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From Rookies To Synthesis: Agile Solutions For Sustainable Doctoral Studies

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FROM ROOKIES TO SYNTHESIS: AGILE SOLUTIONS FOR SUSTAINABLE DOCTORAL STUDIES

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ABSTRACT

Modern doctoral education in engineering lies at the intersection of three topical phenomena: firstly, the surge of wicked sustainability concerns and the subsequent burgeoning demand for cross-disciplinarity. Secondly, the rapidly developing new technologies and global knowledge economy provide a thriving problem-solving potential, although – thirdly – this requires proactive and innovative collaboration beyond the scope of a single discipline. Thus, doctoral education needs new practices to ensure that students are equipped with new kinds of competencies to solve unpredictable and wicked sustainability problems. In order to reach these demands, we need to favor collaboration over competition. Here we approach these issues by presenting key findings from a five-year empirical study on doctoral education in engineering. Data were collected by using a journey mapping method on recently graduated doctors in engineering at Aalto University, Finland. Students from the examined research group were compared with a control group. The data were clustered and the main factors contributing to the individual journeys were

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analyzed. Community, colleagues, and collaboration turned out to have the strongest positive impact on their doctoral journey (average +1.26, scale -3…+3), and they were distributed across the thesis process. Most observations were related to external academic factors, such as funding and journal decisions. Additionally, we present research group practices, such as “Rookies club” and "Synthesis groups" that strengthened students’ resilience and internal support on these factors. These practices initiated positive interdependencies among the students and supported sustainable supervision practices. Our results are applicable to a wide range of doctoral education.

1 INTRODUCTION

Modern-day engineering education holds a high potential regarding bold actions for advancing sustainability. Firstly, the surge of wicked societal and environmental problems, their cross-disciplinarity and complexity, as well as potentially useful research outputs to tackle them creates an increasing opportunity for creative multidisciplinary collaboration and integration in research (Tejedor, Segalàs, and Rosas-Casals 2018).

Secondly, the rapidly developing new technologies, global knowledge economy, and modern research hold the potential to leverage and expand integrated understanding of, for example, the nature of human and biophysical systems and their complexities (Stock and Burton 2011; Milojević 2015). Researchers are expected to make significant contributions to frontier knowledge in increasingly complex situations (Durette, Fournier, and Lafon 2016). Interdisciplinarity is integral for developing and utilizing new technologies, as well as tackling the current complex environmental and societal problems that go beyond the scope of one discipline (Townsend, Pisapia, and Razzaq 2015; McCance et al. 2023). Whereas agile and deep learning is already a cornerstone for professional success in knowledge-intensive jobs, the learning-to-learn paradigm is widely setting aside from the aged learning-to-do approach to education and professionalism (Bormann, Williams, and Minkova 2017).

2 METHODOLOGY

2.1 Case study in engineering

The empirical data depicts a timeline of visualizations of twelve doctoral students regarding their doctoral thesis process. The data were collected in small group workshops and the participants were soon-to-be graduating or recently graduated from the same doctoral programme in Aalto University, Finland. The workshops were organized in person or online using Zoom and Miro boards. Before the workshop, the participants were asked to reflect their doctoral thesis journey and collect necessary documents, such as notes. Each participant produced their own journey map: first, they were asked to document activities, milestones, resources, persons, touchpoints and other observations of their journey into individual sticky notes and organize them in chronological order. Next, the participant graded their individual observations following Nilsson's classification (Nilsson, Griggs, and Visbeck 2016) from -3 indicating the strongest negative impact (cancelling or making thesis work impossible) to +3 indicating the strongest positive impact (the action is inextricably linked to progress), see Table 1 for detailed description of these observations.

Table 1. The classification of the student's observations based on their contribution to the work and wellbeing. Each student graded each of their observations individually.

Grade	Explanation
+3	**Indivisible**. The strongest form of positive contribution, in which the action is inextricably linked to the advancement of the thesis and/or wellbeing.
+2	**Reinforcing**. Aids the achievement of a thesis goal. One objective directly creates conditions that lead to the achievement of another goal.
+1	**Enabling**. Created conditions that further the research/thesis goal and/or wellbeing. The pursuit of this one goal enables the achievement of another goal.
-1	**Constraining**. Limits options on research/thesis goal. The pursuit of this goal sets a condition or a constraint of the achievement of research/thesis goal.
-2	**Counteracting**. Clashes with the research/thesis goal and/or wellbeing.
-3	**Cancelling**. Strongest form of negative interaction. This factor makes it impossible to reach research/thesis goal and/or strongest negative impact on wellbeing.

The students used this grading system to both analyze and describe their own journeys. This process provided results which are discussed in Section 3.

2.2 Doctoral students

The twelve students formed two groups of equal size.

Group 1 consisted of six doctoral students from a research group, the culture of which emphasizes belongingness, subsidiarity, and co-creation of practices for peer learning and strong community. Each doctoral student had a diverse team of advisors led by the supervising professor. The students worked in a project that focused on strengthening doctoral education and interdisciplinary peer learning practices (Taka, Verbrugge, and Varis 2021).

Group 2 consisted of six doctoral students from other research groups in the same unit, but who had no collaboration with the Group 1 students. These students were working in more traditional research groups and doing more independent research. Furthermore, they were actively supervised in, for example, weekly one-to-one meetings with their supervisor as well as in weekly research seminars.

Each student had one to three thesis advisors including the supervising professor (Group 1 average 2.3; Group 2 average 1.3). Eleven students published an article-based dissertation that consisted of 4.2 peer-reviewed publications on average (4.0 in Group 1; 4.5 in Group 2). The average graduation time of the studied doctoral students was 5.3 years (target time 4 years; range 4—6 years). Notably, the number of doctoral students who had completed their master's degree in the same unit was five in Group 1, and only one in Group 2.

2.3 Data analysis

All the workshop data were collected into canvases and visualized in Miro online whiteboard tool. The participants were coded with running identification number (s01

to s12) and the notes were anonymized. All the notes (N=407) were manually clustered into eight key themes and analyzed separately for pre-midterm and post-midterm phases, and they were also analyzed in a chronological order. All the data analysis and visualizations were performed in RStudio.

3 RESULTS

3.1 Key contributing factors

The obtained data highlights the diversity of individuals and their experiences in their doctoral journey. On average, students in Group 1 made 31 observations, compared to 37 in Group 2. The observations were clustered into eight thematic groups (Table 2), and this paper focuses on the group with the most positive contribution to the students: the community and colleagues. The average rank of these observations was +1.26, median +2 (N=36, 49% from Group 1) university activities. The other clusters with median rank above zero were external academic factors (such as research visits, conferences, and journal or funding decisions), research (research activities, such as data collection, experimentation, and scientific writing), researcher skills and identity, and the university activities. The factors with an average rank below zero were supervision, external non-academic factors (family, spare time and pandemic-related issues), as well as personal emotions and self-management.

Table 2. The main clusters of doctoral students' observations and their mean and median values. The scale is from -3 to +3, and in each cluster, the minimum value was -3 and the maximum +3. Group 1 indicates the share of observations in each cluster presented by the Group 1 doctoral students. The share of positive and negative observations in each cluster is also reported.

	N	Mean	Median	Group 1 %	Positive / negative
Community, colleagues, collaboration	37	1.26	+2	51%	78 / 22%
External academic	60	0.98	+1	60%	72 / 28%
Research	57	0.87	+1	46%	77 / 23%
Researcher skills and identity	42	0.36	+1	35%	62 / 38%
University activities	50	0.19	+1	66%	56 / 44%
Supervision	49	-0.07	-1	18%	47 / 53%
External non-academic	57	-0.27	+1	37%	37 / 63%
Personal emotions and self-management	54	-0.37	-1	48%	35 / 65%
Total	**407**	**0.35**	**1**	**45%**	**57 / 43%**

3.2 Research group culture for collective success

The research project focused on developing practices for interdisciplinary research excellence, peer learning, and holistic wellbeing. Critical factor for this was the group

culture, which the head of the research group defined using a subsidiarity principle; it holds that a higher ranking body should aid the lesser body to coordinate activities of the greater community, and that decision-making should be taken to the lower appropriate level and closest to those affecting (UNDP 1999).

Furthermore, the group was designed with beneficial and low-risk interdependencies that favored collaboration over competition. The supervisors invested effort in ensuring doctoral students' funding for the entire project, and the Group 1 students described this as a critical factor in allowing them to focus on long-term research planning and risk-taking. However, the students were lacking funding-related pressure and experience in applying funding, which may challenge them in their future work. Notably, the secure funding may explain the low grades in observations of external non-academic factors, as students in Group 1 may have been overly comfortable in their own premises and the team.

To successfully apply the subsidiarity principle into practice, the managers designed "a community tax" concept, which allocated 5% of each research group member's work time for the common good. There was no specific follow-up for this, but it was mainly based on a common agreement. In practice, this turned out to be challenging for a few colleagues who had been working in the team for a longer period. These new culture-building norms and practices were experienced as artificial and unnecessary in a situation that was experienced as well-functioning for personal purposes. In practice, the group needed novel practices and a culture that would be agile in a highly dynamic, academic context. In fact, the research group grew from ten people just before the project to more than thirty by the end of the project.

These group-level norms were critical in ensuring sustainable practices and holistic well-being in the group. It was critical especially for two reasons: first, it strengthened the space for individuals' psychological safety and belongingness. Belonging to a team is one of our basic psychological needs and personal motives, strongly contributing to group-level cohesion (Ryan and Deci 2000). The well-defined, co-developed norms were highly beneficial in new employee onboarding, as they were immediately included in the group functions with a high respect and appreciation of everyone's diverse competencies. Second, these norms set the scene for initiating and facilitating collaboration and peer learning practices.

3.3 The matrix-based activities of the research group

In Group 1, the collaborative practices and interdependencies among researchers were designed across two dimensions. Firstly, the research group level practices focused on intragroup collaboration, support, and peer-learning (Figure 1). Following the subsidiary principle, each group identified their topical needs and co-developed practices to meet those needs. These workshops were organized at least annually, and the activities were iterated based on active reflection from past experiences. These collaboration activities – called 'puuhas', meaning light everyday task in Finnish, ranged from weekly research seminars to research dissemination, skills clinics, and nature walks.

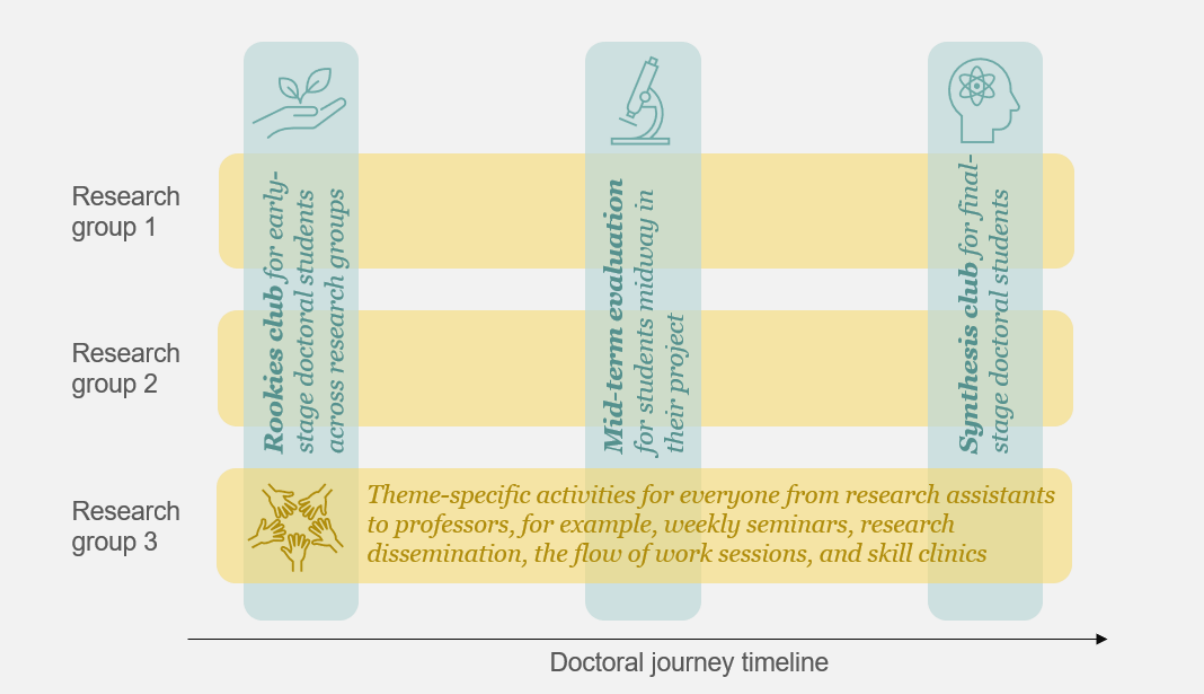

Figure 1. The schematic illustration of designing the peer learning and collaborative practices for research groups and for the interteam learning. The model encourages intra and intergroup collaboration and favors interdependencies over competition. The horizontal, research group specific activities are continuous, focusing on the themes, methods, and depth, whereas the vertical activities focus on interdisciplinary and novel collaboration, focusing more on the stage of doctoral studies. They are fixed-term and target on the needs on that specific stage.

Each team member was assigned to one puuha, and these small groups designed their way to coordinate and facilitate the activities. The hybrid hierarchy allowed the professors to step back and let the doctoral students and postdocs learn about management, planning, organizing, and communication, among many other skills. The professor described how both the doctoral education and research group culture benefitted from these practices: supervision was proceeding in stages, students were open and active in seeking for collaboration, the communication was planned and systematic. For students, the established group profile and reputation were important in supporting their own identity development.

The other dimension of the activities was based on the stage of doctoral students' studies. These activities mainly facilitated intergroup activities and utilized the unwritten, experience-based knowledge in the groups. Rookies club was a group for new doctoral students, focusing on providing scaffolding, peer support, and critical knowledge for the first steps in their research and learning. The monthly meetings focused on providing support and a safe space for discussions. These meetings were later also used for working together and for creating a flow of work time. Synthesis groups were offered for those starting to write their article-based thesis summaries. Based on our research, this was often the time of an existential crisis, poorly structured process, and loneliness. Furthermore, in the beginning of the third year in their studies, students prepared together for the official midterm evaluation and presented their progress reports in pairs.

The Synthesis group aimed to provide structure for the writing and synthesizing process. Students from the previous groups had documented their tips and advice, and these were collected into a “road map” describing the critical steps and things to consider. The groups collected students from different research groups, allowing the groups to focus more on the process, rather than the research topic. Peer support focused on theoretical frameworks, research communication, and disseminating the work. The assumption was that support for the research topic and novelty would come from the supervisors.

These above-mentioned activities were not piloted in the control group, which resulted in student observations of lost and loneliness. For example, some students in Group 2 were lacking supervision, especially with the cohesion of the work. They were also struggling to find information about all the requirements and practical tips, while lacking culture of knowledge on where to ask for help. During the midterm evaluation, students expressed feelings of uncertainty and lack of overall focus on their work.

One student from Group 2 expressed that their supervisor was too busy to support in the final stretch, and they were not comfortable with the level of complete independence. Students had feelings of not sufficient progress.

4 SUMMARY AND ACKNOWLEDGMENTS

This paper presents research-group level sustainable practices that focus on peer learning, interdependencies, and holistic wellbeing. First dimension is the research group level, focusing on continuous practices to initiate collaboration, deep learning the field, and strengthening peer support. The second dimension focuses on practices targeted on the needs on a specific stage of the studies. These fixed-term practices aim to transfer knowledge and provide support from senior colleagues in the team. These practices are easy to initiate by following the subsidiarity principle and an inclusive culture, and a commonly agreed investment in such activities.

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