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Educational Requirements for Aviation and Automotive Engineering: Review of the Anticipation Case Study on Competencies in Aviation and Automotive Engineering During 2014-2021

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Abstract

Technical progress is rapid in aviation and automotive engineering. Even if these branches are different in many ways, they also have similarities, especially in the technical and service sectors. Quite a few technological innovations were first used in aircraft, and, after a few years, those innovations received their own applications in automotive engineering. The common features of these two sectors have not been compared earlier. This study examines the automotive and aviation anticipation results and how the themes have developed between the years 2017-2021. Because of rapid technical development, it is important to determine what knowledge and skills will be needed in the future. This information also predicts the main directions for the education of future mechanics. The main focus of the study was to get respondents (N=81) – experts in the field – to consider their professional competencies from various views and in different time periods, according to the Janus Cones method. The survey describes future professional competencies that will be necessary for successful working in aircraft technology and automotive engineering.

The result of the study is that skills and knowledge need to be used widely, creatively and combined with thinking to produce a new type of knowledge for competence in a certain context. A thematic content analysis led to the components of professional competencies for aircraft technology and automotive engineering being subsumed under five common categories: vehicle technology and proficiency, quality and environment, safety and security, general skills and knowledge, and customer service. Four of these competencies are clearly context bound to aviation and automotive engineering; however, they might also be usable in other technological branches and various study programmes. General skills and knowledge were the only components that referred to general competencies. The results of this study are intended to help with planning curricula that will meet the needs of the next generation of aviation and automotive engineers.

Author Keywords. Skills, Professional Competence, Aviation Engineering, Automotive Engineering, Anticipation, Education.

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1. Introduction

Technological development in every branch of society is occurring rapidly, with the result that nearly every profession will change in the future. Some technologies are even disappearing, while lots of new ones are yet to be born. The current discussion concerns the future requirements of employees and their competencies. Qualitative determination of future employee requirements and new types of professions provide information for vocational education about the new kinds of skills and knowledge that will be needed in the workplace in the future. It also allows vocational and higher education institutions to consider which professions and study programmes are needed. Above all, technical progress is rapid in aviation and automotive engineering. In these industries, it is absolutely necessary to obtain the right professional competencies for the technical and service sectors.

The population of Finland is about 5.5 million people, and the gross domestic product (GDP) in euros is about 240 billion. Education is the basis for success in Finland. Because of this, compulsory education was raised to the age of 18 in Autumn 2020, with the goal of educating the entire age group. At the end of 2020, 871,036 people were under the age of 15, and 3,422,982 people were aged 15 to 64. Air transport accounts for 3.2% of Finland's GDP, and the total transport share of the GDP is about 10%. Trade in motor vehicles constitutes its own share of the GDP, but it is included in the wider statistics of the trading sector (Ristikartano et al., 2014; Finavia, 2021; MINEDU, 2021; Statistics Finland, 2021).

Qualitative investigation and anticipating future professional requirements and competencies as well as workforce demands for aircraft and automotive engineering are important in order to develop education. Without a quantity prediction, there is no information on which to base a plan for the number of study programmes and professional paths. Vocational education for aircraft and automotive mechanics includes the same elements of study, for example, diagnostics, electronics, hydraulics and pneumatics.

A key question is what kind of competencies – attitudes, knowledge and skills (Mulder, 2012) – should be a focus of vocational and higher education in the near future to enhance students' professional competencies to meet future workforce requirements? Consideration of future professional competencies is a significant tool of quality prediction since it will increase information for future competencies and clarify in detail what changes are needed to the content of vocational education in aircraft and automotive mechanics study programmes. The need for professional competencies generally means demands for professional skills and knowledge as well as so-called soft skills or general skills. Quantitative prediction of workforce need produces information on how many study places and workers will be needed in different professions. Technological development will also change maintenance services. According to Perhoniemi (2020), because of the increasing number of battery electric vehicles, sales of and profit from periodic maintenance work will have fallen by 20% in 2024. This will also have an effect on the number of automotive mechanics needed. Aviation maintenance processes are also changing, with operations being outsourced. Maintenance has been split into smaller, separate tasks and checks. In this way, operators can reduce time on the ground, and often, they do smaller maintenance operations during overnight stops. Nowadays, the E-check concept enables the avoidance of daytime maintenance for the first five years of an airliner's lifetime so that nearly all the technical services are performed during nightly pauses (Fournel, 2005). The goal of prediction is to foresee needs and changes in education volume and quality early enough to respond to societal needs. Anticipation should also provide knowledge of a balance between requirements and supply in the workforce. Quality anticipation can provide information on entirely new kinds of requirements in new types of professions and alter competence to reflect the skills and knowledge that education should launch in the future.

This paper considers the situation in the aviation and automotive fields in Finland. The data were gathered from experts working in the fields. The main focus is to present an anticipation description of what types of professional competencies and qualifications will be most important for aviation and automotive engineering in the future. An expert survey was used

(N=81) to produce new knowledge regarding qualifications for professional competencies in aircraft and automotive maintenance services in the future. Because of the similarities in aircraft and automotive education, the common study question was: What competencies do experts consider necessary for future engineering and maintenance services? A consideration of changes is executed in educational volume, and content always demands quality anticipation. The paper suggests content for education and reforms for higher secondary vocational education and higher education. This quality anticipation in the aircraft and automotive fields is part of a larger project for the planning of future employment in automotive, transportation and aviation branches that started in 2014 (Huhtala, 2014).

2. Theoretical Background References

2.1. Professional Competence and the Education System

In Finland, it is possible to obtain aviation and automotive education at the higher education level provided by universities and universities of applied sciences and at the upper secondary education level provided by vocational schools. The Finnish vocational school system offers three types of qualifications: initial, further and specialist vocational. Vocational education develops both the student's professional skills and growth into a civilised person and member of society. The aim of vocational education and training (VET) is to develop and maintain the vocational skills of the population and provide competent human resources for companies. Every year, Finland produces around 100 aircraft mechanics and 1,500 automotive mechanics with initial vocational qualifications. In addition to these figures, it produces from 10 to 100 students with further and specialist vocational qualifications, depending on technical orientation. The Finnish higher education system comprises universities and universities of applied sciences. Universities of applied sciences are multi-field institutions of professional higher education and engage in applied research and development (FNAE, 2020; MINEDU, 2020).

Professional competence is not simply knowledge learnt in education; today, it refers to the ability to use knowledge and skills in social interaction. In fact, competence consists of several parts, such as knowledge, skills, attitudes, experience and personal qualities. These all create the basis for work-life competence (Otala, 2008). Professional competence is a combination of both skills and knowledge. As these are used widely and creatively and are combined with thinking, they will produce a new type of knowledge as an aspect of competence, which also includes a way of organising work and working as part of a team, and the capability to be flexible, accept changes at work and develop one's own work skills (Hätönen, 2005). According to Hero (2019), a future orientation is important for keeping one's focus in the midst of new experiences and finding opportunities for new ways of doing something, even ideas to produce innovations. Using creative thinking skills helps with idea generation and problem-solving. By using cognitive skills, it will be possible to create new knowledge in the form of analytical thinking. Professional competence is a combination of various competencies, such as knowledge, skills and attitudes. However, it is always context bound (Mulder, 2012). The area of management was one of the first in which competence models were developed. Competence models still have a special role in organisations and enterprises where there are plenty of different functions, such as finance, sales and marketing, leadership, informational systems and logistics. According to Mulder and Winterton (2017), competence-based education is a huge step towards a further authentic and holistic education, where students can learn a deep and coherent unity instead of fragmentary information. Employability and position settlement in society requires graduates of the next generation to be able to adapt their knowledge to a specific context. For example, effective job performance demands problem-solving and co-operative skills (Kolb & Kolb, 2011). They also need the ability to adapt to changes, such as changing value patterns, intercultural tensions, societal risks and uncertainty (Mulder et al., 2007).

2.2. Knowledge and Teaching Competence

Knowledge has many dimensions, and it is impossible to classify professional knowledge in a simple form. According to How and Murphy (2001), human thinking is a blend of beliefs, values, knowledge and moral judgements. Knowledge is often factual, verified and logically organised ideas, whereas belief is the combination of ideas and propositions. Both knowledge and belief give a person a feeling for staying in the truth despite justification or external validation. Markauskaite and Goodyear (2014) classified knowledge into three categories: public, personal and organisational. This tripartition is also suitable for anticipating the needs of future skills and knowledge. Public knowledge is created by the available culture and comprises two different topics: codified public knowledge, which includes, for example, education resources, qualification standards and information from books and journals; and non-codified public knowledge, which includes the professional learning that comes through participation in working practices. Personal knowledge is the combination of mental constructs, such as facts, stories, procedures, experiences and principles. Organisational knowledge can be specified briefly as an internal property of an organisation, which is not only agreement on the knowledge of the people who work in the organisation because it is also affected by the environment of the enterprise (Markauskaite & Goodyear, 2014). One way to define skills is to divide them into two main groups: hard and soft (general skills). Hard skills are those that can be obtained through education or training on the job. Soft skills are typically a group of personality characteristics, such as social and language skills or creativeness. According to Seery et al. (2016), soft skills have four grades: capture, context, coherence and perspective.

For teachers, the rapid technical progress in aviation and automotive engineering makes teaching a challenging task. Teachers also have differences in maintaining professional skills. According to a study of information technology training for vocational teachers in automotive and transport engineering, the attitudes of the training attendees were different in three locations around Finland. Most of the automotive teachers were familiar with the automotive-based digital testing and diagnostics equipment, but they were also aware that their students had better skills in information technology compared to them. It was also important to note that teachers felt very pleased with this training in an automotive context because it was the first time they had received generic technological training (Saari et al., 2015). New kinds of information technology and diagnostics systems demand a great deal of updating of the education of the teachers of aviation and automotive engineering and maintenance. In one case study, where the goal was to improve social media (SOME) skills among vocational teachers, it was found that the ability to utilise SOME tools among automotive vocational teachers was poor. It was also surprising that the automotive and transport engineering genres were quite traditional and conservative towards new information technology like SOME (Linna et al., 2015).

2.3. Aviation and Automotive Engineering

Anticipation is an instrument for the development of competence and learning. The OECD Learning Compass 2030 outlines the main objectives, which are conditions, core skills, knowledge, attitudes and values. These are prerequisites for all curricula and their implementation. The Anticipation-Action-Reflection (AAR) cycle is an iterative learning process. In this three-step process, learners continuously improve their thinking and act rationally and responsibly. In the anticipation step, learners become informed by considering what kind of actions taken today could have consequences for the future. In the second step (action), learners have the enthusiasm and ability to take action towards well-being. In the reflection step, learners improve their thinking, which creates possibilities for better actions towards societal, individual and environmental well-being. (OECD, 2019). The differential plasticity of all kinds of skills by age has important implications for the design of effective curriculum work. If the formation of skills is started in time, it will support stronger later-life learning and engagement in school and society (Kautz et al., 2015).

Aviation and automotive industries are different in many ways, but they also have similarities, especially in the technical and service sectors. Quite a few new technological innovations were first used in aircraft, and after a few years, those innovations found their own applications to automotive engineering. Especially in recent years, technical progress has been rapid in aviation and automotive engineering and maintenance processes. Climate change and emission reduction will require innovations in green and renewable energy. Technical challenges and changes in maintenance will be quite similar in both aviation and automotive engineering. In order for these challenges to be addressed, aviation and automotive branches need new kinds of competencies, such as knowledge, skills and attitudes. According to Linna et al. (2015) and Saari et al. (2015), the implementation of new learning objectives and curricula also requires the continual training of teachers. In order to achieve these objectives, more sector-specific teacher training is needed.

3. Methods

Forecasting professional competencies requires a wide understanding of future changes. After the right policy has been decided, the hardest part is to change traditional courses of action. This study of aircraft and automotive mechanics competencies is part of a larger research project. An automotive, transportation and aviation survey was implemented in Finland in 2013 using a qualitative research method. The period of anticipation extended to 2025 (Huhtala, 2014). In clarification each branch formed their own entity. The main focus of this study is compare and combine the ancipating study and results in the aviation and automobile engineering to follow the developing until the year 2021. The main aim of the anticipating survey was to get the respondents – that is, the experts – to think about their professional competence from various views and also in different time periods. There are three main groups in companies: managers, foremen/women and workers. Professional competencies and qualifications for managerial and foremen positions can be acquired in universities or universities of applied sciences. Qualifications for worker positions can usually be acquired through vocational schools as part of higher secondary education. These three main groups were presented as ready-made occupational groups in the companies, but the respondents could also add their own occupations or special craft skills to the other occupational groups. There were 16 experts representing the aviation section and 65 experts representing the automotive section. The respondents were distributed as follows: managerial position (avia, 18%; auto, 38%), worker positions (avia, 32%; auto, 33%), foremen/women positions (avia, 18%; auto, 10%) and in the other assignments (avia, 32%; auto, 18%). The questionnaire of this study was sent to the Finnish aviation training committee, Finnair Flight Academy, and all member companies of the Finnish Central Organisation for Motor Trades and Repairs.

The survey was divided into three time periods for considering employees' professional competences: short-term qualifications, medium-length qualifications and long-term qualifications. All questions were open, and all presentations of the subject matter were as neutral as possible. The aim was to ensure that the questions did not guide the respondents' thinking and answering. The survey revealed qualifications from the occupational groups for two periods: medium-length qualifications (after five years) and long-term qualifications (after 10 to 15 years). This is in accord with the Janus Cones method (Figure 1), which looks backwards and makes predictions for the future with the timing steps.

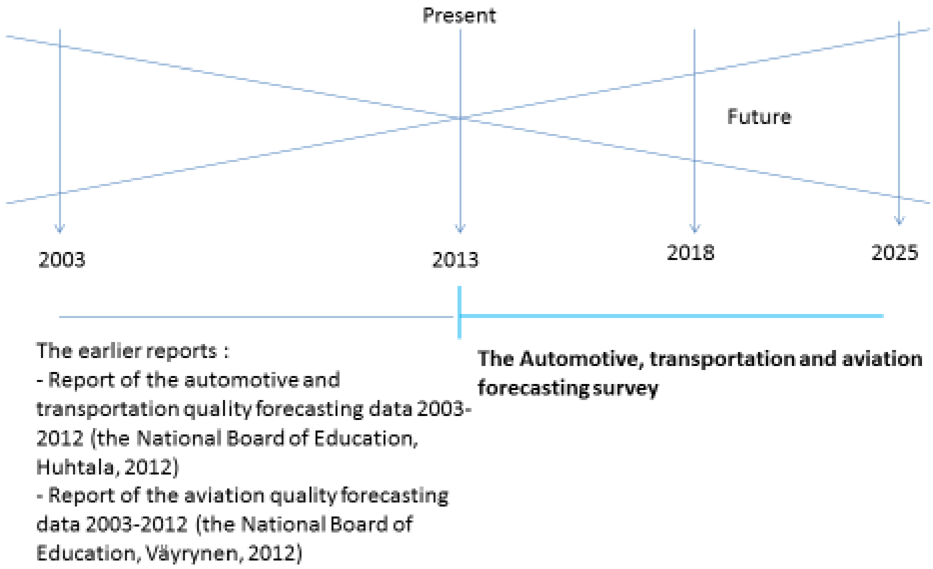

Figure 1: Janus Cones method applied to automotive, transportation and aviation anticipation (Huhtala, 2014)

In the Janus Cones method, each vertical marker denotes a specific time period, such as 5, 10 and 15 years. The centre of the two cones describes the present moment (Saffo, 2007; Sanders, 2017; Carleton et al., 2013). The left cone describes the past, and, in this case, the past information came from earlier reports (Huhtala, 2012; Väyrynen, 2012). The themes of the main categories for the analysis were formed according to Huhtala (2012) and Väyrynen (2012), and the original phrases of the respondents were categorised on this basis. The right cone describes the future. Future patterns can often reflect past patterns, but in our study, they did not completely repeat them. Many sections, which may have no connections, can influence the other processes (Saffo, 2007; Carleton et al., 2013; Heinonen & Ruotsalainen, 2013). In this study, the main concerns were rapid technical progress in aviation and automotive engineering and upcoming changes in maintenance work. These results would define what the important competencies would be for future maintenance work, and conclusions would be drawn about how education should be developed according to the results.

The survey responses were divided into three time periods according to employees' professional competencies: short-term qualifications, medium-term qualifications and long-term qualifications (Figure 1). All questions were open, and all presentations of the subject matter were as neutral as possible. The aim was to ensure that questions did not guide respondents' considerations and answers. The study used thematic content analysis

(Krippendorf, 2019), and the written data were reviewed and monitored using categorisation. The answers of the respondents were first categorised into baskets that were then assigned to five subcategories. Below, results that summarise core competence categories until 2025 are presented. The specific results for the time periods of 5, 10 and 15 years are presented in detail in Huhtala (2014).

Common features of aviation and automotive branches which are the results of the anticipation study, form a categorisation basis, examining developments between 2017-2021. A review of the literature (2017-2021) was performed by searching for articles using keywords e.g. anticipation, aviation, automotive, technology, maintenance, forecasting. These keywords were used in various combinations. The search was made mainly using the University of Turku library's Volter databasis.

4. Results

At these results are combined both in aviation and automotive engineering anticipation study results. The results take also into account how the anticipation has developed during the years 2017-2021.

On the basis of the thematic content analysis, five main categories for the components of professional competence in maintenance work for the future were found: vehicle technology and proficiency, quality and environment, safety and security, general skills and knowledge, and customer service. These anticipation results formulate the categorisation themes from a review of the literature 2017-2021.

4.1. Vehicle Technology and Proficiency

Vehicle technology and proficiency includes diagnostics, programming, telematics, electronics, mechanics, new forms of energy, and new alloy and chemistry skills. To carry out diagnostics, programming and electronics on vehicles with the new technology, there is a need for handling new types of instruments and the use of ICT knowledge according to the vehicle systems, as well as knowledge of electronics that can vary quickly. Diagnostical skills are changing because of self-diagnostical systems. New kinds of vehicle technologies, such as biofuel and electrical, are examples of the need to have knowledge and skills in the new forms of energy. This is also the case for new alloys, such as composite materials that are used in airframes and chassis, which is a totally new aspect of material handling and repair.

Review of 2017-2021 studies:

Arnaldo Valdés et al. (2019) has defined goals for maintaining and extending industrial leadership in aviation and results have the samekind of elements as in this anticapation study. They have five main clusters, which covering the following fields: 1. Mechanical engineering, including biomedical engineering, robotics, and manufacturing 2. Physics, automation, telecommunications, electric-electronics, and computer science 3. Materials science optics, nanoscience, and remote sensing 4. Energy and polymer science 5. Acoustics, thermodynamics, environmental studies, and geology. According to Arnaldo Valdés et al. (2019) aviation research policy should have goal that every cluster can continue gaining excellence in different subfields.

Holkeri (2020) defined the term 'service' in aviation as technical services that are mainly activities related to the introduction of equipment, maintenance, repair, overhaul, logistics, training, documentation, modification and upgrading, as well as the disposition of equipment. Aviation is a quite strongly regulated industry, and decisions about outsourcing non-core elements of the business processes need to be evaluated against several aspects so that costs are not the only factor. By understanding these mechanisms, it is possible to develop the efficiency of aviation in a safe and controllable manner, and this understanding can also provide a basis for studying other equally regulated industry segments. However, the outsourcing of technical services is not only cost-driven in aviation, as clarity and partnership-type relations (a common goal is to work together) appear to be the key success factors in the eventual working relationship (Holkeri, 2020).

Accordin to Obadimu et al. (2020) Minimum Equipment List (MEL) is important, because of increasing complexity of aircraft systems and the diversity of operational requirements, environmental conditions, fleet configuration. MEL is not only related to aircraft, it has also role in service operated by humans within a specific environment.

Information and communication technology solutions (hardware or software based) are increasing in the automotive sector. Vehicles have been transformed into electronic hubs of communication, information, entertainment and other applications. The roles of software, greater computing power and advanced sensors have increased. They enable most modern innovations, from efficiency, connectivity, autonomous driving and electrification to new mobility solutions. Increasing levels of autonomy require the quality and security of vehicle software and electronics to guarantee safety. This means that the vehicle industry has to rethink today's approaches to vehicle software and electrical and electronic architecture (Burkacky et al., 2019; Burkacky et al., 2018). Rumez et al. (2020) researched deals with an overview of protocols and communication patterns for automotive architectures based on the service-oriented architecture (SOA) paradigm and compared them with signal-oriented approaches. They presented deliberations on the current situation of the section of automotive approaches in the fields of firewalls, intrusion detection systems (IDSs), and identity and access management (IAM).

According to Wang et al. (2017), 'traditional maintenance targets' could also develop with an analytical approach. A customer's driving preferences have a great influence on the wear of the automotive parts, for example, on the wear and tear on the braking system. Service companies could provide personalised services for the customer based on the customer's driving behaviour data. This might be one way to eliminate the dilemma of the passive service model and effectively improve service quality.

The digital environment in automotive sector creates new competencies, which are related to information exchange, communication skills and digital literacy. Data processing in automotive industry is also transforming: Automatically processed information increases 5-6 times and at the same time receiving analytical data and management decisions will be decrease 3–4 times (Trubitsyn, 2020).

4.2. Quality and Environment Competence

The second component was quality and environment competence, which included quality and environmental systems and standards. The respondents raised the issue that in the future, there will be an expanding need to be aware of various national, EU and international standards, which will be crucial in order to provide high-level service. The quality of service was seen as a combination of understanding and using quality systems. Also, vehicle, equipment and component manufacturers have their own quality standards, which have an effect on maintenance work. In aircraft maintenance, quality and quality standards play a key role because they define the main lines of security. This combination of quality and security also increases in automotive maintenance, for example, in electrical and telematic systems.

Review of 2017-2021 studies:

According to Kim et al. (2019) aviation is the fastest growing mode of transport in terms of CO_2 emissions, with 2050 global aviation emissions estimated to be 300–700% of 2005 levels and one solution could be biofuel. They have analyzed the transition to aviation biofuels from many perspectives such as: socio-technical, comprehensive, highlighting key barriers and instigators. Alves et al. (2017) has explored biorefinery technologies for aviation biofuels supply chains in Brazil. According to the study co-production of biojet fuel and biochemicals might be a promising alternative.

4.3. Safety and Security Competence

The third component was safety and security competence. The main issues the respondents raised were new vehicle technologies, especially electrical and self-steering vehicles, and the special knowledge and skills that are needed to work safely with these vehicles. This was a part of occupational safety where general well-being in the midst of the changes in the workplace and workforce requirements were concerning the experts. In aircraft maintenance, quality systems play a key role in safety and security. In automotive maintenance, quality systems are important for guiding the general action, but the quality system is not yet a part of individual vehicle maintenance work, as it is in aircraft maintenance.

Review of 2017-2022 studies:

Zio et al. (2019) have looked at application of reliability technologies in aviation. According to Zio et al. reliability techniques consist e.g. following elements: reliability analysis and design, reliability requirement, quality assurance, maintenance, fault diagnosis and prognosis.

Dobrowolska et al. (2020) emphasis the safety of employees and the importance of management in their research. Human factor is an element, which have a significant impact on the level of safety. The development of attitudes towards safety and their relationship to the sense of risk needs the safety management policy in air transport.

Quality control is also part of safety systems. Kar (2019) and Gilliland (2019) compared the safety procedures of aviation and medical industries. The main thing that makes the aviation industry safe is a willingness to analyse mistakes and use them as learning opportunities to improve future performance. According to Kar and Gilliland, this ‘growth mindset’ might be one of the most important aspects of aviation safety, and it should be applied to healthcare. This kind of thinking provides an opportunity to learn not only from mistakes but also from shared experiences. In automotive engineering, new technology (e.g. communication and information technology solutions, autonomous driving and telemaintenance) causes the same kind of reflection.

4.4. General Skills and Knowledge

The fourth component was general skills and knowledge, and this included common teamwork and interaction skills, human resource management skills, language skills and information technology skills. The specialist skills were seen as those that are needed to enhance the cooperation of several specialists to solve complex problems within maintenance.

Review of 2017-2022 studies:

Zamkovoi et al. (2019) has ended mainly with the same education strategy in the aviation results as Huhtala (2014). Strategy for specialist education in the aviation industry includes seven components: 1. Multifunctional and interdisciplinary education programs, including training in information technology and production design. 2.Adaptation of education programs to employer needs and the introduction of models of professional development and education that can accommodate current workers. 3. Broad introduction of a competency approach, focused on the development of human qualities that prepare the worker for constant learning, interdisciplinary collaboration, and the assimilation of innovations.4. Ongoing improvement in the qualifications of specialists and teachers, with the creation of platforms for remote learning and learning organizations (see also: Linna et al. 2015; Saari et al. 2015). 5. The use of artificial intelligence and deep learning. 6. The creation of new educational models, in cooperation with the management of aviation enterprises. 7. State financing of the modernization of education and the formulation of educational requirements for specialists.

According to Jerman et al. (2020) automotive sector requires a new kind of competences. The future employees will need creativity and capability to exploit the high potential of available technologies. In addition to technical knowledge, they need also responsiveness, adaptation to change, problem solving, emotional intelligence, leadership and teamwork competencies.

An organization should try to predict changes and new events, which allows the development of business activities. Vecchiato et al. (2020) suggest the automotive sector enhance research to increase understanding of the relationship between foresight and managerial cognition.

4.5. Customer Service Competence

The fifth component was customer service competence. This competence includes social and communication skills with customers as well as service. Internationality and networking skills were also important. The customer satisfaction point of view was seen as the most important competence among all personnel groups.

Review of 2017-2022 studies:

According to Sopjani et al. (2020), a new shared mobility service could have a role in changing the meaning of private car commuting in terms of its related impact, and it might also increase knowledge and trust in ecologically sustainable options. There are still many challenges to face before shared mobility services can be used in everyday practices. Daily life logistics (e.g. families), time affluence, and effort requirements are critical variables for enabling practice changes towards more sustainable mobility alternatives with private car use (Sopjani et al., 2020).

The automotive industry has observed, that the service business is much more complex and more uncertainty compared to their core businesses. The next step from pure product manufacturers to providers of mobility as a service will require radical changes. The benefit, however, is that mobility services are opening entirely new customer groups that were previously out of the product business reach (Genzlinger et al., 2020).

Table 1 shows aviation and automotive anticipation results as categorisation themes for a review of the literature 2017-2021.

Article	Subject	Categorisation themes				
		1. Vehicle technology and proficiency	2. Quality and environment competence	3. Safety and security competence	4. General skills and knowledge	5. Customer service competence
Alves et al. (2017)	avia	x	x			
Burkacky et al. (2018)	auto	x		x		
Burkacky et al. (2019)	auto	x		x		
Dobrowolska et al. (2020)	avia		x	x	x	
Genzlinger et al. (2020)	auto	x			x	x
Gilliland (2019)	avia			x	x	
Holkeri (2020)	avia	x		x	x	x
Jerman et al. (2020)	auto	x	x		x	x
Kar (2019)	avia			x	x	
Obadimu et al. (2020)	avia	x	x	x	x	
Rumez et al. (2020)	auto	x		x		
Sopjani et al. (2020)	auto		x			x
Trubitsyn (2020)	auto	x			x	x
Arnaldo Valdés et al. (2019)	avia	x	x			
Wang et al. (2017)	auto	x	x	x	x	x
Vecchiato et al. (2020)	auto				x	
Kim et al. (2019)	avia	x	x	x		
Zamkovoi et al. (2019)	avia	x	x		x	
Zio et al. (2019)	avia	x	x	x	x	

Table 1: Review of the aviation and automotive articles 2017-2021

5. Conclusions

The results indicate that the themes of the anticipation study (the period of anticipation extended to 2025) are still current and valid. New method of review combines aviation and automotive aviation content and their combination is also reflected in the results. Clearly the most development and competence in the branches is defined through technological advances (1. Vehicle technology and proficiency) (e.g. Wang et al., 2017; Burkacky et al., 2018; Rumez et al., 2020). This is typical for the fields of technology, but problematic for defining the needed competences. Quite often the actual new needed competences remain undefined. However, skill-related foresight has been addressed in the studies of the Arnaldo Valdés et al. (2019), Obadimu et al. (2020) and Trubitsyn (2020).

In both branches is lifted up the point four (General skills and knowledge), but its contribution is explained by the fact that the subject is wide and covers in general, many content that are also important for other branches. On the other hand, there are also sectoral studies on this theme (e.g.; Zamkovoi et al., 2019; Jerman et al., 2020).

On the third and fourth places are Safety and security competence and Quality and environment competence, which reflect the quality and safety orientation of both branches and of the importance of vehicle safety systems. In terms of quality systems, the aviation sector has moved further, but environmental issues such as emissions and alternative fuels are relevant for both branches (e.g. Kim et. al, 2019; Zio et al, 2019; Obdimu et al., 2020).

The fifth theme, Customer service competence, has a clear emphasis on the automotive sector. This is explained by the fact that in the automotive sector service personnel also do customer service and in the aviation sector, customers are usually aviation companies (e.g. Genzlinger et al., 2020; Holkeri, 2020; Sopjani et al., 2020). The combination of anticipation results broadens the perspectives of both sectors. Technology innovations usually come through aircraft technology to automotive technology. On the other hand, the automotive sector can provide customer expertise from the perspective of internal customer.

The development and adoption of technology are typically assessed further into the future than them eventually materialize. Such are, for example, the development of electronic devices and new forms of energy. Aviation and automotive industry should be more clearly expressed, what kind of competence is needed in the future.

6. Discussion

As the results of this study show, technical progress is rapid in aviation and automotive engineering. Although these branches differ in many ways, they also have many similarities, especially in the maintenance sector. It was interesting to find that the respondents from various professional groups shared a vision of future competencies without significant differences. The methods of the study – Janus Cones (Figure 4) and thematic analysis ¬– are generally used in anticipation research. Anticipation itself is a challenging study method (Saffo, 2007; Carleton et al., 2013), especially in technology branches, since it is very easy to consider knowledge and skills related to new technology and engineering. However, by means of our survey, quality anticipation succeeded in gathering the five components of the aircraft and automotive maintenance elements of professional competence. With this information, it is possible to develop aviation and automotive engineering education. The challenges of the future will focus on how the field of education will use these results as they plan aviation and automotive education and curricula.

Of the five main categories of professional competencies for future maintenance workers produced by the thematic analysis, four of these competencies are clearly context bound (Mulder, 2012) to aviation and automotive engineering; however, they might also be usable in other technological and business branches and various study programmes. General skills and knowledge were the only component that referred to general competencies (Seery et al., 2016). The thematic analysis did not handle the competencies from public, personal and organisational points of view, as Markauskaite and Goodyear (2014) suggest. The results of the study share the definition of Hätönen (2005) that skills and knowledge need to be used widely, creatively and combined with thinking, and in this way, they present possibilities for producing a new type of knowledge as an aspect of competence in a certain context. This result considers future employees' professional competencies from the aspects of safety and security, vehicle technology, proficiency, quality and environment, and customer service. These components do not represent particular knowledge and skills areas. Instead, they represent content areas, where skills and knowledge have to be used in a context-bound situation (Mulder, 2012) in an analytical and future-oriented manner (Hero, 2019) that creates new knowledge and broadens employees' professional competence. These areas include ways of organising work, teamwork, being flexible and accepting changes in the workplace (e.g. Lewis, 2004; Gebauer & Friedli, 2005; Hätönen, 2005). For example, the basic rules and principles of safety and security (knowledge) have to be applied (skills) in a certain workplace in a way that guarantees both occupational and customer safety (e.g. Baines, 2009).

An implication of these results for study programmes is not merely the five content areas of future professional competence but also the way of studying and learning them that uses knowledge in a real context. This means more experiential learning (Kolb & Kolb, 2011) in a real workplace context instead of studying theory to acquire knowledge in the various programmes and practising it afterwards to develop a person's skills. Employability and position settlement in a society requires that the new generation of graduates be able to adapt their knowledge to a specific context. Climate change, for example, presupposes effective work performance in the form of problem-solving and co-operative skills (e.g. Gilliland, 2019; Kar, 2019). There is also a need for the ability to adapt to change, such as changing value patterns, intercultural tensions, societal risks and uncertainty (Mulder et al., 2007).

The Janus Cones method allowed us to undertake thematic content analysis on data (Carleton et al., 2013; Krippendorf, 2019), creating knowledge about educational requirements for aviation and automotive engineering. Anticipatory data of the professional competencies extended to 2025. The data for the study were from 2013, but the discussion about future professional competencies in engineering and maintenance work is even more relevant today. Climate change, post-COVID-19 consumer habits and changes in the market economy require continuing energy and development. The questionnaire for this study was sent to the Finnish aviation training committee, Finnair Flight Academy, and all member companies of the Finnish Central Organisation for Motor Trades and Repairs. The number of respondents (81) reflects views of anticipation. The results represent Finnish aviation and automotive branches. Therefore, the results are not generalisable outside of Finland, but they can be used in the evaluation and development of study programmes and curricula in the aviation and automotive sectors.

Literature review (2017-2021) shows that anticipation results have materialized relatively well. Combination of aviation and automotive engineering anticipation results gives a wider view of competence and education development needs.

The results of anticipation provide direction for future skill needs, and a curriculum creates the foundation for teaching. However, practical results are achieved only with the help of solutions made in teaching. The teaching of technical skills should develop even more working community skills. The maintenance and repair of complex equipment and systems require a wide range of competencies, which can no longer be produced by an individual. In the future, even more teamwork, cooperation and team management (combining individuals' knowledge and skills) will be needed in order to achieve the desired goals.

For vocational, secondary and higher education teachers, there should be increased in-service training, as well as training for student teachers in the field of aviation and automotive education. The teachers should have training in electronics and information, and in hybrid, electric and material technologies. It should also be important for teachers to achieve more competence in applying teaching methods in the workplace or in real-life contexts. Because of rapid progress in aviation and automotive engineering, it is necessary to adopt a multisectoral policy towards engineering science and study programme development in information technology, mechanics, chemistry and electronics. The most important challenge in vocational education is the large number of degrees, which leads to a fragmented educational structure. In the future, it will be more important to concentrate on many-sided competencies rather than narrow and limiting degree systems and qualification titles. One solution could be a modular system that offers students more possibilities for choosing an orientation and course of studies. University-level research should also be used more in anticipating. That is one reason for and a good example of why all educational degrees should be more co-operative. One possible solution could be an annual seminar for all degrees in aviation and automotive education.

The requirements for competencies will become broader as technologies become more complicated. Future employees will be hybrid workers, whose competencies need updating from time to time, and the traditional vocational degree will become history.

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