

# **Is the required Skillset of the Operator 5.0 and the Ageing Workforce compatible? A Review to indicate Synergies and Target Conflicts**

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## **Abstract**

Recent years have been the start of research regarding the topic of Industry 5.0. One of the first fields that have been researched regarding this topic was the human factor since this next industrial revolution has its focus on human-centred production. Due to that, the vision of the so-called Operator 5.0 was mentioned. Similar to its predecessor, the Operator 4.0, this vision contains some skills that are helpful during this revolution. Thus, the ongoing demographic trend of the aging workforce leads to some alternations in the average operators' skills as well. The theoretical background elaborates fundamentals of the Operator 4.0 as well as the Operator 5.0 and already known findings for the skills of the aging workforce. This method shows an exploratory research of the required skills for the Operator 5.0. A combined research question including the demographic trend will be defined in order to compare the results. The databases of Scopus, Science Direct, IEEE and Web of Science have been screened and the mentioned skills have been grouped. The qualitative results show synergies regarding resilience as well as conflicts regarding technology affinity as well as some uncertainties regarding other skills. Further, a comparison to the characteristics of the Operator 4.0 as well as an outlook for future research is given.

## **Keywords**

Demographic Trends, Aging Workforce, Industry 5.0, Operator 5.0, Human-centred

## **1. Introduction**

Dealing with an ageing workforce has become a major challenge for industrial companies since this demographic change is a long-lasting trend. On the one hand, it brings certain issues to different professions of a manufacturing plant, such as pro-duction management, industrial engineering or logistics. On the other hand, it cannot be said that this only leads to disadvantages, and it has no benefits having a higher average age across the shop floor associates.

However, since the role of the Operator is changing a lot and the demographic trend is influence the production in general, it can be discussed whether there are conflicts or synergies of these to progresses.

Talking about the changing role of the production Operator, the so-called Operator 5.0 (O5.0) is a recent concept of an industrial worker involved in the fifth industrial revolution. When searching the database of Scopus, you do not find any hit when searching titles, abstracts and key words for “Operator 5.0” in 2020. In 2021, you find the frequently cited paper from Romero and Stahre about the Operator 5.0 (Romero and Stahre 2021).

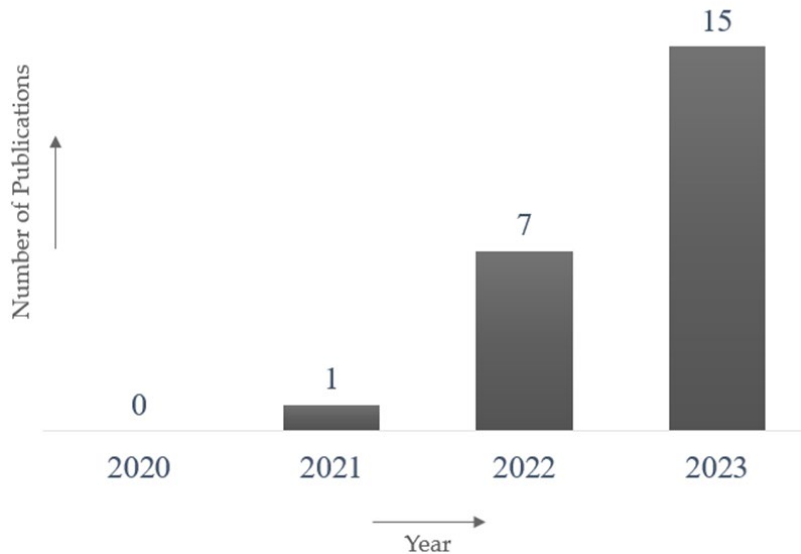


Figure 1. Number of Publications per Year in the Database of Scopus having “Operator 5.0” in TIT-ABS-KEY

And with this initiation, the topic has been researched exponential. It has been the same year that the European Commission has announced the next industrial revolution (European Commission 2021). Figure 1 shows the findings in the platform Scopus, where 2022 seven papers and in 2023 15 papers have been published.

It can be expected that there will be more findings in the future. The search string “Operator 4.0” delivers 175 findings in the database of Scopus at the end of 2023. However, the topic of the Operator 4.0 is still not researched completely (Gladysz et al. 2023; Golovianko et al. 2023). Yet, the next industrial revolution is at the ready (European Commission 2021; Golovianko et al. 2023). Furthermore, this revolution is bringing up the topics even more, having human-centered production as a major headline. One topic that has been discussed is the demographic trend and how companies might deal with the aging workforce. Since Industry 5.0 has its focus in human-centred solutions, the role of the aging workforce becomes even more important (Adel 2022; Lindner and Reiner 2023).

In this paper we want to give estimations whether the demographic trend influences Industry 5.0 in a positive or negative way. Therefore, a theoretical review describes both the fifth industrial revolution and the Operator 5.0 as well as the demo-graphic change and the aging workforce. After that, a clear research question will be defined. For this question, the already existing knowledge about the Operator 5.0 out of the most recent research since 2021 will be reviewed. The findings will be compared to the facts that are available about the aging workforce.

In this paper, the Operator 4.0 as well as the Operator 5.0 are defined as the ideal production associate dealing with the challenges and innovations of the respective industrial revolution. Therefore, the O4.0 is working in an environment having Cyber-Physical Production Systems and the O5.0 in one where he or she is the core part of a human-centered production (Golovianko et al. 2023; Romero and Stahre 2021).

Since human factors will play a major role in Industry 5.0 and the demographic trend will continue to influence the labour market, this topic needs to be addressed (Lindner and Reiner 2023; Calzavara et al. 2020; Kalateh et al. 2022).

A first result shall be whether synergies or target conflicts can be expected. Qualitative results that give a trend for this correlation are the research objectives.

## **2. Theoretical Background**

### **2.1 Industry 5.0 and the Vision of the Operator 5.0**

Industry 4.0 has been seen as era of digitalisation (Golovianko et al. 2023; Mathur, Dabas, and Sharma 2022; Mishra and Paul 2023). Working with terms like Big Data, Internet of Things, Artificial Intelligence (AI) and the Operator 4.0 (Mishra and Paul 2023; Bousdekis, Apostolou, and Mentzas 2020). The Operator 4.0 is therefore an industrial worker that, for example, exists in symbiosis with AI (Bousdekis, Apostolou, and Mentzas 2020). But in 2021 the European Commission as well as some scientific institutes started to introduce the start of Industry 5.0 (Romero and Stahre 2021; European Commission 2021; Xu et al. 2021). This industrial revolution has its focus on personalisation, the integration of human and machine interaction as well as human-centricity (Kalateh et al. 2022; Mishra and Paul 2023). Currently, it is possible that Industry 4.0 and Industry 5.0 co-exist as a hybrid in the upcoming years (Golovianko et al. 2023).

As already mentioned, the concept of the Operator 5.0 has been brought up by Romero and Stahre in 2021. Similar like his predecessor, it describes an industrial worker, that works in symbiosis with the changes of the fifth industrial revolution and has a good skillset in terms of resilience. (Romero and Stahre 2021). Including this one, 23 papers have been published at the database of Scopus by the end of 2023. The majority cites Romero and Stahre. 17 out of these 23 papers have their work mentioned in the references. Further, two more do have Romero as author or co-author. Only four findings regarding the Operator 5.0 are not referencing to their initial work. This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

### **2.2 Demographic Trends and Aging Workforce**

That the demographic change leads to an aging population due to low birth rates and life expectancy is a trend that influences society for quite some time now (Calzavara et al. 2020). Since Industry 5.0 focusses on human-centred production, the influence of the aging work-force on industrial companies might increase even more. There is quite a lot of re-search regarding risks, potentials and challenges of this trend (Calzavara et al. 2020; Frerichs 2015).

It already has been targeted that the aging workforce, or older people in general, is subject to changing skills. For instance, cognitive functions and resilience-related skills might change (Angevaare et al. 2020; Perez-Rojo et al. 2022; Taylor and Bisson 2020). In turn to that, the vision of Operator 5.0 has also some skills that industrial workers should have in the future (Kalateh et al. 2022; Hattinger and Styliadis 2023).

## **3. Methodology**

To summarize first findings for the Operator 5.0 skillset, a systematic review will be used as method. The skills will be compared afterwards to the changing ones of the aging workforce whether there are synergies or any target conflicts.

The literature search follows the procedure below (Figure 2). It starts with the identification of data sets through a database search, in which keywords, abstracts and titles serve as search criteria. The keywords are selected according to a previously formulated research question. Optionally, other already known articles can also be included. After the elimination of duplicates, the data records are screened using the abstracts. The remaining articles are then examined by analysing the full text in detail. Based on certain criteria, certain articles can be excluded from further consideration. Finally, the remaining articles are integrated into the discussion (Dörner, Bures, and Pirkl 2022; Moher et al. 2009). To find search strings, a research question will be defined first (Moher et al. 2009; Santos, Pimenta, and Nobre 2007; Snyder 2019). The PICO approach brings a methodical guide. It is an abbreviated schema and provides a standardized solution, thereby enabling comparability at a scientific level (Dörner, Bures, and Pirkl 2022; Santos, Pimenta, and Nobre 2007).

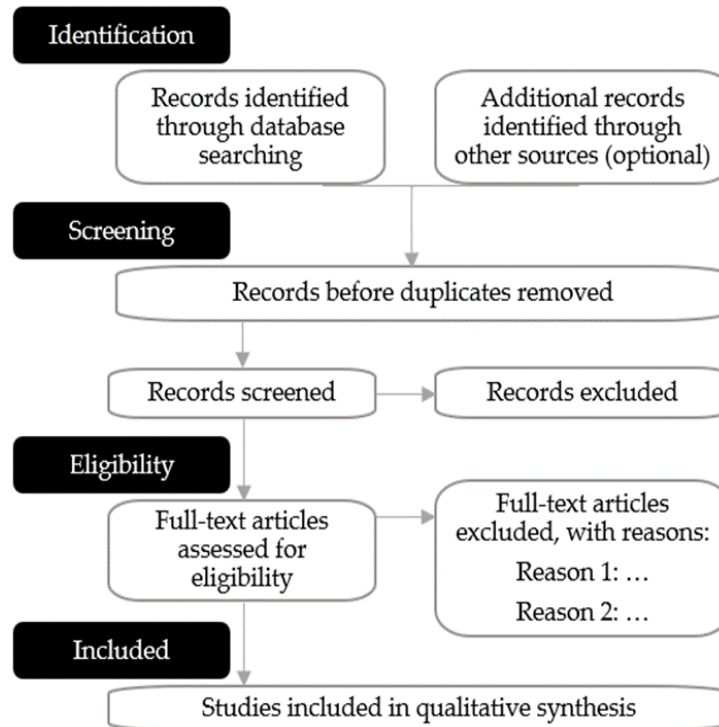


Figure 2. Article Selection Process (Dörner, Bures, and Pirkl 2022; Moher et al. 2009)

PICO starts with the problem itself (Santos, Pimenta, and Nobre 2007). Facing demographic change, the aging workforce is a major issue for society, but also for industrial companies. In the case at hand, the demography and the aging workforce is the problem that needs to be dealt with. Further, an intervention and (optional) a comparison is done (Santos, Pimenta, and Nobre 2007). The intervention is the fifth industrial revolution and its focus on human-centricity. The comparison for the aging workforce will be the required skills for the Operator 5.0. In order to do so, the review will screen the most recent Industry 5.0 papers regarding the necessary skillset for the Operator 5.0. Afterwards, they will be compared to the already known changes of the average production worker’s skillset due to the demographic trend. This marks the outcome, whether there are synergies or conflicts to be expected (Santos, Pimenta, and Nobre 2007).

The summarized result of the PICO method is shown in Table 1. The approach helped to find the following research question: Are there any synergies or target conflicts to be expected between the changing skillset of the aging workforce and the required skills for the Operator 5.0?

Table 1. Resulting Research Question following the PICO Approach

PICO	Research Question
Problem	Demographic Trend & Aging Workforce
Intervention	Industry 5.0 & Human-centred Design
Comparison	Required Skills for Operator 5.0
Outcome	Synergies or Target Conflicts

#### 4. Data Collection

The research question from Table 1 has been visualised in Figure 3. It shows the balancing of the two input factors. On the left side, the demographic trend and the changing skills of the aging workforce and on the right side, Industry 5.0 and the required skills for the Operator 5.0. But the output, in this case a predominant side for either synergies or conflicts, cannot be predicted with the current data.

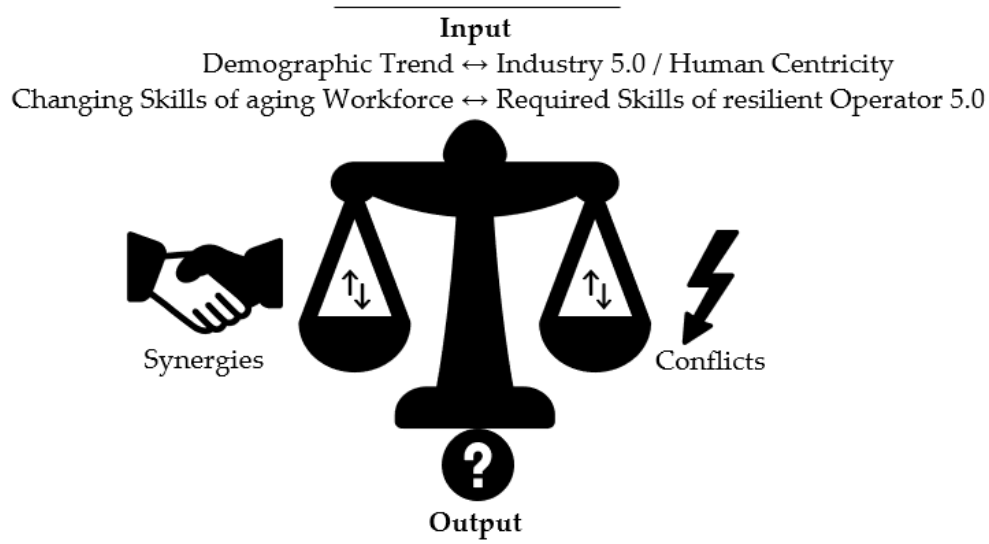


Figure 3. Visualised Research Question showing the unknown balancing between Synergies and Conflict

The method will be divided into two parts. The first run-through should find the necessary skills that are required for the Operator 5.0 using the approach shown. The second one should look for changing skills that are linked to the aging workforce. The required skills for the Operator 5.0 will be summarized in a synthesis. As a next step, these skills will be evaluated whether they grow depending on the worker's age or not. After this, the results will be compared, whether there are synergies or conflicts in the respective skillset.

While looking for a suitable search string for the review, the following facts were found. Looking in the database of Scopus with only the search string "Operator 5.0" has 23 results since the start of Industry 5.0 in 2021 (European Commission 2021; Xu et al. 2021). However, since 23 papers are in total manageable, all of them were included. If we would narrow down the search string more, including, including term like resilience or skills, only 6-9 results were found. In conclusion, these 23 papers will start the review method. By adding the databases Web of Science, ScienceDirect and IEEE, it has helped to broaden the scope of research. The total score has been 35 papers, respective 24 papers after cutting out the duplicates. For those 24 papers, the abstracts have been screened. This first screening has been used to sort out papers that have no focus on human factors. The majority of the 17 papers that have been left out after the screening phase have had their focus rather on the new technologies of Industry 5.0 or the working system itself instead of the production operator. In the eligibility phase, the full-text of the remaining seven papers have been analysed, whether there are required skills for the Operator 5.0 mentioned. After excluding four more papers with no focus in the respective skills, the result of the review method has been three papers for the synthesis, see Figure 4. The limited number of findings makes it rather an exploratory research than a systematic review.

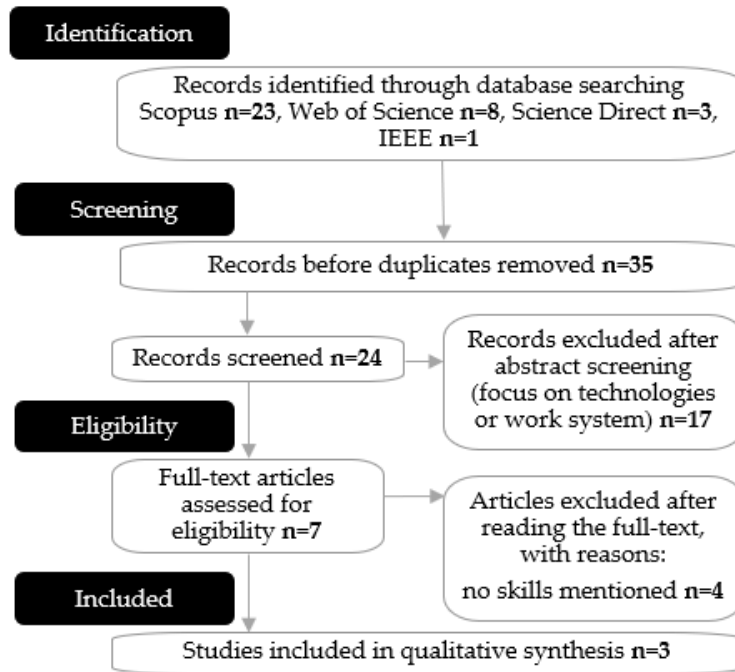


Figure 4. Method to identify the three Findings for the Synthesis (Dörner, Bures, and Pirkl 2022; Moher et al. 2009)

## 5. Results and Discussion

### 5.1 Results for the Synthesis

One of the three finding is the already cited conference paper from Romero and Stahre, having its focus in describing the vision of the Operator 5.0 (Romero and Stahre 2021). Further, the paper from Kalateh et al. about the human role in human-centric industry is included (Kalateh et al. 2022). The last and most recent one is from Hattinger and Stylidis and discusses the transformation to the resilient Operator 5.0 from a quality perspective (Hattinger and Stylidis 2023). Table 2 gives an overview of the three final findings.

Table 2. Results for the Synthesis (Romero and Stahre 2021; Kalateh et al. 2022; Hattinger and Stylidis 2023)

Finding	Title
Romero and Stahre, 2021	Towards the Resilient Operator 5.0: The Future of Work in Smart Resilient Manufacturing Systems
Kalateh et al., 2022	The human role in Human-centric Industry
Hattinger and Stylidis, 2023	Transforming Quality 4.0 towards Resilient Operator 5.0 needs

All of the three findings mentioned necessary skills for the ideal Operator 5.0. However, they not only listed them but described them very detailed. For the purpose of this comparison, the details have not been considered. Moreover, it has been focused on the key words of those skills. An overview of all mentioned skills out of the three findings is given in Table 3.

Table 3. Synthesis of the required Operator 5.0 Skills (Romero and Stahre 2021; Kalateh et al. 2022; Hattinger and Stylidis 2023)

Finding	Skills
Romero and Stahre, 2021	Anticipation; Robustness; adapting to change; recover from unprecedented situation
Kalateh et al., 2022	Communication skills; critical thinking; creative problem solving; entrepreneurship; management; empathy
Hattinger and Stylidis, 2023	Proficiency in advanced technologies; strong problem solving; adaptability; communication skills; willingness to learn and embrace new technologies, focus on KPIs

### 5.2 Resulting Skillset for the Operator 5.0

After the synthesis, the found skills have been grouped under five headlines to make them more manageable. Since some mentions have been similar or the same, that has been practicable. All mentioned skills from Romero and Stahre can be found under the headline of resilience. Hattinger and Stylidis also mention adaptability as resilience-related skill. Affinity for new technologies is used as a headline for both having the proficiency to use them and the willingness to learn and embrace them. Kalateh et al. as well as Hattinger and Stylidis mention communication skills and other social skills such as empathy. Also, they both mention an entrepreneurial mind-set for things like KPI focus, management and entrepreneurship which will be one group and critical thinking and problem solving. With this headlines, it is possible to summarize the synthesis with a skillset of five major abilities of the Operator 5.0 (Romero and Stahre 2021; Kalateh et al. 2022; Hattinger and Stylidis 2023).

In conclusion, the skillset for the Operator 5.0 includes resilience, affinity for new technologies, critical thinking and problem solving, entrepreneurial thinking as well as social skills communication and empathy as the summary in Figure 5 shows (Romero and Stahre 2021; Kalateh et al. 2022; Hattinger and Stylidis 2023).

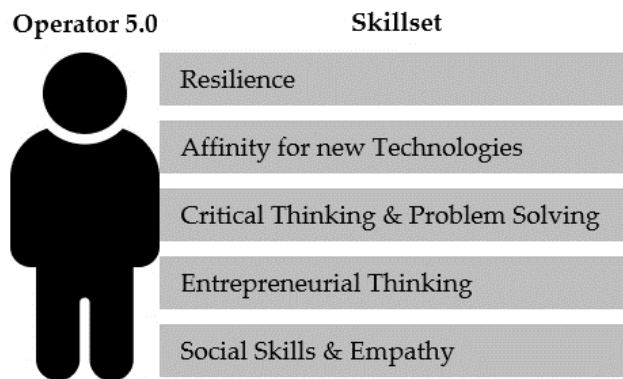


Figure 5. Combined Skillset for the O5.0 from the Synthesis

The five skill groups will now be compared to the already research knowledge of changing skills of the aging workforce. The expected results will be qualitative. It will focus on whether a synergy or a conflict on the skillset is more likely to be expected. Starting with resilience, Romero and Stahre state that this is the skill to focus on when it comes to the Operator 5.0 (Romero and Stahre 2021). This brings a first synergy with the demographic trend. Many studies show that a high percentage of older people are well skilled in terms of resilience (Angevaare et al. 2020). Perez-Rojo et al. screened many more research papers, coming to the same result (Perez-Rojo et al. 2022). Especially during Covid-19 pandemic, the number of studies regarding resilience in older ages increased. New technologies are key in every industrial revolution. So, the affinity for new technologies is a key skill for the Operator 5.0. Nevertheless, there are many barriers for older people in using them (Harris, Blocker, and Rogers 2022). It is commonly known that younger workers, or younger people in general, use a wide range of new technologies (Olson et al. 2011; Peek et al.

2014). Hence, a study from Schroeder et al. in 2023 showed that there is still a research gap when it comes to older adults' intention to use digital technologies (Schroeder et al. 2023). For problem solving, no clear influence can be given with the data at hand. On the one hand younger individuals are said to have a stronger alignment between autonomy goals and self-centered problem-solving (Hoppmann, Heckman Coats, and Blanchard-Fields 2008). And on the other hand, older adults show a higher correspondence between generative goals and problem-solving focused on others (Hoppmann, Heckman Coats, and Blanchard-Fields 2008). Kalateh et al. named creativity as a skill regarding problem solving (Kalateh et al. 2022). Hence, it is difficult to find a correlation with creativity and worker's age (Chan et al. 2013; Cui, Wang, and Liu 2022).

Entrepreneurial Thinking and the focus on company values und KPIs is said to be shaped in an inverted u-shape, meaning it is highest in ages between 30-50 years and lower for younger and older ones (Zacher et al. 2021). That correlates with the career commitment. However, this skill is hard to predict in modern society since the changing jobs and companies is more common than it has been years or decades ago (Brimeyer, Perrucci, and Wadsworth 2010). Since the aging workforce prefers methods from human resource management that focus on rewards, recognition and participation as well as performance evaluation, rather than flexibility, this brings in the guess of tendential synergies in this very point. Also, job security becomes more important for older people (Pinto, Da Silva Ramos, and Nunes 2014). Therefore, sustaining the company can be seen as major goal for them. Regarding social skills and empathy, for instance, Pollerhoff et al. said empathy decreases (Pollerhoff et al. 2022). In turn, Oh et al. found that the older age groups have more empathy (Oh et al. 2020). Beadle already stated five years ago, that more research is needed regarding this topic (Beadle and De La Vega 2019). However, they said that according to their review, more studies point out that emotional empathy is increasing with age, where cognitive empathy decreases. Emotional empathy means feeling emotions that depend on what other people are experiencing, while cognitive empathy is the ability to take another person's perspective (Beadle and De La Vega 2019). The expected influence is a tendential synergy, too. This is due to older people's good communication skills, especially when it comes to interpersonal problems (Blanchard-Fields, Mienaltowski, and Seay 2007).

Table 4 shows the overview of the five major skill groups from the synthesis and the expected influence after this comparison.

Table 4. Summary of expected Synergies and Conflicts

<b>Skill</b>	<b>Expected Influence</b>
Resilience	Synergies expected
Affinity for new Technologies	Conflicts expected
Critical Thinking & Problem Solving	No clear influence
Entrepreneurial Thinking	Tendential Synergies expected
Social Skills & Empathy	Tendential Synergies expected

### 5.3 Discussing Changes among recent Literature

Since three findings is a low number for a systematic review, other search strings will be added in order to get better findings regarding the skillset and its influences. Since the term of Operator 5.0 is a very recent topic, the respective skill well be reviewed with the predecessor, the Operator 4.0.

Therefore, we will screen the database with a search string that combines the term of Operator 4.0 with each one of the five skills mentioned in Table 4. An overview can be found in Table 5. For some skills, synonyms or declination of the word is used.

Starting with resilience-related skills. Here, the respective noun and adjective are combined into the search string "Operator 4.0" AND (Resilience OR resilient). The affinity for new technologies is a little bit more complicated. Here,



multiple synonyms are used. For instance, a new technology is often named as emerging or disruptive. This offers the benefit of not naming the respective technology. A new, emerging or disruptive technology in Operator 4.0 era might not be one anymore. Critical thinking and the problem-solving ability remain, same for social skills and empathy. For Entrepreneurial Thinking, the word Entrepreneurship has been added.

Table 5. Created Search Strings for first Comparison

Skill	Search String
Resilience	“Operator 4.0” AND (Resilience OR resilient)
Affinity for new Technologies	“Operator 4.0” AND (New OR Emerging OR disruptive AND technologies)
Critical Thinking & Problem Solving	“Operator 4.0” AND (“Critical Thinking” OR “Problem Solving”)
Entrepreneurial Thinking	“Operator 4.0” AND (“Entrepreneurial Thinking” OR Entrepreneurship)
Social Skills & Empathy	“Operator 4.0” AND (“Social Skills” OR Empathy)

The search is not as structured as the initial review for the O5.0 was. However, this should only lead to some further discussion whether there have been major changes in the skillset from the Operator 4.0 to the Operator 5.0. Searching the database of Scopus delivers some results for that. In comparison to the first review, no filter regarding the publication date has been made. Table 6 summarizes the 14 total findings, having two search strings with no result.

Table 6. Number of Findings for each Search String

Search String	Findings in Title, Abstract, Key Words
“Operator 4.0” AND (Resilience OR resilient)	10
“Operator 4.0” AND (New OR Emerging OR disruptive AND technologies)	0
“Operator 4.0” AND (“Critical Thinking” OR “Problem Solving”)	3
“Operator 4.0” AND (“Entrepreneurial Thinking” OR Entrepreneurship)	0
“Operator 4.0” AND (“Social Skills” OR Empathy)	1

For this search, no time range for the date of publication has been added. However, most of the 14 total results are from 2021 on, only one is from 2018. Thus, three out of the five search strings delivered results in the database of Scopus.

Table 7 shows the findings for that link the Operator 4.0 to resilience-related skills. A majority of the findings focusses on the health of the operator and how to track these characteristics (Ambrogio et al. 2022; Berti et al. 2023), having the aging workforce in mind. Despite having the risk of trust issues when the company tracks too much information, this highlights also the necessary social skills of the Operator if these measurements find understanding. Overall, the findings mention some skills that are also related to the main findings of this article regarding the O5.0, resilience and affinity for new technologies. A healthy Operator is also mentioned a lot. (Ambrogio et al. 2022; Berti et al. 2023; Cimino et al. 2023; Danys et al. 2022; Gladysz et al. 2023; Kaasinen, Anttila, and Heikkilä 2023; Kim et al. 2022; Romero and Stahre 2021; Ruppert et al. 2022; Zambiasi et al. 2022)

Table 7. Findings for the Search String “Operator 4.0” AND (Resilience OR resilient) (Ambrogio et al. 2022; Berti et al. 2023; Cimino et al. 2023; Danys et al. 2022; Gladysz et al. 2023; Kaasinen, Anttila, and Heikkilä 2023; Kim et al. 2022; Romero and Stahre 2021; Ruppert et al. 2022; Zambiasi et al. 2022)

<b>Author &amp; Year</b>	<b>Title</b>	<b>Operators characteristics</b>
Ambrogio et al. (2022)	Workforce and supply chain disruption as a digital and technological innovation opportunity for resilient manufacturing systems in the COVID-19 pandemic	Resilience; Health; Affinity for new technologies
Berti et al. (2023)	Towards Human Digital Twins to enhance workers' safety and production system resilience	Health
Cimino et al. (2022)	Empowering Field Operators in Manufacturing: a Prospective Towards Industry 5.0	No focus on Operator
Danys et al. (2022)	Visible Light Communication and localization: A study on tracking solutions for Industry 4.0 and the Operator 4.0	Affinity for new technologies
Gladysz et al. (2023)	Current development on the Operator 4.0 and transition towards the Operator 5.0: A systematic literature review in light of Industry 5.0	Resilience; Affinity for new technologies
Kaasinen, Anttila and Heikkilä (2022)	New Industrial Work: Personalised Job Roles, Smooth Human-Machine Teamwork and Support for Well-Being at Work	Health; Affinity for new technologies
Kim et al. (2022)	Human Digital Twin System for Operator Safety and Work Management	No focus on Operator
Romero and Stahre (2021)	Towards the Resilient Operator 5.0: The Future of Work in Smart Resilient Manufacturing Systems	Resilience
Ruppert et al. (2022)	Intelligent Collaborative Manufacturing Space for Augmenting Human Workers in Semi-Automated Manufacturing Systems	Affinity for new technologies
Zambiasi et al. (2022)	Supporting Resilient Operator 5.0: An Augmented Softbot Approach	Resilience; Health

Barrata et al. (2023) mentions multiple social skills besides critical thinking and problem solving in regard to the O4.0 (Baratta 2023). The other two findings mentions new skills in general, but also regarding new technologies (Scheffer et al. 2021a; Heikkilä, Honka, and Kaasinen 2018a) (Table 8).

Table 8. Findings for the Search String “Operator 4.0” AND (“Critical Thinking” OR “Problem Solving”) (Baratta 2023; Scheffer et al. 2021b; Heikkilä, Honka, and Kaasinen 2018b)

<b>Author &amp; Year</b>	<b>Title</b>	<b>Influence to the Operator</b>
Baratta et al. (2023)	How Cognitive Capabilities for Smart Operator enhance Human-Robot Collaboration	Critical Thinking & Problem Solving; Social Skills & Empathy
Scheffer et al. (2021)	How to make augmented reality a tool for railway maintenance operations: Operator 4.0 perspective	Critical Thinking & Problem Solving; Affinity for new technologies
Heikkilä, Honka and Kaasinen (2018)	Quantified Factory Worker: Designing a Worker Feedback Dashboard	Critical Thinking & Problem Solving; Affinity for new technologies

Regarding social skills, only one finding mentions them linked to the Operator 4.0. Further, Margherita and Zabudkina (2023) also highlights the need for digital skills as well, what is interpreted as affinity for new technologies. (Margherita and Zabudkina 2023a) (Table 9).

Table 9. Findings for the Search String “Operator 4.0” AND (“Social Skills” OR Empathy) (Margherita and Zabudkina 2023b)

<b>Author &amp; Year</b>	<b>Title</b>	<b>Influence to the Operator</b>
Margherita and Zabudkina (2023)	Building human-centric organisations with Industry 4.0 technologies in the Industry 5.0 era: A micro and meso level perspective	Affinity for new technologies; Social Skills & Empathy

In summary, four out of the five skills mentioned in Figure 5 were found for the Operator 4.0, too. Entrepreneurial Thinking seems to be a topic that is new to the Operator 5.0 in comparison to the Operator 4.0.

## 6. Conclusion and Outlook

Since the demographic change is more of a megatrend that lasts decades, it is likely that even the next industrial revolutions need to deal with it (European Commission 2021). Operator 4.0 as well as the Operator 5.0 will be influenced by the parallel trend of the aging workforce. Therefore, research, as done in this paper, needs to be done consistently and ongoing over the next years and decades in order to get industrial companies as well as the society ready. The review shown has its limitations since there were only three findings due to the topicality of the O5.0. However, future work could analyse the influence of demographic trends on the Operator 4.0 as well to get a more comparable and comprehensive result.

It is going to be more and more important to increase the synergies and counteract the conflicts. Further, the unpredictable skills still need to be focussed since they can have an influence as well, even though it is even less predictable than the other skills. For instance, Schroeder et al. on the one hand states that there is still a research gap for the intention of older people using digital technology, which could be used for counteracting barriers (Harris, Blocker, and Rogers 2022; Schroeder et al. 2023). This is an example, with major influence since technologies are key for every industrial revolution (Mathur, Dabas, and Sharma 2022). However, especially in Industry 5.0 the resilience-related skills such as robustness, adapting to change, recovery from unprecedented situation are important for this very next industrial phase (Romero and Stahre 2021).

As discussed, a clear quantitative statement of the dominant site cannot be given with the data that is currently on hand. For a structured review, three final findings are not sufficient. However, it is still possible to give tendencies for most of the required skills. The synthesis of the review shows, that there are different possibilities on how demographic trends can influence the future of Industry 5.0. The comparison and enhancement of the outcome with the knowledge of the Operator 4.0 can help. However, more research regarding the O5.0 needs to be done. Especially the entrepreneurial thinking needs to be found in more studies, since this is a major novelty from O4.0 to O5.0. A clear distinction between these two might be possible once more papers of the O5.0 have been published.

For future experiments, it is important to evaluate the skills of younger and elder production operator both qualitative and quantitative. If so, it would be possible to state which skills regarding the vision of the Operator 5.0 become more or less likely. If the result would be a proven correlation between the operator’s age and the readiness to become an Operator 5.0, this synergies or target conflicts might become bigger. Especially in Europe, where the demographic trend leads to a higher average age of industrial production workers, decade by decade (European Commission 2021; Calzavara et al. 2020).

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