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Developing a Joint Training Course for German Aerospace Companies: Cooperation and Co-Design of Customer Oriented Training Material

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Abstract

Companies of the German aerospace industry rely on hiring employees with no prior experience in aerospace software development, who require an elementary introduction to the relevant topics. A network of eight companies formed under a publicly funded research project aims to develop a compact, joint training course for employees who enter the field of software development without experience in aerospace. The Ingolstadt University of Applied Sciences designed this training course with the required theoretical and practical content. This paper describes the methodology and the steps carried out by the university, starting with the needs analysis in cooperation with experts of software development departments of the companies. The needs analysis took into consideration the different internal work processes and compared the company needs with the subject-related study courses offered in Germany in order to accumulate the common fundamentals of potential employees. The module outline of the course was developed by selecting the content of the training covering the thematic breadth and was completed with the teaching methods and the training material. The evaluation incorporated a short training course for the target group with quantitative and qualitative research methods to assess this joint training course and to explore its benefits among different companies. The developed compact joint training course is able to fulfil the companies' aims by combining the experts' know-how within a stringent course design process. The feedback provided by the participants offered suggestions on how to develop further this methodology and the training course.

Keywords: methodology, new employees, needs analysis, aerospace software development

1 Introduction

The shortage of skilled employees in several industry fields is a long known fact (OECD, 2019; Federal Ministry for Economic Affairs and Energy, n.d.; Bellman & Hübler, 2014). The shortage is imminent especially in the aerospace industry where the engineers need specific skills (VDI und Institut der deutschen Wirtschaft, 2019). The employees are often hired from other pertinent fields e.g. physics, mathematics or software engineering with experience in the automotive industry (Bellman & Hübler, 2014). Such employees enter the aerospace field with previous experience, but not in aerospace; and therefore, require an introduction to aerospace software development. Training courses on specific topics are offered in-house or from international and local providers, but often only address a specific topic in the overall aerospace software development context. Aerospace companies in Germany express the need to offer such training that gives an overview of aerospace software development. This need accompanied by a research project funded by the Federal Ministry for Economic Affairs and Energy, aims to develop a training course taking into account the special situation of training new employees with previous or no experience in aerospace software development.

2 Project & Aim

This network of eight companies from the German aerospace industry was formed in 2017 under a publicly funded research project in order to enhance the aerospace software development processes. The German Project Management Agency for Aeronautics Research and Technology on behalf of the Federal Ministry for Economic Affairs and Energy funded and coordinated the Avionic System Software Embedded Technology-2 (ASSET-2). The project was aimed at developing novel solutions in cooperation among companies working in the same fields that ensure the competitiveness of the German aerospace industry. The eight companies that participated in ASSET-2 represent manufacturers, suppliers, and service providers.

A challenge was how the new developments, innovations and the latest state of technology and research from ASSET-2 will be conveyed to personnel of the companies. This in combination with the shortage of qualified workforce in aerospace software engineering led to the launch of a separate part in the ASSET-2 project, which ended in March 2020. The answer to the question mentioned above, on how employees can acquire innovation, progress and knowledge, is through a training course (Noe, 2010; Heidemann, 2012). The training course was required to cover the needs of eight different companies located in Germany with different internal work processes. The target group of the course would be the (soon) to be acquired employees or the current personnel of these companies who enter the field of aerospace software development without prior experience. They may come from fields outside of aerospace e.g. STEM study courses or the automotive industry. Concerning the current personnel, they may be employees from mechanically or electrical related fields of expertise who intend to work in software-related projects. The project implemented from University of Applied Sciences (Technische Hochschule Ingolstadt - THI) was aimed at developing a compact, joint training course for employees who enter the field of software development without aerospace experience. The training course ought to be a joint course dedicated to all companies of the network, in which

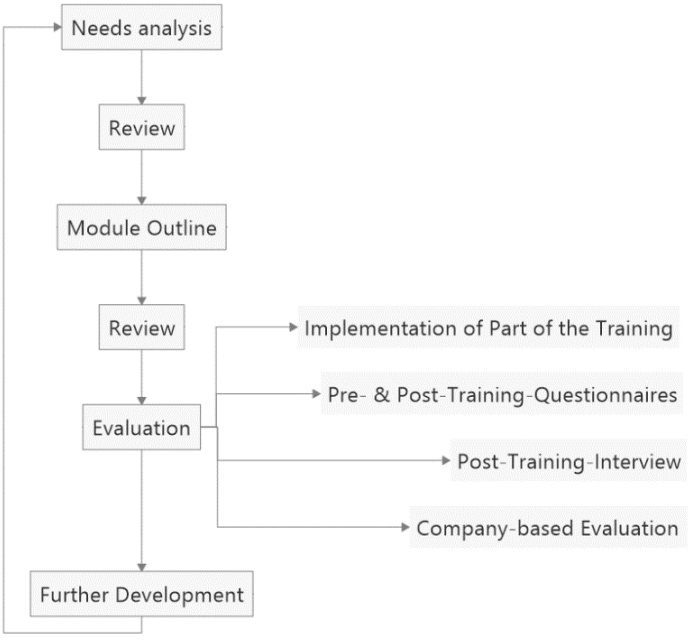
both their current or future employees could participate together. The overall duration of the training course should not exceed the time limit of seven days, which is to serve as an introduction to their new work reality and requirements. The network is internationally oriented and takes into consideration that employees may not speak German fluently. Aerospace companies often work with diverse partners and their employees predominantly speak English. Therefore, the training course is also set to be in English.

This paper describes the methodology i.e. the steps carried out by THI, starting with the needs analysis in cooperation with experts from companies' software development departments in order to answer the following question: How can we develop a compact and joint training course for the needs of recently acquired employees in companies of the aerospace industry in Germany?

3 Methodology

The methodology refers to how this training course was developed in cooperation with the experts of the network companies and how the required material was co-designed. Co-designing states for the cooperation between diverse individuals taking part in the design process in this case e.g. researchers, trainers, experts and potential participants (Steen et al., 2011, Sanders & Stappers, 2008). Thus, the methodology is comprised of the following steps illustrated in the following figure, whose implementation will be described as follows:

Figure 1: Methodology



The methodology of developing the training course starts with the 'needs analysis' to identify the learning needs of the target group and to build a suitable course to cover these. This took

place during workshops and meetings among experts. The experts were either section or general managers in their respective companies or engineers who are experienced in their work field. Hence, this variety widens the perspective‘s and content’s spectrum.

The brainstorming session during the first workshop gathered the learning needs of the companies’ employees from the experts’ point of view. After the first workshop among the experts, further technical personnel assessed the gathered wide content in order to conclude to the learning needs of the companies’ employees. THI intended to identify a common basis of knowledge and skills as a starting point for the training. Sixteen different kinds of study courses (e.g. B. Sc. & M. Sc., Informatics, Aviation & Avionics, and Software System Development) were examined along with their module outlines from different universities in the region of the project partners. Further recognized aerospace University courses were also recognized to identify the knowledge base of graduates. THI compared the results of the questionnaires with the available study courses in Germany in the related fields. As this analysis of the study courses did not offer enough information regarding the background knowledge of the target group, additional information was gathered during a later stage from the Pre-training-questionnaires.

The review after the needs analysis was arranged at this point to define the spectrum of the training’s content. The review took place as a discussion among THI and experts with the intention to focus the wide spectrum of content within the time available for the training course. Based on the companies’ perspective the wide range was prioritized over the depth of the training, in order to offer an overview to the employees about major fields of aerospace software development.

The module outline describes the content of this training course. Subject is the differences between the background knowledge and the content desired from the companies, which intends to cover the learning needs of the employees that enter this field. The learning needs were determined from experts during the needs analysis as mentioned above. The learning needs were translated to general learning aims that were divided and analysed in chapters. The necessary teaching duration of every chapter was defined according to the numbers of subchapters of each chapter. The chapters were further divided into subchapters that contained the specific content. The training course material was developed as slides including handouts for participants and instructors, materials for the hands-on practical exercises, and flip charts. The material for instructors contains all the necessary information about the training course in the form of teaching methods, articles that are not available for public use, exercises and their solutions, literature references, and equipment.

The second review follows the development of the module outline, in order to reach the overall acceptance of the training course for all companies. The experts at this point received the whole training course material and examined it in regard to their company’s specific processes and terminology. This is so that the participants attending this course begin as optimal as possible in each company’s work environment. During this step, there may be details that need to be changed to establish the final material, as well as to verify the training course before the implementation.

The implementation of part of the training belongs to the evaluation and aims at examining the teaching methods and the separation between theoretical and practical subchapters. Due to time

restrictions, an appropriate representative part of the whole training was chosen and executed with the target group as a two-day-long workshop. In this workshop classic lectures, practical exercises in groups and a discussion with an expert from a company were used as teaching methods. Employees from the companies that recently entered the field of aerospace software engineering participated in this workshop to evaluate the teaching methods regarding the material: the difference between theory and practice. The participants had different educational backgrounds and were working on different projects and locations at the companies in the network across Germany.

On the first day of the workshop, before the start of the training course, the participants answered a Pre-training-questionnaire. Alternatively, if possible, the Pre-training-questionnaire can be digitally distributed before the workshop in order to understand the participants' expectations without these being affected by the training course itself. The Pre-training-questionnaire consisted of questions about their educational and professional background, expectations for the content of the training course and their learning needs from their personal point of view. The Pre-training-questionnaire also intends to incorporate the professional background of the participants into the training course, especially in the case of employees who already have experience in other fields or at any of these companies.

Directly after the training course, the participants filled out the Post-training-questionnaire, where they assessed the overall training. Their role was to evaluate according to their personal opinions to what extent the materials and teaching methods used were suitable for the learning aims.

The participants answered both questionnaires anonymously: the Pre-training-questionnaire and Post-training-questionnaire. The answers from the Pre- and Post-training-questionnaires were attached with randomly generated codes in order to be able to connect and compare the answers of the participants before and after the training. Through this comparison, it was possible to draw conclusions about the educational and professional background of the participants and as well as to evaluate the material and teaching methods.

Interviews with the participants were conducted three months after the implementation of this training. They were interviewed personally via telephone by the researcher. No video interviews were possible, because of companies' regulations. This qualitative research method was chosen with the purpose to look back on the training taking into account the new experiences the participants gained during the three months of working on relevant projects, as well as any further critique about the training course.

A company-based evaluation took place in-house between the participants and the experts of the company. The participants and the experts discussed the potential gain for each company and delivered their conclusions about the value of this training course for their company. These company-individual perspectives validated the training course for each of the companies in particular, with regard to future implementations.

The final stage of this methodology is the further development of the training course according to the evaluation and the feedback from the participants as well as the experts. Here, the technical suggestions were considered and used in upgrading the course, which results in a

cyclic process that leads to the next implementation and evaluation. Concrete plans for further development according to the participants' feedback are discussed in the following chapters.

4 Outcome & Feedback

The outcome is a training course with a duration of 56 hours, equivalent to 7 days of training and more than 1100 slides of learning material. This training course contains the fields of process, requirements engineering, embedded architecture and design, verification, and configurations and change management.

The methodology used for the development of this joint training course for German aerospace companies was assessed positively for the following reasons:

- The frequent reviews by the experts along the designing process of this training course kept it strictly focused on the learning needs of the companies. Throughout the course development, the cooperation with the experts and project partners was continuous through meetings of various kinds (e.g. telephonic and face-to-face). The fact that the experts voiced their opinions and conveyed feedback, on every step of development and at the end of the evaluation of this training course, allowed a fast and smooth improvement process. This communication empowered an information flow from the companies to THI regarding course materials and enabled access to most-updated insights from their in-house working practices.

- The target group comes with different educational and professional backgrounds in this training course. To take this into account, this methodology includes a Pre-training-questionnaire in order to ask for the participants 'educational and professional backgrounds and needs. Despite the focus on companies' perspective on the learning needs of the participants, this methodology acknowledged the different previous backgrounds of the participants and therefore set the Pre-training-questionnaire. The answers from the Pre- and Post-training-questionnaires could be connected. This enabled the correlation of the answers in order to analyse connections between the training course material and the educational and professional background, which leads to considering the learning needs of the employees.

- The methodology required to start with the identification of the learning needs and the learning aims. The teaching methods were chosen depending on, which aim every chapter needs to fulfil. The categorisation according to the learning aims resulted in a distinction of the teaching methods that can promote each learning aim e.g. remembering, understanding, and applying information. The variety of teaching methods was positively perceived by the participants and the existence of practical exercises was explicitly named. Because of new employees' lack of professional experience, exercises through practice and basic theory in such a course offers valuable insights into work life. Many of them worked on real exercises and working environment for the first time during this training. As the participants stated: the opportunity to collaborate and discuss with employees from other companies, other sectors and from different working projects also promotes their own interest in their

working subject. For example, the participants had the opportunity to engage with experts who took part in the course. For this particular implementation, of the teaching method "discussion with an expert" the participants got together with the experts for lunch and talked casually about their topics of interest.

5 Discussion

Developing a training course for a network of companies and co-designing it with experts offers tremendous gains for the researcher and/or the trainer. The benefits of co-designing a project concern the project itself, the users or participants and the organisations involved (Steen et al., 2011). The methodology used in this research allows insights from the industry work life to be transferred into the training course. The opportunity to acquire the knowledge directly from experts working on the relevant fields solves problems of finding the knowledge and the experts. Newly formed concepts for aerospace software development of the ASSET-2 project that do not exist in written or online literature were incorporated into the training course.

A needs analysis before the development of a training course is considered to be essential and is found as a starting step in the literature (Noe, 2010; Heidemann, 2012; Schwuchow, & Gutmann, 2015). In this case, the ground inside the network was prepared to boost the cooperation among the experts of the different companies. The cooperation offered remarkable exchange opportunities among companies and employees. The experts, apart from being involved in the needs assessment process, became acquainted with different working procedures and perspectives concerning interesting, controversial or unsolved topics in their respective fields by participating in this process of constructing and designing the course.

A known risk of such co-design methodologies is the friction in collaboration between the diverse people involved (Steen et al., 2011; Roser, & Samson, 2009). The collaboration among eight different companies brought controversies and proved to be the most demanding issue during the development process of this training. To agree on specialised technical content and learning needs, a procedure of coordination among project partners, experts, and THI was necessary. Every review took place after a milestone was reached and it secured the 'up-to-this-point developed content' by approving it. This provided reliability and trust among the companies and project partners.

The feedback from the participants indicated the need to have a training course, which is more flexible and individually developed. The methodology presented in this paper can promote individualization. The clear module outline offers an overview of the learning aims of each chapter and a clear structure that can support the partial engagement with the course material. The role of the Pre-training-questionnaire to distinguish the previous knowledge and experience enhances the possibility to divide the training course material depending on the personal needs of the participants. It would allow the participants to adjust the training course according to their learning needs and their educational and professional background. The participants would be able e.g. to choose which parts of the training course they are going to attend, or how much time they will dedicate to a chapter, or if they want to repeat a chapter or subchapter. The quantity of the learning material of the training course will remain the same. The participants

could determine for themselves when or which material they will attend based on their learning needs. Skipping a part of the course is possible at an off-line course.

The tool to increase the individualization in the training course is digitalization. The training course material could become digital and parts of it could be available via an online platform. Considering the fact that employees travelled from other German cities to participate in this training course, the possibility to have remote access through a digital platform was viewed positively by both participants and companies, due to time and costs saving. Nevertheless, part of the training course ought to remain in a face-to-face environment in order to sustain the communication and interaction during the exercises.

6 Conclusion

The methodology to develop a compact and joint training course with the desired content addressed to employees entering the field of aerospace software engineering has been applied. The developed compact joint training course is able to fulfil the companies' aims by combining the experts' know-how into a training course. With the help of a stringent course design process with milestones and pre-scheduled reviews, the cooperation among all project participants was ensured. The needs of the companies and their employees are taken into account on every step of the methodology.

The development of the training course does not end with the evaluation. The evaluation by the experts and the participants offered material for further development and reboots a new development phase. Upon the two main points regarding individualization and digitalization, the development of the methodology and the course can be continued in the future. Hence, it promotes the evolution of the subject, the collaboration among companies and opens new horizons for future research projects.

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