Ingenjör4.0 – A National Upskilling Programme to Bridge Industry's Skill Gap

Available online at www.sciencedirect.com

ScienceDirect

Procedia CIRP 120 (2023) 1286–1291

www.elsevier.com/locate/procedia

56th CIRP Conference on Manufacturing Systems, CIRP CMS '23, South Africa

Ingenjör4.0 – A National Upskilling Programme to Bridge Industry's Skill Gap

Greta Braun[a], Johan Stahre[a], Bengt-Göran Rosén[a,b], Mattias Bokinge[b]

[a]*Chalmers University of Technology, Chalmers, 412 96 Göteborg, SWEDEN*
[b]*Halmstad University, Kristian IV:s väg 3, 301 18 Halmstad, SWEDEN*

* Corresponding author. Tel.: +46 734 483 591. *E-mail address:* greta.braun@chalmers.se

Abstract

Manufacturing industry needs major transformation to meet disruptive environmental, social, and economic challenges, thus requiring a highly skilled workforce. This paper presents key functionalities, results, and best-practices for the launch and operation of a national upskilling platform. The Swedish upskilling programme Ingenjör4.0's operations have been constantly user-monitored through participant surveys measuring appreciation for training content from the participants and identifying areas with potential for improvement. Thematic analysis of 137 survey responses identified dimensions relevant for an upskilling programme's success. Results show that success factors and hurdles typically lie within the following dimensions: relevance, organization and structure, working life competencies, support from teachers, and collaboration with other learners.

The paper concludes that national programmes like Ingenjör4.0 can, in a short time, have deep impact on skill levels for manufacturing industries in areas such as industrial digitalization. Highlighted success factors are: participant appreciation of highly relevant content, collaboration with other participants, highly competent teachers, and the collaboration between universities. Obstacles for the learners are feelings of mismatch in challenges and prior knowledge, lack of feedback and applicable working life examples in the teaching, and the need for increased collaboration with other participants.

Keywords: Upskilling, Industry 4.0, Digitalization, Future of Work.

1. Introduction

Manufacturing industry needs major transformation to meet disruptive environmental, social, and economic challenges, thus requiring a highly skilled workforce. Two main drivers can be identified, i.e., the rapid technological change resulting from general digitalization of society and the slower but equally important demographic changes of many regions in the world. Both drivers calls for radical increase of industrial digitalization skills [1]. In particular, the demographics of the western world shows a strong decline in the numbers of young and digitally skilled workers [2]. The substantial lack of people in the future workforce threatens the competitiveness of industry and society. This has led to massive upskilling needs for large groups of industry employees. Despite large amounts of education providers, skill gaps remain. Studies show that people in the workforce in need of continuous learning or even lifelong learning that has found motivation, still lacks time and financing [3], [4]. Also policy makers see an urgent need for innovation and talents that support that development. As an example, the European Commission intends to train 1 million talents within Deep Tech over a period of three years, as proposed in the European Innovation Agenda [5]. The goal is to create a database over deep tech talents, startups, companies,

10.1016/j.procir.2023.09.164

and learning opportunities and include a matching tool for the different actors to find suitable talents, or relevant learning items [5].

In a unique effort to leverage industrial digitalization on a national level, the governmentally funded Swedish manufacturing innovation programme Produktion2030 has established an online upskilling programme called Ingenjör4.0 together with the Swedish Production Academy (the Academy consists of the professors of Production Engineering in Sweden) [6].

Ingenjör4.0 is a multi-sided platform for online learning that mobilizes and enables 13 collaborating Swedish universities to offer learning modules targeting industry 4.0 and deep tech technology learning to Swedish industry. After two years of operation, 580 engineers, production managers, sustainability managers, etc. have enrolled in Ingenjör4.0, and their responses have been very positive. Even so, there is room for improvement, especially with regards to retaining the students that signed up for the programme. This paper uses empirical findings from Ingenjör4.0 to 1) thematically analyze the participant's perception of the challenges and success factors with the programme, and to 2) lay forward high-potential improvements on a large-scale, national industrial upskilling programme.

2. Theoretical background

In light of the digitalized manufacturing era, also called **Industry 4.0**, many work tasks change in their nature [7] but also in their allocation [8]. Some tasks that today are performed by humans are better suited for machines and supported by algorithms [4]. Historically, manufacturing industry has been an early adopter of new technologies, resulting in constant changes in the work tasks performed by its employees. This does not mean that humans in the future will have no work tasks, as often raised as a fear of workers who are scared to lose their job; it's rather the opposite. There is strong evidence that technological unemployment is still far away, even in the light of recent advances in artificial intelligence [9]. In 2020, the World Economic Forum [4] estimated that through reallocation of tasks between humans and machines 85 million jobs will disappear, while 97 million new jobs will be created by 2025. Humans will still be key to enable the transformation and they will need new skills to leverage solutions using the technology.

Understanding and embracing the skill-shift is particularly important for engineers, since their normal role is to develop and implement new technologies and create innovation. Thus, upskilling the group of engineers first will have a rapid and strong leveraging impact on the adoption of Industry 4.0 technologies. The Global Manufacturing Competitiveness Index (GMCI) studies highlight talent as the number one key driver for global manufacturing competitiveness [10].

Within the conceptual framework Operator4.0 the authors describe the shift towards technology-enhanced workers and the need for new skills to be able to use the tools [1]. However, the technological transformation is accompanied by other changes such as the **demographical change** [11], and increasing requirements on sustainability [3]. In a lot of developed countries, there is a decline in the working population. At the same time, women are underrepresented in industrial jobs, especially in hierarchically higher positions [12]. This leads to a **talent shortage** and a difficulty to recruit, while the existing workforce and their empowerment becomes even more crucial. This is further highlighted in a new concept which the European Commission calls **Industry 5.0 [13]**. This concept puts the new era of industry on three pillars: sustainability, resilience, and human-centeredness [14]. From a social sustainability perspective, this implies that industry should put the human in the center and empower humans by giving them the right tools and supporting them in their upskilling [13].

However, there are obstacles for employees that hinder their learning and slows down the upskilling revolution. Studies show that less than 13% of registered users of Massive Open Online Courses (MOOC) complete the course they signed up for [15]. What causes the **dropout** is summarized as: lack of interest in the topic itself, lack of time, courses being to challenging, lack of support from peers or teachers, not being able to learn independently, insufficient technological skills for using the platform, wrong expectations, timing, or other experiences that scared them off [15].

Due to the urgent need for well-functioning, effective, and motivating upskilling programmes, this study aims at identifying and understanding the participants' perception of the programme Ingenjör4.0.

3. Methodology

In spring 2022, data collection with quantitative and qualitative survey questions was carried out to get individual answers from the participants of the Ingenjör4.0 programme. Out of 299 registrations of 217 individuals who intended to take learning modules in the platform, 269 modules were started by participants. Out of those, 141 participants successfully completed their learning. After finalizing their learning module a survey shows up, and 137 participants answered it. The survey consisted of quantitative and qualitative questions, whereof the qualitative were included in this study. The quantitative questions gave quantitative data about the participants' time effort in the platform, relevance for their professional work, the webinars, discussions with other participants, application in work-life, career-development, level of difficulty, and recommendation of the programme to a colleague, but the results mainly provide context and do not relate directly to the research questions posed in this study.

The main results in this study stemmed from the analysis of the two qualitative questions asked in the end of the survey which are 1) What was the best aspect of the programme? And 2) What would you change or improve in the course module? The participants were asked to answer in free text.

In the next step, the survey answers were analyzed according to thematic analysis method following the steps described by Braun & Clarke [16]: familiarizing with the data (read and reread to find patterns), coding (find meanings in the data related to the research questions), finding themes (from the codes, interpret the relation to the research question and find themes to summarize the codes), reviewing potential themes (check if there is enough data for each theme, check if some

themes should be separated or combined), defining and naming themes (look at the data belonging to each theme and check that they aren't to different or too narrow, create sub-themes), and present (tell the story of the data in a clear way) [17].

The first three steps of the analysis were done independently by two of the authors until both had defined themes that could be identified from the survey answers. The step of defining themes is described as finding patterns and realizing something that seems relevant for the research question [16], in this study specifically the challenges and success factors for the participants. The suggested lists of themes and the grouping of answers from the two authors were found to be similar and were compared and discussed. A consensus was achieved by:

- merging the two lists of themes,
- discussing the found themes and the according grouping,
- combining some themes, and separating others.

Within the defined themes, comments about challenges and success factors were grouped. Next, the reviewed themes were discussed with the other authors together with the data belonging to each theme. In a last step, one author created visualizations of the themes and sub-themes that represent the data.

In a last step, the results were interpreted to suggest high-potential improvements for this upskilling programme from a user perspective. This was done by first discussing each dimension of challenges and success factors in relation to the features of the platform and what already is a success factor and what could be improved. Then, the dimensions of the challenges and success factors were related to the potential improvements and a visualization was created by connecting the challenges and success factors of each dimension to one or several of the high-potential improvements. This analysis was carried out by the leadership team of the Ingenjör4.0 project by reflecting the identified challenges and success factors of each dimension from the user's perspective and by suggesting concrete requirements to take into consideration from the learning provider's perspective, which in this case is the Ingenjör4.0 project.

4. Results

The results of the two qualitative questions are presented in this chapter. The first question in this study was to find the challenges and success factors of the programme from the learner's perspective. The identified themes from thematic analysis of the 137 survey answers are relevance, organization and structure, working life competencies, support from teachers, and collaboration with other learners. Within those themes, respondents shared their positive comments and their critique on the upskilling programme.

The answers that were bundled into the theme **relevance** relate to the level of difficulty for the learner. While some respondents found the module too difficult, others even wished for more in-depth content and tougher quizzes. Some respondents thought that the module gave them a good overview over the topic. Several respondents appreciated that the content was strongly connected to research.

The most frequently mentioned theme was **organization and structure**. Respondents were commenting on the well-functioning platform but also pointed out the hurdle of technical issues. Some respondents were not satisfied with the scheduling of the live webinars and said they would have wanted to know more in advance the time of the webinars. Others thought the schedule worked well. The quality of videos and microphones was pointed out by several respondents as a point for improvement.

Many respondents talked about the achievement of **working life competencies** through Ingenjör4.0. Some respondents were missing more practical examples or tools to make the connection to their own work while others appreciated the tools they learned to use in the module. There were different opinions on how well the content would be applicable in their work and how well the module prepared them for it.

Another identified theme in the survey answers was **support from teachers**. Several respondents highlighted the highly competent and knowledgeable teachers in the modules. They also felt supported by the teachers during the live webinars and that their questions could be answered. Another topic raised concerning teachers was the lecturing style. Some respondents were satisfied with the lecturing style while some had struggles following, because they would want more real-life examples, and more variation in the content.

The last identified topic is the **collaboration between learners**. Many respondents appreciated the discussions during the live webinars and even wished for more or longer occasions to talk to other learners. A concern raised was that sometimes the collaboration could be improved. One survey respondent suggested to have a concrete case to work on during the live webinar, to increase the interaction. Finally, the respondents appreciated that they could get to know people from other companies and expand their network. Others suggested that they would like to collaborate even more with the people from their own company who also were enrolled. The results from the thematic analysis of the survey answers are presented in figure 1.

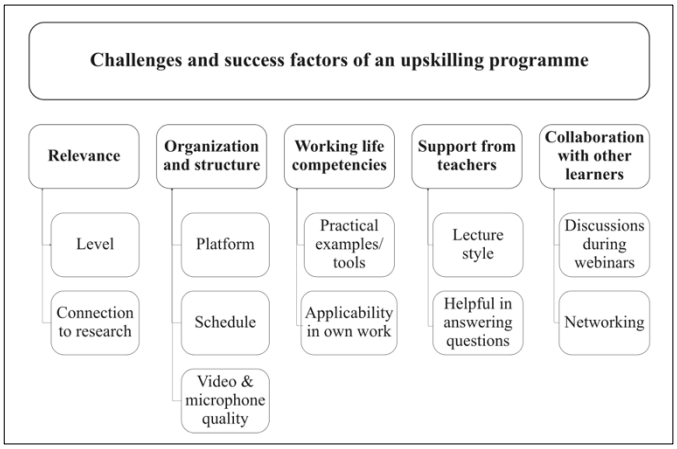

Fig. 1. Challenges and success factors of an upskilling programme.

Possible development lines for the upskilling programme are identified within the second research question by connecting the challenges and success factors from the participant's perspective with the setup of the programme. The

identified dimensions of challenges and success factors were discussed with the leadership team of Ingenjör4.0 by connecting the dimensions relevance, organization and structure, working life competencies, support from teachers, and collaboration with other learners to the way the platform is carried out and could be improved. High-potential improvements are identified by going through each dimension and discussing what is done within Ingenjör4.0 that leads to the positive feedback from the participants on this dimension, but also what could be done or improved within Ingenjör4.0 to meet the participant's needs. This results in the five suggested high-potential improvements on an online upskilling programme.

From the survey answers about relevance, it became clear that the participants value that they are taught by experts on the topic, namely professors from different Swedish universities. To unite all the topics that an engineer needs to learn about in one platform, **collaboration of universities, professors, or experts are key to ensure state-of-the-art content**.

The participants' comments about organization and structure show the importance of a technically functioning platform. In the Ingenjör4.0 project this is rendered possible by giving the teachers a **framework where they can build their modules, using building blocks.**

The participants' responses about relevance, organization and structure, working life competencies, and support from teachers all show that each individual experiences the learning differently, both when it comes to level of difficulty, but also when it comes to the content itself, the support needed, and the time when the learning is carried out. This results in a need for **customizing learning to individual's needs**. Examples from the discussion on how learning could be customized are by supporting the learner in the decision-making of choosing the module, helping them find the content that is relevant just for them, adding optional extra exercises, or adapting the way things are taught to the learning style preference of the learner.

Many respondents mentioned the advantages of having live webinars and being able to communicate with the teachers. The resulting requirement on an online upskilling programme is to have a platform where communication between learner and teacher is realized and **teachers can support the learners through live webinars**.

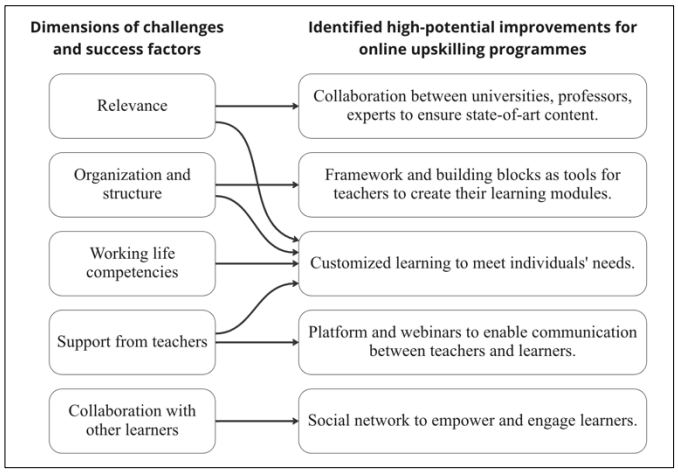

Fig. 2. High-potential improvements on online upskilling programme.

From the comments that participants made about the live webinars and the possibility to connect with people from other companies, but also their own, the requirement on building a **network where participants can learn together** gets key. As part of the social learning, this could enhance their motivation.

The suggested high-potential improvements for an online upskilling programme are summarized in figure 2.

5. Discussion

Based on the experiences and empirical results of the Ingenjör4.0 initiative, we have clearly identified five dimensions of an upskilling programme that are strongly connected to the success but also to challenges for the learners and their motivation. Within the five dimensions – relevance, organization and structure, working life competencies, support from teachers, and collaboration between learners – success factors and challenges have been identified.

The method used allowed respondents to answer in free text and opinions about both challenges and success factors were shared. However, the analysis performed resulted in themes which highlight the duality in the perception of the users. Most of the respondents wrote one or more sentences to each question and elaborated their opinion. The responses were analyzed together, even if stemming from two different questions (1. What was the best aspect of the programme? And 2. What would you change or improve in the course module?).

The thematic analysis of the results led to themes that resemble the dimensions of the HowULearn questionnaire, validated by Helsinki University and used broadly in university context to assess students' learning experience [18]. This questionnaire was used in another study about the Ingenjör4.0 programme and concluded that the dimensions important for the learning experience are study approach of the learner, organization and structure of the programme, relevance and support, feedback, mental wellbeing, and working life competencies. Part of these dimensions could be found in the survey answers of this study. To make sure that the coding and thematic analysis was not based on the own bias from previous work, the coding was done independently by two people, whereof one person hadn't worked with the HowULearn questionnaire before. Still, when reading the survey results and making notes, the bias of the researcher impacts the result and, in this case, the former experience of measuring dimensions in a learning experience were to some extend influencing the result. Also, the quantitative questions in the survey that were not included in this paper, could have impacted the respondents in their answers since the themes in the two included qualitative questions resemble the to some extent the questions in the beginning of the survey.

This study results in a major contribution for the further development of the Ingenjör4.0 programme, but also for other similar programmes, to prevent pitfalls and work with the known success factors. For industry this is an important contribution since many companies are trying to find solutions for upskilling their employees. For society it's important to have a strong industry that empowers employees to learn new things in order to stay valuable for their company.

Even if it was 137 respondents, one limitation lies in the fact that only one upskilling programme for engineers was investigated. The findings can be used generically when defining high-potential improvements for an upskilling platform or when starting one, but there will be a need to reflect on the context the learners work in and see if there could be differences, e.g., if the people are engineers or not, or if the modules are about digitalization in industry. Another limitation is that the 137 respondents represent views from engineers who completed their module in Ingenjör4.0, (since they get to answer the survey after completing). Data from participants that didn't complete their studies are therefore missing. In the future, it's crucial to understand why these participants didn't complete their learning and dropped out.

The answers show that many respondents appreciated the deep knowledge of the teachers. This implies that the collaboration between universities brings value since each module is created by professors and researchers who are experts on the topic and who are nationally and internationally recognized in their fields, often in combination of groups from several universities.

It was insightful that even though all the respondents work within similar positions in industry, the opinions about one of the identified dimensions can be very varied. Therefore, it is important to focus on the individualization of learning and how this could be implemented in such an upskilling platform. The individualization could be about the depth of the content, the teaching style, the scheduling of the live webinars, and more. Another interesting factor is the that almost none of the respondents related the relevance of the module to the aims of their company. The connection between which module the participant choses and the company goals should be further investigated in future studies.

This study is a first step in improving the Ingenjör4.0 platform from a participant perspective. More data from an increased number of participants will improve the precision of the analysis.

6. Conclusions

The transformation of industry and the demographic change requires radical initiatives for upskilling the workforce. The programme Ingenjör4.0 is one attempt that seems to be successful. However, without motivated learners who complete their learning, the lack of talents will remain. This study increases the understanding of high-potential improvements of upskilling programmes and highlights success factors and challenges for learners. This is achieved by thematic analysis of 137 survey results of participants of the Swedish upskilling programme Ingenjör4.0. After coding and thematically group the answers, the two research questions could be answered.

From the learners' perception, the challenges and success factors of the online upskilling programme lie within the dimensions - relevance, organization and structure, working life competencies, support from teachers, and collaboration with other learners.

The suggested high-potential improvements on online upskilling programmes are – 1) collaboration between universities, professors, and experts to ensure that the content is highly relevant; 2) a framework and building blocks for teachers to create their course in line with the other offerings in the platform; 3) customized learning to meet personal needs both when it comes to choosing a suitable learning path with relevant content, but also when it comes to learning style; 4) a platform that enables communication between teachers and learners to boost the feeling of support; 5) collaboration between learners by providing a social network and facilitating discussions.

In the short run, this work will lead to improvements of the Ingenjör4.0 programme. In the longer run, it can help other upskilling programmes and lead to the raise of successful learning journeys and a decrease of the existing skill gap in industry.

Acknowledgements

The authors gratefully acknowledge the funding that makes this work possible. The work presented in this paper is partially funded by the Swedish Innovation Agency, Vinnova, as a part of the Ingenjör4.0 project. The Ingenjör4.0 programme is a result of national collaboration between Professors and teachers at 13 universities within the Swedish Production Academy. The authors gratefully acknowledge this Academy. The authors are also grateful for the support from the Swedish national research and innovation programme Produktion2030 as well as from the Production Area of Advance at Chalmers University of Technology.

References

[1] Romero D, Stahre J, Taisch M. The Operator 4.0: Towards socially sustainable factories of the future. Computers & Industrial Engineering 2020;139:106128.
[2] Eurostat [Internet]. Ageing Europe - statistics on working and moving into retirement 2019 [cited 2023 23 Jan]. Available from: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Ageing_Europe_-_statistics_on_working_and_moving_into_retirement&oldid=581874.
[3] DHL [Internet]. Upskilling to meet the challenges of the future of work DHL website: DHL; 2021 [cited 2023 24 Jan]. Available from: https://www.dhl.com/global-en/delivered/globalization/upskilling-to-meet-the-challenges-of-the-future-of-work.html.
[4] World Economic Forum. Future of Jobs Report 2020. Available from: https://www.weforum.org/reports/the-future-of-jobs-report-2020.
[5] European Commission. A New European Innovation Agenda. 2022. doi/10.2777/066273.
[6] Swedish Production Academy. Ingenjör4.0 2022 [cited 2023 23 january]. Available from: https://www.ingenjor40.se.
[7] Frey CB, Osborne MA. The future of employment: How susceptible are jobs to computerization?. Technological Forecasting and Social Change 2013;114:254-280.
[8] Boston Consulting Group. Report on Man and Machine in Industry 4.0. 2015. Available from: https://www.bcg.com/publications/2015/technology-business-transformation-engineered-products-infrastructure-man-machine-industry-4
[9] Agrawal A, Gans J, Goldfarb A. Power and Prediction: The Disruptive Economics of Artificial Intelligence: Harvard Business Review Press; 2022.
[10] Deloitte Touche Tohmatsu Limited, Competitiveness Co. Global Manufacturing Competitiveness Index. 2016. Available from: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx-global-mfg-competitiveness-index-2016.pdf
[11] European Commission. European Commission Report on the Impact of Demographic Change. 2020. Available from: https://commission.europa.eu/system/files/2020-06/demography_report_2020_n.pdf

[12] McKinsey and Co, In L. Women in the Workplace. 2020. Available from: https://womenintheworkplace.com/2020.
[13] Breque M, de Nul L, Petridis A. Industry 5.0 - Towards a sustainable, human-centric and resilient European industry. Policy brief European Commission. 2021. Available from: https://research-and-innovation.ec.europa.eu/knowledge-publications-tools-and-data/publications/all-publications/industry-50-towards-sustainable-human-centric-and-resilient-european-industry_en
[14] Leng J, Sha W, Wang B, Zheng P, Zhuang C, Liu Q, et al. Industry 5.0: Prospect and retrospect. Journal of Manufacturing Systems. 2022;65:279-95. https://doi.org/10.1016/j.jmsy.2022.09.017.
[15] Onah D, Sinclair J, Boyatt R, editors. Dropout Rates of Massive Open Online Courses: Behavioural Patterns. Proceedings of the 6th International Conference on Education and New Learning Technologies; 2014 Jul 7-9; Barcelona, Spain. EDULEARN14; 2014.
[16] Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006;3:2:77-101. doi:10.1191/1478088706qp063oa.
[17] Braun V, Clarke V. Thematic analysis. Cooper H, Camic PM, Long DL, Panter AT, Rindskopf D, Sher KJ, editors. APA handbook of research methods in psychology; 2012;2:57-71. Washington, DC: American Psychological Association.
[18] Parpala A, Mattsson M, Herrmann KJ, Bager-Elsborg A, Hailikari T. Detecting the Variability in Student Learning in Different Disciplines—A Person-Oriented Approach. Scandinavian Journal of Educational Research 2021;66:1-18. https://doi.org/10.1080/00313831.2021.1958256.