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Article

Next Generation Small Urban Manufacturing: Apprentices' Perspective on Location Factors, Mixed-Use, and Shared Spaces

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Abstract
Advancements in technology and architecture enable mixed-use development while normative settings like the European Commission's New Leipzig Charter support the concept of a productive city. Nonetheless, small urban manufacturers (SUMs) including crafts still face displacement due to property prices, conflicts with housing, planning laws, and building regulations. Urban planning and economic development emphasise the importance of identifying and redeveloping suitable sites for urban manufacturing companies. Largely unanswered, however, is whether the next generation of manufacturers (apprentices) want mixed-use locations within the city or space sharing, and if so, under which conditions. Based on two written surveys, this article examines the location requirements of SUMs in Germany and the willingness of apprentices in the Ruhr area to embrace mixed-use buildings and shared spaces. The study focuses on three craft groups: store crafts, workshop crafts, and construction site crafts. The results show that SUMs in Germany and manufacturing apprentices in the Ruhr prioritise car- and security-related infrastructure, as well as low real-estate costs. Store crafts specifically seek affordable and well-connected ground-floor locations. Construction site crafts prioritise (un)loading facilities for trucks on industrial land over sustainable transport infrastructure, and they differ significantly from the other craft groups in terms of mixed-use preferences. However, all craft groups express openness to mixed-use locations with offices and additional workshops and shared spaces like garages, canteens, and showrooms. The article suggests that commercial courtyards could effectively meet the requirements and desires of apprentices and urban planners alike.

Keywords
built environment; company sites; mixed-use; productive city; shared spaces; urban manufacturing; urban planning and design; vocational students

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1. Introduction and Context

Urban manufacturing, or urban production, is defined as "making and converting tangible goods in mixed-used and often densely populated areas by preferably using local resources and local value chains" (Brandt et al., 2017, p. 27; see also Brixy et al., 2023; Hill, 2020). In this article, we focus on small urban manufacturing (SUM) companies (Mistry & Byron, 2011) including crafts and distinguish between them using the Chamber of Crafts Düsseldorf classification (Handwerkskammer Düsseldorf, 2022) of craft groups: construction site crafts, workshop crafts, and store crafts.

Small urban manufacturers (SUMs) are experiencing a decline in number of employees, companies, and production sites (Bonny, 2021; Brixy et al., 2023; Ferm, 2016; Ferm et al., 2021; Greenhalgh et al., 2021). This is due to international competition with economies of scale, low transport costs, or not-priced-in CO_2 emissions, as well as high wages and high rents, which threaten the profitability of products produced or repaired locally (Gärtner & Schepelmann, 2020). SUMs also compete locally with

other real-estate sectors, such as office buildings and hotels in commercial areas and housing in mixed-use areas, which can result in high property prices and industrial gentrification (Ferm, 2016; Graham & Spence, 1997). Furthermore, challenges in mixed-use areas include conflicts with housing, planning laws, building regulations, or material transportation, which can lead to SUMs relocating into commercial or industrial areas or even company shutdowns. The overall result is that for manufacturing companies and their employees, everyday commutes are getting longer as mixed-use city planning, including manufacturing, has become a rarity (Steinborn, 2020).

In response to these challenges, urban planners and politicians outlined guiding principles, such as the New Leipzig Charter, to reintegrate production and manufacturing into mixed-use neighbourhoods and secure manufacturing spaces. The document sets the normative goal of transformative urban development, including the cornerstones of the productive city with short distances and space for small and medium-sized manufacturing companies, urban agriculture and the green city, including the circular economy (European Commission, 2020). In addition, due to the Sustainable Development Goals, the Paris Agreement, and the European Commission's Green Deal (Angstmann et al., 2022; Hörnschemeyer et al., 2022) there is an increasing focus on the circular economy including industrial symbiosis, area or resource sharing and exchange, and environmental innovation and its diffusion (Clausen & Fichter, 2021; Domenech et al., 2019). SUMs can promote the circular economy primarily through maintenance and repair and also the reprocessing and refurbishing of existing properties to reduce raw material consumption (Hausleitner et al., 2022; Tsui et al., 2021).

From an urban planning and economic development perspective, it is necessary to identify, keep, and redevelop sites to suit small-scale manufacturing companies as part of the circular economy, including production and repair shops or waste treatment in the urban area (Brandt et al., 2017; Fedeli et al., 2020). Several cities, including Berlin, Bremen, Brussels, Düsseldorf, and Vienna have recently developed strategies to promote and maintain mixed-use structures including SUMs (Meyer, 2023).

The research project UrbaneProduktion.Ruhr, funded by the Federal Ministry for Education and Research from 2016 to 2022, focused on structurally weak districts in the Ruhr area as opportunity areas for SUMs. The project aimed to develop recommendations for action and living labs to attract manufacturers to vacant stores to enhance district attractiveness and create diverse employment opportunities (Läpple, 2016). The Ruhr in northwest Germany with its approximately 5.1 million inhabitants was chosen because of its ongoing transformation and its character as a metropolitan region with little space for manufacturing and industry. Once a leading industrial region in Europe, heavily reliant on steel, coal mining, and chemical industries, the Ruhr has been undergoing structural change towards a more service-oriented economy since the late 1950s (Zakrzewski, 2019). However, unemployment remains relatively high, and not all former employees from the mining sector and defunct industries have found employment in services (Dahlbeck et al., 2022). Furthermore, the redevelopment of industrial areas is costly due to contamination, and there is a lack of new commercial and industrial space. While cities like Düsseldorf, Munich, and Vienna have developed mixed-use spaces for SUMs (with a certain degree of subsidisation) the Ruhr has not.

Despite these developments, there is limited prior knowledge regarding the specific location requirements and willingness to use mixed-use buildings or share spaces of SUMs in general, and no information at all about the next generation (Handwerkskammer Düsseldorf, 2022; Meyer, 2019; Mistry & Byron, 2011; Steinborn, 2020; Zentralverband des deutschen Handwerks [ZDH], 2019). Planning and participation processes have failed to give attention to the next generation, particularly apprentices and students who will follow in the footsteps of current urban manufacturers (Bathen et al., 2022; Meyer, 2023). Nevertheless, planning and changes made in the built environment today will directly affect this group.

Therefore, this article addresses the following questions: (a) What are the location requirements of SUMs and manufacturing apprentices, and do they differ? (b) Are there differences among the craft groups? (c) Can manufacturing apprentices envision using mixed-use buildings and shared spaces, and if so, in what way? (d) What should be considered when planning buildings or sites for future SUMs?

To address these research questions, the article provides a comparative study of two surveys regarding required location factors: one of SUM companies in Germany, based on a secondary source analysis (Malec et al., 2019; Meyer, 2019) and another of apprentices (next generation of manufacturers) in the Ruhr area. Further, the surveys were compared in order to cross-check the validity of the results. In addition, the apprentices' survey considers their willingness to use mixed-use and shared spaces to achieve a productive and circular city. The study differentiates between the samples according to the three craft groups to uncover the special requirements of each. The hypothesis is that there are differences between the crafts groups that influence their location and mixed-use requirements in the cities.

The next section considers the theoretical background of the investigation. Section 3 turns to the methodology, which is followed by the presentation and discussion of the results. The article concludes with recommendations for action and further research questions.

2. Small Urban Manufacturing: Location, Mixed-Use, and Shared Spaces

Urban manufacturing bridges theories of location (Christaller, 1933; Weber, 1909), clusters (Porter, 2000),

and regional innovation systems (Asheim & Isaksen, 1997; De Propris & Hamdouch, 2013) on the one hand and approaches of a foundational (De Boeck et al., 2017), circular (Hausleitner et al., 2022; Tsui et al., 2021) and local economy (Brandt et al., 2017; Henn & Behling, 2020; Krenz et al., 2022; Lowe & Vinodrai, 2020) on the other. While the theories play a more important role in mainstream economic development, they also are usable for SUM (Sassen, 2009). Work on the foundational economy looks "at the local and regional consumption and the (potential) production of daily life goods" (De Boeck et al., 2017, p. 1880) as well as creating local jobs. The circular economy aims for a climate-neutral future and advocates mixed-use and shorter distances between manufacturer and consumer, more repair options within cities, and circular economy services (Hausleitner et al., 2022; Paech, 2016; Tsui et al., 2021). SUM companies play a particular role in sustainable urban development, e.g., in the sectors of energy transition, resource conservation, demographic change, mobility, nutrition, and resilience (Handwerkskammer Düsseldorf, 2022). Moreover, as part of the local economy SUMs play a role as crafts with particular spatial relevance as they frequently carry out a direct supply function for the local population and are committed to the local development of the location (Henn & Behling, 2020).

Despite the potential benefits, as Brandt et al. (2017, p. 27) point out, "the proximity to living spaces requires…low-emission modes of production to avoid conflicts with residents." Consequently, it is essential to create an environment for urban manufacturing that benefits manufacturers and residents alike (Rudolf et al., 2023).

Following a classification of the Chamber of Crafts Düsseldorf (Handwerkskammer Düsseldorf, 2022, p. 2), this article categorises SUMs into three groups of crafts, which are also used to analyse the empirical data:

1. Construction site crafts are predominantly found on construction sites. The specific location requirements are less pronounced and essentially focus on the required area and traffic access. They include: (a) construction, e.g., masons, building mechanics, construction fitters, and civil engineers; and (b) interior construction, e.g., carpenters, heating, ventilation and air conditioning (HVAC) plant mechanics, and electrical engineers.
2. Workshop crafts often have very specific location requirements which can conflict with neighbouring uses, especially housing. They include: (a) crafts for commercial use, e.g., metalworkers, plant mechanics, galvanisers, electromechanical engineers (excluding information technicians, cleaners); (b) automotive sector, e.g., automotive mechatronics technicians or service mechanics; and (c) construction components, e.g., furniture producers, glaziers, and joiners.
3. Store crafts rely on attractive city and district centres. Space requirements are generally lower, but the quality of the surroundings is more important. They include: (a) food (technology), e.g., bakers, butchers, brewers, and confectioners; (b) health craft, e.g., orthopaedic technicians, hearing aid manufacturers, and dental technicians (often heavily digitalised); and (c) service providers, e.g., tailors, musical instrument makers, and cobblers (excluding hairdressers, barbers, and beauticians).

In the following sections, we look at the location factors for SUM companies and existing shared spaces, infrastructure, and facilities as an architectural and technological solution to achieve mixed-use.

2.1. Location Factors for Small Urban Manufacturing

Classical location theory emphasises transportation accessibility as a crucial determinant, while labour availability is less significant. Weber (1909) later introduced agglomeration economies as a third factor (Sassen, 1991). Recent empirical studies on location factors for urban manufacturing companies tend to focus on global factors to shed light on reshoring and industry 4.0 activities (Bhatnagar & Sohal, 2005; Burggräf et al., 2019; Busch et al., 2021; Ellram et al., 2013; Johansson & Olhager, 2018). In contrast, this study looks primarily at small-scale, local factors that are significant for small and medium-sized enterprises and local crafts.

Nowadays it is more difficult for SUMs to find desirable locations. Historically, small businesses clustered along industrial streets and railway arches, fostering vibrant local manufacturing communities. Unlike railway viaducts, industrial streets with small-scale buildings have experienced residential and commercial gentrification with mixed-use buildings often integrated into them (Ferm et al., 2021). A global political shift towards neoliberalism has "led to the privatization of government-owned land, reducing municipalities' abilities to protect industrial land" (Tsui et al., 2021, p. 13) and municipalities have converted much industrial land for higher tax revenues. In addition, SUMs have a limited search radius for location. In comparison to large companies, small businesses often choose city sites based on proximity to the founder's residence rather than rational decision-making (Hahne & Stackelberg, 1994).

In light of this, we take a comparative look at location factors in the crafts sector drawing on various applied empirical studies (see Table 1 in the Supplementary File). The studies clearly illustrate that good transport connections, especially to the motorway, are by far the most relevant factor for craft companies (Domenech, 2020; Handwerkskammer Düsseldorf, 2022; Hausleitner et al., 2022; Landes-Gewerbeförderungsstelle des nordrhein-westfälischen Handwerks, 2005; StadtGUUT, 2022; ZDH, 2019). Furthermore, proximity to customers, good public

transport, availability of parking and expansion spaces, and skilled workers are also important. In addition, low costs for the property are essential (Handwerkskammer Düsseldorf, 2022; StadtGUUT, 2022). Domenech (2020) shows that storage space is crucial for 25% of the surveyed companies, although companies often refrain from storing materials due to spatial constraints and prefer to optimise their processes. One problem is the lack of storage space for waste management and recycling, which "leads to cross-contamination and reduces the ability to introduce high-quality recovery and recycling of industrial and commercial waste" (Hausleitner et al., 2022, p. 95). Storage space is therefore essential to contribute to the circular economy.

According to Sevcik et al. (2022), the most significant potential for urban commercial real estate can be found in city districts, particularly for properties that are more difficult to market due to the age of the building and the high demand for high-quality amenities. As space requirements differ according to craft groups (ZDH, 2019), the question arises as to whether and which of the craft groups would want to use mixed-use spaces.

2.2. Mixed-Use Buildings, Shared Spaces, and Services as Environmental Innovation

The original European city was characterised by mixed land-use and mixed-use buildings. Medieval townhouses consisted of business and production rooms on the ground floor, apartments on the upper floors, and storage under the roof. The Wilhelminian buildings constructed in dense blocks were also mixed-use (Söfker-Rieniets & Schmidt, 2023). Due to industrialisation and its emissions, the rapid growth of cities and new transportation options, mono-functional residential areas increasingly emerged based on concepts like Howard's "garden city" and Le Corbusier's "functional city" and fences came to represent company sites (Hüttenhain & Kübler, 2021). With the New Leipzig Charter and concepts like the 15-minute city, short distances and mixed-use buildings are experiencing a renaissance (European Commission, 2020; Roost & Jeckel, 2021; Ryckewaert et al., 2021). With the amendment of the Building Use Ordinance in 2017, Germany introduced the *Urbanes Gebiet* ("urban area"; according to the German Building Use Ordinance §6a BauNVO) intended to facilitate the planning of mixed-use cities combining living, services, and manufacturing (Brandt et al., 2017; Schoppengerd, 2023). So far, however, planning for such areas often just mixes services (gastronomy, office, retail stores, social or cultural institutions) and residential functions. New builds of mixed-use structures that include manufacturing remain scarce (Bathen et al., 2022; Haselsteiner et al., 2023; Rudolf et al., 2023).

Nonetheless, individual manufacturers are increasingly having contact with the public and the urban fabric and, in some cases, creating visibility and permeability on company sites (Sgobba, 2012). Concepts like industrial symbiosis (Chertow, 2007), the sharing economy (Lessig, 2008), and sharing spaces (Hahne, 2018; Hausleitner et al., 2020) or machines (Handwerkskammer Düsseldorf, 2022) have evolved in an attempt to achieve higher utilisation of facilities, conserve resources, save costs, and promote cooperation in the context of the circular economy (Handwerkskammer Düsseldorf, 2022; Hausleitner et al., 2022; Lange, 2017). Hüttenhain and Kübler (2021) show that some transforming multi-national companies are highly interconnected on-site (e.g., use waste heat for other processes or develop material cycles). The context and size of the site determine the contact points with the public. These may include ground-floor public areas, attractive public spaces, (social) infrastructures like an open canteen (Figure 1a), and space for external operators like shared storage space. This may involve trivialities, such as offering a storage area for another company (e.g., for the rental of sauna barrels; Figure 1b). "In this way…the necessary critical mass can be reached for some facilities through the joint use of staff and neighbourhood. Offers become more profitable….They serve as intermediaries between the company and the city" (Hüttenhain & Kübler, 2021, p. 373).

By organising small and medium-sized craft companies in commercial courtyards, especially in multi-storey commercial locations (Figures 1c and 1e), costs can be lowered, facilities (e.g., shared kitchenettes, Figure 1d; or shared car-parking, Figure 1e) and resources can be bundled, and synergies can be created. They can trigger ideas of by-product reuse, infrastructure sharing, and the joint provision of services for crafts (Haselsteiner et al., 2023). Within an urban context, sharing resources has become an increasingly attractive option. For start-ups in particular, the possibility of sharing expensive machines can be a good alternative to investing in their own equipment (Handwerkskammer Düsseldorf, 2022; Figures 1f and 1g). For example, in Solingen, knife sharpeners and manufacturers are currently using a previously vacant store as a showroom, event space, and sharpening workshop (Figure 1h).

However, there are obstacles regarding data security, liability in the event of damage, restriction of flexibility, and entrepreneurial responsibility with a high degree of trust required between cooperation partners. According to the Chamber of Crafts, shared-use sites thus offer innovation impetus, but will only be considered for a minority of businesses (Handwerkskammer Düsseldorf, 2022). There is motivation for sharing if "resource sharing can reduce costs and/or increase revenues or industrial symbiosis can enhance long-term resource security by increasing the availability of critical resources" (Chertow, 2007, p. 13).

In existing industrial areas, it is often difficult to know the requirements and perspectives of all the local companies, which usually differ, and individual companies lack the resources or ideas to transform an area. Through the development of a complex manufacturing network by

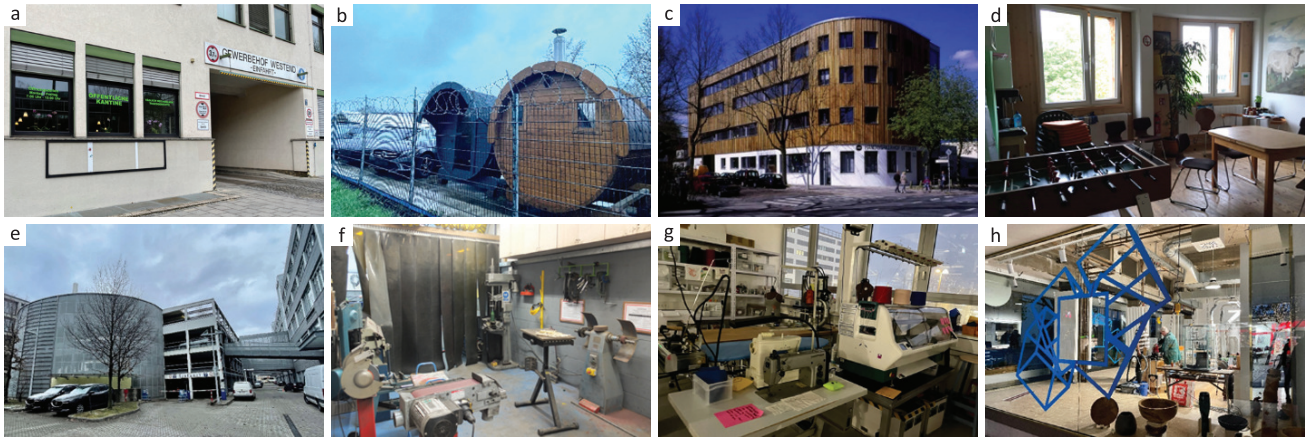

Figure 1. Overview of examples of existing shared spaces eligible for SUMs: (a) Canteen in commercial courtyard Munich-West; (b) storage area used for sauna barrels and cars, Bochum; (c) commercial courtyard Hamburg-Ottensen (Yvonne Rokita); (d) kitchenette in commercial courtyard Hamburg-Ottensen (Marcel Schonlau); (e) parking spaces in commercial courtyard Munich-East; (f) individual machines in the RUB Makerspace, Bochum; (g) production room Black Horse Workshop, London; (h) showroom "Gläserne Werkstatt," Solingen.

actively linking complementary businesses and services, facilitating exchanges of technology, creating synergies, and collaborating on complex projects, opportunities for industrial symbiosis and the circular use of resources may emerge (Bathen et al., 2022; Hausleitner et al., 2020). However, will SUMs be willing to share facilities?

3. Methodology

To address the challenges of displacement of SUMs, the limited industrial land available for them, and the scarcity of models of mixed-use that include SUM, this article aims to discuss how the next generation of potential urban manufacturers envision their locations.

We hence conducted an online survey of manufacturing apprentices in the Ruhr in 2020 and 2021 and compared the results with a "SUMs Survey" in Germany carried out in 2019 (Malec et al., 2019; Meyer, 2019). Both surveys investigated the perceived importance of location factors, allowing us to compare the perceptions of present SUMs with the next generation of manufacturers. For the "Apprentices Survey," we designed and pretested a questionnaire targeting the next generation of workers and entrepreneurs in manufacturing disciplines (Williams, 2003). The aim was to determine their requirements concerning desired locations, including mixed-use and shared spaces (according to existing shared spaces in Figure 1). In the German dual-training system, apprentices already work in companies and thus have gained initial experience with location requirements. The questionnaire (Supplementary File) includes questions with four-point Likert scales and dichotomous, ranking, and a few open questions; it was adapted and structured into five sections: general information, (training-)company characteristics, value chains and sales markets, images for future location factors and site characteristics, and socioeconomic data.

Table 1 displays the methodological procedure, responses, and sample characteristics including company size, craft group, and gender of the participants. There is a misrepresentation of the three characteristics. Construction site and workshop crafts are barely represented in the survey of SUMs and companies from the store craft sector are overrepresented compared to the apprentices' survey (for more information about the samples see Table 2 in the Supplementary File). It is assumed that this explains the differences in terms of gender and company size. The average age of the apprentices was 23 and more than half (56%) of them plan to be self-employed, 20% do not, and the rest is uncertain (see Table 3 in the Supplementary File). We considered all responding apprentices in the analysis, as their wishes about their future workplace are of concern, be it as managing owners or employees.

Due to the Covid-19 pandemic, the apprentices' survey was conducted exclusively online. It was distributed to 138 teachers from 25 vocational colleges and 68 professors and lecturers from three universities of applied sciences and one technical university covering about 60 disciplines. Initially, teachers, professors, and lecturers in the central Ruhr area were asked to forward the link to their students in the final year of training in 2020. Due to the low response rate, we extended the period and contacted student councils at various universities and three Chambers of Crafts. Despite this, the response rate hardly increased and the initial teachers and lecturers were contacted once more in 2021, which finally resulted in 13% of the teachers forwarding the questionnaire. The response rate of the students who received the questionnaire was about 24%. This included 79% apprentices, 9% students from universities of applied sciences, and 12% university students—all referred to as apprentices in the following. Since not all participants answered all questions equally in the surveys, the

Table 1. Methodological background and sample characteristics.

	SUMs	Apprentices
Research method	Secondary analysis of a SUM company owner survey (Malec et al., 2019; Meyer, 2019)	Survey of manufacturing students and apprentices conducted in 2020–2021
Research area	Germany	Ruhr area
Research interest	Location factors	Location factors Conceivability of mixed-use buildings and shared spaces
Number of responses	114 (80 fully completed) Response rate: 6.6%	357 (181 fully completed) Response rate: ~24%
Number of employees at company		
1–2	55%	3%
3–10	31%	17%
11–50	12%	40%
51–250	2%	40%
Craft group		
Construction site crafts	14%	36%
Workshop crafts	10%	39%
Store crafts	76%	25%
Gender of participant		
Male	50%	74%
Female	50%	26%

numbers (*n*) differ in the tables (Bartlett et al., 2001). Further, we must note that in the case of apprentices, all crafts were surveyed and no distinction was made according to location, as we generally wanted to know which future locations they would be interested in if they were planning to become self-employed. In contrast, in the SUMs survey, only urban locations were addressed. Data collection problems were mainly due to limited access to vocational and university students due to the pandemic and the lack of technical infrastructure in the vocational colleges.

In the following, we compare the apprentices and SUMs survey using descriptive statistics and mean value compression for independent samples. To identify the differences between the surveys and the craft groups, a Mann-Whitney-U (for two groups) respectively a Kruskal-Wallis-test (for the three crafts groups) was performed on independent samples since there is no normal distribution. To summarise the location factor items, a factor analysis (maximum likelihood) was performed (see Table 4 in the Supplementary File), resulting in seven factors explaining 42% of the variance of the data.

4. Results and Findings

First, we look at differences in location factors between the two samples, followed by differences in craft groups within each sample. Then, for the apprentices, we present the results of whether and what kind of mixed-use buildings and shared spaces they can imagine.

4.1. Location Factors by Sample

Starting with the results of the location factors (Table 2), the most important location factors according to the mean for the SUMs are the low real-estate costs (3.67), which are also very important for the apprentices (3.13). Most important for the apprentices (3.39) and also important for the SUMs (3.33) is the car- and security-related infrastructure, which includes security against burglaries as well as the availability of parking spaces, good internet, mobile phone, road connections, and availability of space. The results confirm previous studies on SUMs.

The factors of central ground-floor location, close to home and low real-estate costs differ significantly between the two surveys. In the SUMs survey, store crafts and small companies predominate, which might explain the higher relevance of a central ground-floor location and being close to home. These findings underline that it is worth considering ground-floor locations for SUMs, as well as car and security-related infrastructure and low real-estate costs, both in the reactivation of vacancies in city centres and in the redevelopment of districts. The SUMs show greater importance of location factors that are more attributable to urban mixed-use

Table 2. Relevance of location factors for SUMs and apprentices.

	Relevance for SUMs			Relevance for apprentices			Mann-Whitney-U-test
Factor	*n*	mean	*SD*	*n*	mean	*SD*	Significance (two-sided *p*)
Sustainable transport infrastructure	76	2.83	0.87	184	2.82	0.73	0.705
Car and security-related infrastructure	76	3.33	0.60	184	3.39	0.39	0.695
Proximity to other facilities	75	2.54	0.79	184	2.48	0.57	0.517
Close to home	74	2.47	1.04	184	2.10	0.64	0.012*
Low real-estate costs	75	3.67	0.68	183	3.13	0.68	< 0.001*
Central ground-floor location	76	3.29	0.79	185	2.55	0.67	< 0.001*
(Un)loading facilities for trucks on industrial land	73	2.42	0.89	185	2.60	0.77	0.147

Notes: Values of 1 "unimportant" to 4 "very important"; * significant difference.

locations than manufacturing apprentices. Therefore, to gain a deeper understanding of the apprentices, we make further differentiations following the craft groups.

4.2. Location Factors by Craft Groups

The Mann-Whitney-U-test showed hardly any significant differences between the craft groups for the SUMs. The similarities of the surveyed SUMs may explain the few differences. The only significant difference between the two craft groups is sustainable transport infrastructure that is more important for store crafts (Table 3). In the apprentices survey we compare three craft groups because of the larger population. The Kurskal-Wallis-test shows that workshop crafts differ significantly from construction site crafts with regard to sustainable transport infrastructure. In addition, workshop crafts differ from store crafts in terms of car and security-related infrastructure. There are further significant differences between store crafts and the others concerning the central ground-floor location and (un)loading facilities for trucks on industrial land. In the case of apprentices, there is a clearer distinction. As expected, store crafts prefer central ground-floor locations, whereas truck-loading areas and good car and security-related infrastructure are less important.

4.3. Conceivability of Mixed-Use Buildings and Shared Spaces by Apprentices

The location factors show that central ground-floor locations play a role in the store crafts, but they do not shed light on whether and what kind of mixed-use structures are envisioned by the apprentices. Table 4 gives an overview based on craft groups of the conceivability for apprentices of having further uses in their building and of sharing spaces. It becomes apparent that most of the crafts can imagine sharing the building with a service use (0.80) or an additional workshop (0.73). However, there is a significant difference between the construction site's crafts and the others—with construction site crafts being less open to sharing with an additional workshop, retail, and gastronomy. Further, it is interesting that the store crafts cannot imagine having a residential use in the same building, which is a significant difference from the construction site crafts.

When asked whether the apprentices could imagine sharing their company site, building, individual rooms, or machines with other businesses, there was the most approval from all apprentice groups regarding shared parking spaces (0.80), while 22% of the store crafts already share parking spaces in their actual company situation (see Tables 5 and 6 in the Supplementary File). Further, a majority of all craft groups could imagine using a shared canteen (0.66) or a showroom (0.53). Shared storage space was conceivable, especially for workshop crafts (0.53) and store crafts could imagine sharing a kitchenette (0.54). However, there are no significant differences according to the Kurskal-Wallis-test between the craft groups. Shared spaces are so far not very common in existing manufacturing companies but in some cases are conceivable.

5. Next Generation Small Urban Manufacturing? An Outlook

The article gives insights into the location requirements of SUMs in Germany and the willingness of the next generation of manufacturers in the Ruhr to consider mixed-use buildings and shared spaces. Consideration is given to three craft groups. The results show that SUMs in Germany and apprentices in the manufacturing sectors in the Ruhr area generally require car and security-related infrastructure and low real-estate costs. This confirms existing literature and studies on craft location factors. The importance of central ground-floor

Table 3. Mean value comparison and non-parametric testing by craft groups for each survey.

	SUMs (Germany)						Apprentices in manufacturing disciplines (Ruhr area)								
	Mean value comparison and Mann-Whitney-U-test						Mean value comparison and Kruskal-Wallis-test								
	Construction and Workshop crafts			Store Crafts			Construction site crafts			Workshop crafts			Store crafts		
Location Factors	*n*	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*
Sustainable transport infrastructure	18	2.42*	0.81	55	2.94*	0.86	75	2.63*	0.81	63	3.01*	0.67	46	2.88	0.63
Car and security-related infrastructure	18	3.24	0.50	55	3.39	0.62	75	3.38	0.41	63	3.49*	0.39	46	3.26*	0.35
Proximity to other facilities	18	2.36	0.59	54	2.65	0.83	75	2.41	0.60	63	2.51	0.58	46	2.57	0.48
Close to home	17	2.59	0.96	54	2.46	1.09	75	2.18	0.65	63	2.02	0.63	46	2.07	0.61
Low real-estate costs	18	3.67	0.49	54	3.69	0.72	75	3.21	0.76	62	3.08	0.68	46	3.07	0.53
Central ground-floor location	18	3.16	0.67	55	3.35	0.81	75	2.39	0.61	63	2.47	0.66	47	2.92**	0.66
(Un)loading facilities for trucks on industrial land	18	2.44	0.76	52	2.42	0.96	75	2.74	0.81	63	2.72	0.70	47	2.21**	0.67

Notes: Values 1 “unimportant” to 4 “very important”; * significantly different to each other; ** significantly different to both other groups.

location, proximity to home and low real-estate costs differ between the two surveys, as the SUMs are already in an urban context and the sample characteristics show that smaller companies took part. Regarding the differences between the craft groups, the tested hypothesis, cannot be confirmed for all the location factors. However, a significant difference can be seen in the apprentice’s survey between store crafts, which require central ground-floor locations, and the other crafts. This suggests that store crafts rely on cheap and well-connected ground-floor locations and that they could play a role in both the reactivation of vacancies in city centres and the redevelopment of districts.

For construction site crafts, sustainable transport infrastructure is less important, but (un)loading facilities for trucks on industrial land are more important than for workshop and store crafts. In addition, there were significant differences between the construction site crafts and the others for most of the mixed-use functions (gastronomy, additional workshop, and retail store), suggesting that these are more inconvenient additional building uses for the construction site crafts. Notably, construction site craft is the only group in which mixed-use with residential functions is conceivable. As within this group the location factor “close to home” is slightly higher than in the other groups, it can be assumed that the ideal location would be in commercial areas, and in some cases including company housing.

Generally, the apprentices of all craft groups are open to mixed-use locations with offices and additional workshops. This may be because offices often need less space, are less disruptive of operations, generate additional revenue, and may create synergies. Shared parking spaces or garages and shared canteens are highly conceivable and shared showrooms are conceivable by all apprentices without a significant difference between the craft groups. A shared kitchenette is also conceivable for store crafts and shared storage spaces for workshop crafts.

Table 4. Conceivability of having additional uses in company building or of sharing spaces in the future for apprentices by craft group.

	Construction site crafts			Workshop crafts			Store crafts			Total		
	Mean value comparison and Kruskal-Wallis-test											
	n	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*	*n*	mean	*SD*
Conceivable additional use in company building												
Residential	69	0.26*	0.44	58	0.17	0.38	40	0.05*	0.22	167	0.18	0.39
Gastronomy	68	0.26**	0.44	55	0.49	0.5	32	0.56	0.5	155	0.41	0.49
Service (e.g., office use)	53	0.75	0.43	43	0.91	0.29	27	0.7	0.47	123	0.8	0.4
Additional workshop/production facility	65	0.58**	0.5	48	0.83	0.38	37	0.86	0.35	150	0.73	0.44
Retail (store)	66	0.26**	0.44	54	0.31	0.47	21	0.62	0.5	141	0.33	0.47
Social/cultural institution	68	0.19	0.40	58	0.28	0.45	38	0.23	0.43	163	0.23	0.42
Conceivable location in a commercial courtyard												
	46	0.48	0.51	43	0.56	0.50	30	0.73	0.45	119	0.57	0.50
Conceivable shared space												
Storage space	71	0.49	0.5	70	0.53	0.5	47	0.47	0.5	188	0.5	0.5
Canteen	76	0.63	0.49	75	0.72	0.45	47	0.6	0.5	198	0.66	0.48
Kitchenette	76	0.43	0.5	72	0.5	0.5	48	0.54	0.5	196	0.48	0.5
Showroom/ presentation room	75	0.55	0.5	70	0.51	0.5	50	0.52	0.5	195	0.53	0.5
Office and administration	74	0.36	0.48	70	0.43	0.5	50	0.34	0.48	194	0.38	0.49
Parking spaces/ parking garage	73	0.75	0.43	74	0.82	0.38	42	0.86	0.35	189	0.8	0.4
Production rooms	71	0.34	0.48	67	0.37	0.49	50	0.26	0.44	188	0.33	0.47
Individual machines	73	0.4	0.49	61	0.34	0.48	49	0.31	0.47	183	0.36	0.48

Notes: Values of 0 "not conceivable" and 1 "conceivable"; * significantly different to each other; ** significantly different to both other groups.

Commercial courtyards and "pure commercial buildings" could combine many of the desired location requirements (e.g., low rents, good internet and public transport connections, and shared parking spaces). Since there are hardly any shared properties that include SUMs in the Ruhr so far, e.g., compared to the commercial craft yards in Munich, they could represent a space-saving solution, especially for store and workshop crafts. Subsidies, organised commercial courtyards, commercial area management (Hüttenhain & Kübler, 2021), or a curator (Bathen et al., 2022; Hill, 2020) might be helpful to encourage companies to make vacant space on their sites available to other companies, use a vacant store as shared showroom, or to relocate. Finding new or shared spaces for SUMs and protecting industrial and commercial spaces from gentrification requires a clear vision and political will (De Boeck et al., 2017).

For further research, it may be fruitful to consider apprentices in other regions as well as in service industries or nearby residents as comparison groups, considering the extent to which they could imagine mixed-use properties including manufacturing. Exploring why individual apprentices can or cannot imagine certain additional uses or sharing offers would also fruitfully extend this research.

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Conflict of Interests

The author declares no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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