competencies and research-based knowledge production generates the social impact of HEIs. How these two functions are linked to the current SD demands of society is less clear. To examine the mechanisms behind the SD-related societal impact of the two HEIs, a heuristic model of affecting actors and mechanisms (including stakeholder pressures) was used. The model is constructed according to general innovation theories with a funnel paradigm (Chesbrough, 2006; Kralisch *et al.*, 2018). We posed the following research questions:

RQ1. Is there an interrelationship between the intensity and quality of SD-oriented education and RDI in HEIs?

RQ2. How do external pressures affect SD-oriented RDI outcomes in HEIs?

This study analysed two universities with different operational environments (outside steering policy, funding and stakeholders), organisation and educational and research traditions. To the best of our knowledge, this is the first quantitative study on the intensity of the nexus between SD-related education content and RDI-related knowledge production.

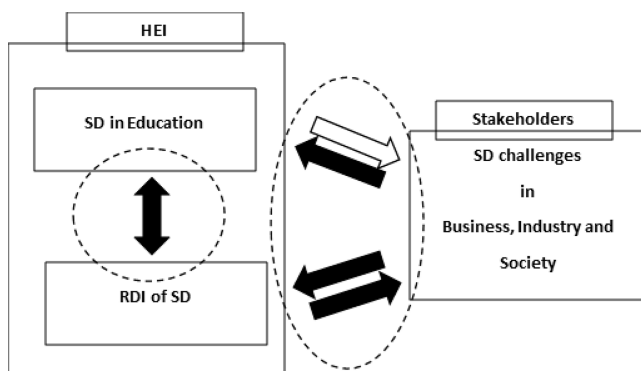
2. Materials and methods

2.1 Theoretical consideration

The intention was to study and model how education and the RDI nexus may be involved in the HEI's capability to handle SD-related wicked problems and enhance their societal impact (Figure 1). HEI's SD impact from the perspective of the education-research nexus has remained relatively ignored in the research literature.

HEIs' traditional roles and missions in knowledge transmission (teaching) and production (research) for knowledge-based societies are being broadened to accommodate activities that facilitate engagement with various stakeholder groups (Pinheiro *et al.*, 2015). The third mission of an HEI is based on strong links between HEIs, industries and the public sector (state or regional authorities) and they should jointly promote attractive local conditions and regulation for win-win situations for the cooperation (Chesbrough, 2006; Pinheiro, 2015; Hladchenko and Pinheiro, 2019). HEI research activities, especially applied research, have shifted towards collaboration with business and industry following the transition from Modes 1 to 2. The role of companies has created suspicion amongst academics but has become established following the paradigm of knowledge ecosystems (Roper and Hirth, 2005). The education-research nexus as a core of curricula depends strongly on the attitudes of academic teachers (Healey, 2005; Annala *et al.*, 2016; Ávila *et al.*, 2017). In addition, the teacher's own research orientation and activities have a strong effect on using and creating new knowledge in their classroom activities (Tight, 2016).

There has been a continuous debate about the priorities and models of the mode of action in the education-research nexus (Healey, 2005; Verburgh *et al.*, 2007). Behind the tension, there are issues such as education management, institutional structures in the HEI, occupied quality systems and established education and RDI practices, and how these issues influence the mode of nexus (Verburgh *et al.*, 2007). As the main document of teaching and learning, curricula reflect the nexus or lack of, by making the content and methods of studies visible (Tight, 2016).



Notes: Arrows indicate possible nexus between education and RDI, and possible interrelationships between an HEI and stakeholders in SD issues. Black arrows indicate the locality of quantitative and qualitative measurements. Theoretical consideration has focussed on marketed boundaries (rings)

Figure 1.
Illustration of the
research frame with
two research
questions

The pressure to reform curricula has strengthened in the twenty-first century as HEIs' position in societies has changed as an essential part of national and international innovation ecosystems, meaning tight links with business and industry (Roper and Hirth, 2005; Pinheiro, 2015). An effective innovation process can be based on the open innovation procedure and co-creation within the innovation ecosystem (Chesbrough, 2006). Hence, as a member of the local innovation ecosystem, an HEI should also have an open and responsive role when they are focussing on their own educational targets. However, the redesigning of curricula seemed to be an in-house project for HEIs (Sammalisto *et al.*, 2015; Caniglia *et al.*, 2018; Tynjälä and Gijbels, 2012).

According to the above theoretical consideration, empirical measurements and a conceptual modelling process were conducted to test the education and RDI nexus involved in the handling process of SD-related wicked problems and HEI's societal impact.

2.2 Description of case universities

There were a total of 12,500 students and 1,340 staff at the University of Feevale (Feevale) in Brazil, and 7,500 and 650, respectively, at Häme University of Applied Sciences (HAMK) in Finland. Feevale was established in 1969, during a period of adjustment in Brazilian higher education policy, which resulted from the economic boom and a need for experts to cope with the challenges produced by this economic progress. To provide economic and social development and achieve recognised excellence, Feevale emphasises its bachelor's degree courses that meet the needs of organisations established near the university, as well as master's and PhD courses based on research conducted by professors.

HAMK was established in 1992 as part of higher education reform initiatives in Finland. Universities of applied sciences were established alongside traditional universities. Aside from professional-oriented higher education, their profile consisted of close relationships with work organisations, regional development and applied research. Close relationships with local companies and increasing research endeavours are underlined in HAMK's actual activities. Education is primarily emphasised at the bachelor's degree level, while the need for applied research in the labour market has increased the supply of master's degree programmes. The HAMK has no PhD programmes.

Interesting insights into the fundamental constraints and facilitators for the integration of SD issues in higher education and research can be obtained by analysing European Union and Latin American HEI systems with variation in national-level pedagogical traditions, SD policies and operational environments (Diogo *et al.*, 2019). Data from earlier research on steering mechanisms of SD education in these two HEIs (Friman *et al.*, 2018) made it possible to test the hypothesis of education and RDI nexus and their societal effects. The former data consist of observations of the intensity of SD-related education in case HEIs.

2.3 United Nations Economic Commission for Europe themes

This case study uses the widely recognised classification of the SD theme for HEIs recommended by the UNECE (2005) as a heuristic framework. UNECE themes are, namely, biological and landscape diversity, environmental protection, natural resource management, rural and urban development, production and consumption patterns, economy, corporate responsibility, poverty alleviation, responsibility in a local and global context, democracy and governance, justice, security, peace, health, citizenship, human rights, gender equality, cultural diversity and ethics. The incidence of a theme was used as an indicator of the presence of SD activities in education and RDI-work. Measurements of the incidence of themes are described below.

2.4 Measurement of sustainable development education intensity

The incidence of these themes in the curricula was measured. At Feevale, the data were collected by analysing the curricula of the degree programmes via content analysis. At HAMK, the data were collected by interviewing the heads of the degree programmes. The data were gathered from both universities during 2015–2016. The mean incidence ratio for the university was applied as an indicator of SD education intensity.

2.5 Measurement of sustainable development intensity in research, development and innovation-work

The traditional and universal mission of universities is to educate professionals and civilians and contribute to the scientific community and global society (Jarvis, 2001). As the most reliable and relevant method of presenting HEIs' research activities, publications are concrete performance indicators. In recent decades, emphasis has varied and is now strongly connected with the utility of RDI results in business and industry (Eyring, 2011). However, publishing is an indicator to realise the results of RDI.

The incidence of UNECE themes in research was analysed by counting the number of theses (BSc, MSc and PhD at Feevale and BSc and MSc at HAMK) and the number of publications in the library databases of the universities. Theses and publications were found using the UNECE themes as search words or phrases. The data collected encompass the years from 2011 to 2015.

As the absolute number of publications and theses varied considerably between these two universities, standardisation of the data was conducted by using the relative incidence of UNECE themes in curricula (h) and research products (numbers of theses and publications) (the relative incidence of a theme = a UNECE themes_{1–19}/total incidence of themes_{1–19}).

2.6 Data analysis

To answer the first research question, the correlation between SD intensity in education and RDI was measured. Data on the average incidence ratio of UNECE's SD themes in the curricula and incidence of themes in thesis and publications were not normally distributed (Shapiro–Wilk W -test). Therefore, a non-parametric method was used for the statistical analysis. The distribution of the relative incidence of UNECE themes amongst research output from Feevale and HAMK was analysed using the Kolmogorov–Smirnov two-sample test. Spearman rank correlation analysis was applied to examine relationships between SD education intensity and research profiles at HAMK and Feevale (note that different data collection methods for educational intensity were used). Analyses were conducted using the statistical programme JMP Pro 15.0 by SAS.

2.7 Qualitative analysis and heuristic modelling

Our intention was to uncover the mechanisms affecting SD intensity in education and RDI-work and societal impacts of HEIs; therefore, further analyses are required to answer the second research question. To depict the mechanisms affecting the HEI situation in the innovation scene, the principles of conceptual analysis (Risjord, 2014) included qualitative data analysis and heuristic modelling.

Firstly, HEIs' functioning in their operational environment was evaluated using conceptual analysis; operations, stakeholders and systemic interactions were written in textual mode (texts not shown). In the conceptual analysis, the influential factors were:

- Institutional tradition that is pedagogical and research practices (inside factor), organisation (inside factor) and various policy steering objectives of HEIs (inside and outside factors).
- Stakeholder relationships (outside factor).
- Funding opportunities (outside factor) of HEIs.

Factors were selected according to the scientific literature (Chesbrough, 2006; Scout and Geels, 2008; Brown *et al.*, 2010; Boons and Lúdeke-Freund, 2013; Holm *et al.*, 2015; Hoover and Harder, 2015).

Secondly, a heuristic model was constructed to offer potential explanations for the observed SD research profiles at Feevale and HAMK. The influential factors were analogous to the conceptual analysis. UNECE's recommendations for SD-oriented themes were used as a framework for addressing the wicked problems of the world. The model was based on the idea of a general innovation process (Chesbrough, 2006; Scout and Geels, 2008; Kralisch *et al.*, 2018). Each factor in the model can be seen as an indifferent, divergent or convergent pressure for the HEIs' activities. Finally, SD-oriented factors and their effects on education and RDI processes were connected to a consistent innovation process with the funnel paradigm. The model depicts the processes by which the two universities participate in the handling of SD-related to the aforementioned wicked problems as part of their societal impact ambition.

3. Results

3.1 Educational intensity vs research outcomes

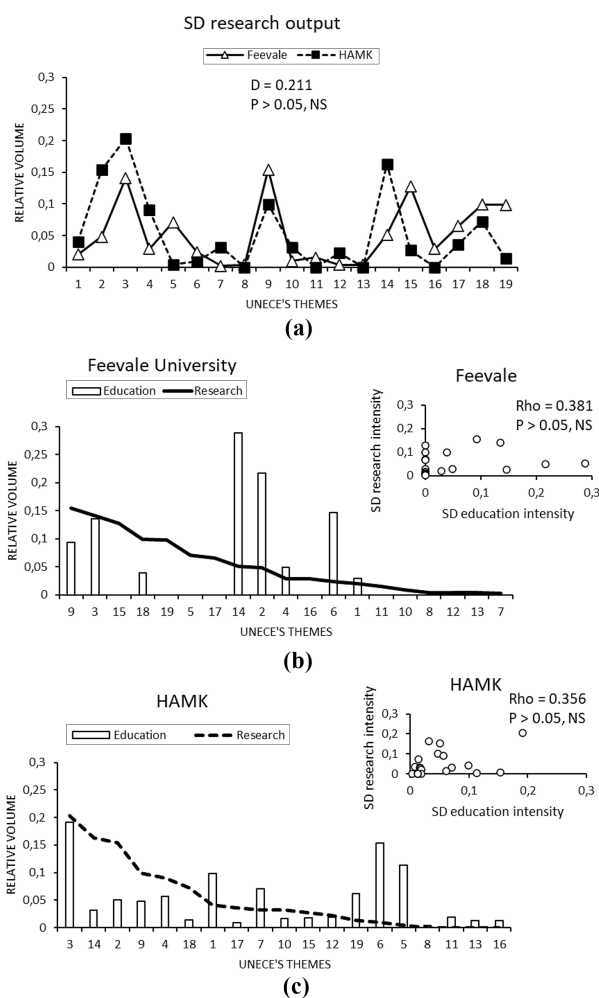
The deviation of research activities across the UNECE themes was equal between the two universities ($D = 0.211$, $P > 0.05$, $n = 19$) [Figure 2(A)]. At both universities, evolved RDI activities can be found in areas connected to ecological (Themes 1–4), local and global responsibility (9) and well-being and social equality issues (Themes 14–19, except the theme “human rights” in HAMK). Less studied areas related to economic (Themes 6–8) or societal themes (Themes 10–13). Overall, the results indicated convergence in the SD-oriented RDI between these geographically distant HEIs.

The volume of SD-oriented education tended to be higher at HAMK (14,476 h used in SD education) than at Feevale (2,515 h). The volume of SD-oriented research outcomes tended to be higher at Feevale (1,238 items) than at HAMK (221 items). The number of SD-oriented research outcomes represented 18% and 4% of the total volumes of research outcomes at Feevale and HAMK, respectively. The correlation analysis revealed no correlation between SD education intensity and research profile at either university ($Rho = 0.381$ and $Rho = 0.356$ for Feevale and HAMK, respectively, $n = 19$, $P > 0.05$ for both universities) [Figures 2(B) and 2(C)]. This indicates that education and RDI processes have different UNECE SD themes as focal points.

3.2 Model of mechanisms affecting sustainable development intensity

Influential factors in the conceptual analysis affecting sustainable RDI activities and education at Feevale and HAMK are summarised in Table 1.

The heuristic model is illustrated in Figure 3. In the model, potential sources of SD-oriented wicked problems were selected according to the UNECE theme list (a “heuristic filtration”) into HEI's processes (integration into the curriculum and research targets). Hence, the complex nature of problems was simplified to 19 themes for SD actions in the HEIs. Pedagogical models and national SD steering policies set the framework for SD



Notes: Kolomogorov-Smirnov two-sample test was used to analyse differences in the distribution incidence of UNECE themes. Distributions of SD education effort (h) and outcomes (numbers of theses and publications) in Feevale and HAMK (B and C). For clarity, data and themes were ranked according to the incidence of UNECE themes in SD outcomes. In small figures, the lack of correlation between SD education and research intensities are shown (Spearman rank correlation). Number of replicates for all analyses was $n = 19$

Figure 2.
Comparison of
distribution of SD
outcomes for both
universities (A)

educational efforts at both universities (including some unknown factors). Factors such as institutional traditions, stakeholder interactions and RDI funding tended to exhibit significant dependency on RDI activities, although the innovation scene was different between the two universities. Institutional traditions also affected the education process. Empirical data indicated that the content of SD education is not correlated with that of SD-oriented RDI results; hence, this interaction was negligible (a missing link). The funding and stakeholder co-operation dynamics connected to global SD megatrends (sustainable use of natural resources, environmental protection activities and promotion of overall societal well-being) particularly tended to cause a convergence of RDI outcomes, despite the divergent settings. Finally, the model indicated that HEIs' societal impact can be separated into two parts, namely, SD-oriented education and RDI.

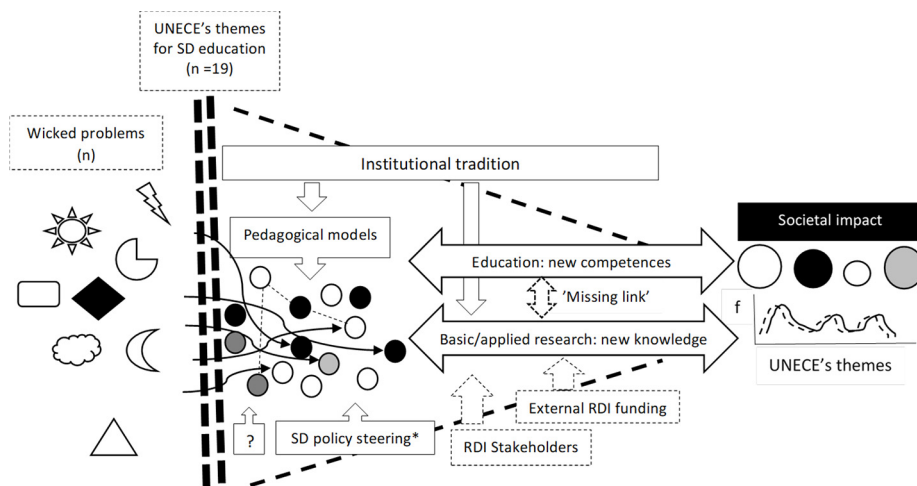
4. Discussion

The objective of the study was to determine how SD-related education and RDI affect the potency of a societal impact (i.e. the third mission) of the two HEIs. The concept of wicked problems was chosen as a connective nominator for SD activities in society (i.e. a non-specified area including probable conflicts of interest). The empirical and modelling results showed the actual mechanisms behind the development process of SD activities of HEIs.

Firstly, data showed that SD-related subjects in RDI had a convergence deviation between these two geographically distant HEIs. Secondly, empirical measures showed no clear interrelationship between SD-oriented education and RDI in either HEI. This indicates that education and RDI processes have different UNECE's SD themes as focal points. The lack of such a relationship may indicate that the maximal potency of SD-related societal impact of both HEIs was diluted: new SD-related knowledge produced in the RDI process was not effectively used in the education of SD-related competencies. On the other hand, the

Table 1. Description of influential factors affecting education process and RDI activities in both universities. Issues were used on the conceptual analysis of the HEIs and their operational environment and further, factors were used in the heuristic modelling

Factor	Feevale	HAMK
Institutional tradition (Pedagogy and RDI)	Content-based Theoretical knowledge base (handbooks) Basic and applied research Professor supervising thesis process	Competence-based Practical knowledge base (handbooks) Applied research and development Student-driven thesis process
Organisation	Science university Autonomous professors	Applied university Managed researchers
Policy and operational steering	Weak top-down steering Strong bottom-up steering Emphasis on regional-national-international sources	Strong top-down steering Weak bottom-up steering Emphasis on regional-national-international sources
Stakeholders	Order of preference: academic community (references), society and companies (customers) Regional-national-international orientation	Order of preference: companies and society, (customers), academic community (references) Regional-national-international orientation
Funding	For universal social and environmental challenges Private-public funding Study fees	For universal social and environmental challenges Public-private funding Study fees only for foreign students



Notes: Connections of RDI functions to educational function, university institution and pressures outside of university were introduced. ? = Unknown factors affecting SD education volume, * = Steering policy is an outside factor at HAMK and an inside factor at Feevale (i.e. top down vs bottom up steering), f = relative proportion of theses or publications concerning certain UNECE SD themes. Text boxes: solid line = factor operating inside of a university, dashed line = outside factor affecting the university. Thick dashed line = the innovation funnel and the heuristic filter. Thin dashed line after the UNECE theme filter indicates a possible combination of themes as an item for transdisciplinary education

Figure 3.
Heuristic model for
the sustainable
innovation process
(RDI) of Feevale and
HAMK

lack of a relationship may indicate that stakeholders' SD needs were not directly transferred into the competence qualification of a curriculum. If the results are a common phenomenon in higher education, it may indicate that HEIs lose their maximal potency when handling the wicked problems of societies.

Modelling revealed that this convergence in RDI outcomes arose from the same kind of local business, industry and societal challenges, implementing effective stakeholder pressures on HEIs.

4.1 Evaluation of the study method and data

This is the first quantitative study revealing the independence of universities' SD-related RDI subjects on educational curricula (Shallcross, 2016). The lack of incidence between the universities' main processes was evident in both cases, despite the different data collection methods for SD education intensity (content analysis vs interviewing). Possible similarities between universities in SD-related RDI subjects have rarely been studied (as oppose to curricula comparisons, Gomez *et al.*, 2015).

The UNECE's (2005) paper with recommended themes for SD education was presented more than 10 years ago. The relevance of the themes (even as a heuristic frame) may be questioned considering today's global threats (Ripple *et al.*, 2017; IPCC, 2018). However, the updated general SD goals proposed by the United Nations are closely related to the UNECE list (United Nations, 2019). Some SD-oriented articles or theses may be ignored by data

collectors, as the UNECE theme names did not match the keywords or phrases of the text. On the other hand, UNECE's heuristic themes can be seen as too extensive to serve as a relevant framework for a subject-level comparison in HEI research production (e.g. compare fictive research themes, such as environmental protection [a UNECE theme] vs climate-sensitive actions in the local chemical industry [a focussed subject]). Due to this generic character of the theme list, it is evident that the list may not be the best way to highlight SD-oriented wicked problems (Daviter, 2017).

4.2 Stakeholder cooperation and funding leads to convergence in research, development and innovation

According to innovation theories, geographical proximity increases cooperation in shareholder (or value) networks (Simard and West, 2006; Scout and Geels, 2008). On the other hand, an innovation process tends to consist of local and area-specific phenomena with strong path dependence (Martin, 2010). Hence, RDI topics on two continents should be relatively independent from each other and be divergent processes.

From the viewpoint of the institutional tradition, Feevale uses bottom-up-oriented steering of SD activities, while HAMK uses top-down-oriented steering, together with stronger governmental and regional steering pressures. In this analysis, this difference means that the "faculty model" (Feevale) may also be more independent (indifferent) from the top-down external and in-house steering actions than in a more intensively managed "school model" (HAMK). The bottom-up development of SD in an HEI can be more vulnerable to divergent transition than top-down steering, and such a development process may fail long-term (Ávila *et al.*, 2017). Hence, in the model, the variation in the organisational solution or steering policy is seen as a divergent phenomenon. However, our empirical research surprisingly showed convergence between the research outcomes. Where does convergence come from?

Feevale was identified as a research university and HAMK as a university of applied sciences. This draws the usual distinction between basic science and applied science (Gibbons *et al.*, 1994). To seek scientific- and research-oriented solutions to wicked problems and promote global SD means, by definition (Rittel and Webber, 1973), these wicked problems cannot be solved by a single field of science or within the academic community alone (Frodeman, 2010; Kitcher, 2011; Mielke *et al.*, 2017). In Finland, the operational basis of a university of applied science is used more than the cooperation between academic and "extra-academic actors" (Koskinen and Mäki, 2016; Rantanen and Toikko, 2012). At Feevale, close relationships between academics and non-academic society have also been an essential mode of research operations. Hence, the stakeholder factor tended to be a convergent pressure in the model.

Typically, the most critical outside factor for HEIs is external RDI funding (Ávila *et al.*, 2017). Hence, in the model, external funding and funding policy are seen as powerful and potentially convergent factors. Business volumes of SD-relevant sectors in Brazil and Finland indicate possible drivers for the convergent evolution of SD-related RDI at HEIs. The idea is that large business volumes, such as environmental protection and the management of natural resources in the industrial sector or the national public health sector (IPEA, 2015; Official Statistics of Finland, 2018a, 2018b; Saldiva and Veras, 2018), may promote (directly or indirectly) RDI activities at an HEI for that sector.

At Feevale, governmental bodies and private companies take part in RDI projects, which may solve some of the problems in society and the markets, and these groups have an evident demand for research subjects. HAMK is a standalone university in its operational region. Hence, there are regional pressures to channel developing funding into HAMK from

companies and public national and EU funding. This regional process also directs HAMK SD-related activities. Realised business volumes and public investments indicate available funding opportunities for both universities in particular sectors. National investments match HEIs' research topics concerning UNECE themes: environmental protection, natural resource management and health. It is likely that both universities have capitalised on the national-level funding potential (i.e. follow the cash flow) and directed their own RDI activities towards these "hot" sectors. Internationally, various public investments tend to be an important tool for societal transition to green practices (Droste *et al.*, 2016). To summarise, this dynamic is well-suited for the convergent stakeholder-funding explanation of sustainable RDI between Feevale and HAMK and supports the heuristic model.

To conclude, the convergence of RDI outcomes between two geographically distant HEIs has arisen from the same kind of local business and societal challenges, implementing effective stakeholder pressures on HEIs. On the other hand, SD-related wicked problems cannot be characterised and handled within a certain academic discipline or within scientific research alone. To solve this heterogeneous collection of problems, scientists, experts and laymen should cooperate intensively. Therefore, the convergence amongst the goals of research resulted from pressure towards practice-based research orientation in both universities. This may push HEIs to the convergent evolution of an SD-oriented social-technological regime shift in both regions (Scout and Geels, 2008).

4.3 Integration of education and research, development and innovation: a missing link

There was no correlation between SD-oriented education and RDI in either HEI. This indicates that education and RDI processes have different UNECE's SD themes as focal points. These results were somewhat unexpected, as most researchers and professors also take part in the education process. The lack of this relationship may indicate that the maximal potency of SD-related societal impact of both HEIs was diluted: new SD-related knowledge produced in the RDI process was not effectively used in the education of SD-related competencies. Why is the nexus missing?

Although our research could not directly reveal reasons for the lack of a relationship, there are several obvious explanations. Firstly, curriculum planners and researchers do not exchange their knowledge about the SD needs of the stakeholders, as the HEI's steering system does not support such knowledge exchange during the planning process (separated processes). Secondly, SD content is based on literature (handbooks); hence, current RDI-based knowledge is unavailable in the curriculum planning process. Thirdly, cooperation with extra-academic networks was not active enough during the curriculum planning process.

As already stated, there are considerable differences in HEIs' in-house and external steering processes. However, in both HEIs, the curriculum planning and construction (including the content of a certain course or module) is based on the results of the analysis and benchmarking of the working life, such as competence demands, employment rates and forecasting trends. Professors, education managers and teachers are responsible for the review and upgrading of the curriculum. If the idea of a close relationship between researchers and stakeholders was correct, and if it indicates SD requirements of stakeholders, it seemed that the curricula process focussed on different needs from working life. There seems to be an unsolved discontinuity in the steering-planning-outcome chain. Strict working-life orientation has received some criticism due to the stressing of general skills instead of professional studies (Kouwenhoven, 2009) and fragmentation to narrow competencies instead of understanding systems and connections (Barnett and Coate, 2004). Recalling recent reports about climate change [e.g. intergovernmental panel on climate change (IPCC)] and SD supporting scenarios (e.g. the UN's SD goals), citizens, organisations

and societies have begun to revise their adaptive strategies to enable the introduction of sustainability into their values and purposes. To support this revision process, the divergence between curriculum content and RDI outcome should be solved to maintain the alignment process in the SD-orientated knowledge transfer (Annala and Mäkinen, 2017).

The pedagogical approach fundamentally differs between Feevale and HAMK, in terms of content–competence dichotomy. In addition, in Finland, the framework of higher education exists at the EU level, whereas in Brazil, it is at the national level. The parameters of curricula and level of achieved competencies are given with no guidelines regarding the content (EU, 2017; OECD, 2018). There are some fundamental differences between the research and education orientations of Feevale and HAMK that can be seen, for instance, through the role of ethics (UNECE Theme 19). At Feevale, ethics is an independent academic discipline, whereas at HAMK, it is embedded in professional and research studies.

To conclude, the lack of correlation in both universities indicated that the SD contents in curricula, which arguably are based on discipline-oriented handbooks of SD (with discipline-oriented content and perspective), have only minor effects on the orientation of RDI activities and vice versa. On the other hand, the lack of a nexus between the curriculum content and RDI activities in the HEIs may indicate that stakeholder SD requirements were not directly transferred into the competence qualification of curricula. If the results of this study are a common phenomenon in higher education, it may indicate that HEIs lose their maximal potency when handling the wicked problems of societies. In a systemic “SD-oriented learning organisation” (compared with Hoover and Harder, 2015), more attention should be paid to the integration of SD-oriented education and research, together with the stakeholders.

5. Conclusions

Convergence of RDI outcomes between two geographically distant HEIs and innovation scenes has arisen from the same kind of local business and societal challenges, implementing effective stakeholder pressures on HEIs. The lack of a relationship between SD content in education and RDI may indicate that new SD-related knowledge produced in the RDI process was not effectively used in the education of SD-related competencies. An effective relationship between stakeholders and HEIs’ RDI process, with a lack of nexus between SD education and SD-orientated RDI process in HEIs, may indicate that stakeholder SD requirements were not directly transferred into the competence qualification of curricula. If the lack of a nexus is a common trend in higher education, it may indicate that HEIs lose their maximal potency when handling the wicked problems of societies. Hence, more research is needed about the interaction of current SD competence education and expectations of stakeholders.

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