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Students' innovation for age-ready smart cities

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Abstract: The development of smart cities has seen a shift in governance systems where citizens have gone from mere recipients of services to co-creators. As smart cities rely heavily on Information and Communication Technologies to achieve their goals, it is a challenge to engage older populations in digital participatory processes. A project-based learning course was developed at the Norwegian University of Science and Technology to challenge master students across all study programs to come up with ideas for tackling this issue. This paper presents the results of their multidisciplinary collaboration applied to real cases in municipalities in Norway. We find that a transgenerational approach is essential in the design and development phase of participatory methods to ensure better implementation and uptake of technologies.

Keywords: smart cities, co-creation, engagement, age-ready cities, multigenerational collaboration.

1. INTRODUCTION

The United Nations General Assembly recently proclaimed the UN Decade of Healthy Ageing for the period 2021-2030. By 2050, it is predicted that over half of the world's population will be living in cities, and by 2050 older adults will account for 16% of the world's population. As a comparison, at the time of the Brundtland report "Our common future" in 1987, older adults accounted for only 6% (Das, Arai, & Kim, 2022). Therefore, there is a need to rethink the way we develop smart and sustainable cities to be not only "age-friendly" as prescribed by the WHO but also "age-ready". The term "age-ready cities" was first used by authors of the "Silver Hues-Building Age-Ready Cities" report commissioned by the World Bank's Urban, Disaster Risk Management, Resilience and Land Global Practice. It builds upon the idea of "age-friendliness" to highlight different pathways of ageing and urbanization to prepare cities for an older urban age focusing primarily on the built environment (Das, Arai, Chapman, et al., 2022). For that, the report proposes a framework consisting of six action areas:

- Universal Design toward age-readiness
- Housing Solutions for age-readiness
- Creating multigenerational spaces
- Improved transportation
- Making technology work for age-readiness
- Efficient spatial forms.

Two of the actions, 'creating multigenerational spaces' and 'making technology work for age-readiness' were selected to work with students during a project-based learning course at the Norwegian University of Science and Technology in Trondheim, Norway. This deliberate focus on these two dimensions is motivated by the growing importance of inclusivity, accessibility, and user-centred design in the field of control science and technology (Aghdam et al., 2022; Bogataj et al., 2021). By promoting cross-disciplinary research and education, universities can help to bridge the gap between different disciplines and create a more integrated and holistic understanding of aging and technology. In this context, the students' innovation has the potential to accelerate the development of more innovative and user-friendly technologies that cater to the needs and preferences of older adults and tackle related societal challenges (Fang et al., 2023; Hsiao et al., 2022).

1.1 Creating multigenerational spaces

The development of multigenerational spaces for an ageing society involves a range of innovative housing solutions, recreational facilities, public amenities, and community groups (Das, Arai, Chapman, et al., 2022; Grum & Kobal Grum, 2020). These efforts are crucial in creating an age-ready city that is adaptive, productive, and inclusive. In cities, where older individuals co-reside with their families or other individuals, there is less of a concern for segregation. However, if opportunities for mingling with others are inadequate, segregation can still occur within the home. Consequently, decision- makers within and outside the family may consider it more work to integrate older persons than segregate them.

1.2 Making technology work for age-readiness

Technology is a critical component of the infrastructure solutions required to support the age-readiness of cities, as it pervades all aspects of life. The world is being transformed by digital platforms, applications, robotics, artificial intelligence, and machine learning, which can greatly ease the lives of older people and their caregivers and service providers (Das, Arai, Chapman, et al., 2022; Nedeljko et al., 2021). These technologies can enable independent living, enhance their social connections, and access to services, and improve their overall well-being. Additionally, technology assists city governments in designing, tracking the use of, and monitoring infrastructure and services.

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1.3 Challenges of older adults in smart city development

In their article, Rogers & Mitzner (2017) highlight the challenges that older adults will face in 2050 due to age-related changes in their physical, perceptual, and cognitive abilities. They will require assistance with Activities of Daily Living (ADLs, such as bathing, toileting) and Instrumental ADLs (IADLs, such as preparing meals, managing medications), as well as Enhanced ADLs (EADLs, such as social communication, new learning). While technological advances could potentially support these activities, low adoption rates among older adults could prevent technology from fully realizing its potential (Fisk et al., 2020). This could lead to social isolation and reduced access to services that rely on technology. To address this issue, Rogers & Mitzner (2017) recommend that designers understand the fundamentals of aging and involve older adults early in the design process to ensure that technologies are easy to use and perceived as useful.

1.4 Participatory approaches

To ensure the success of smart cities projects, public participation has been identified as a critical element, prompting local governments to provide opportunities for citizens to participate. In an increasing number of municipalities, dedicated positions as "participation coordinators" have been opened within the planning departments to facilitate citizen engagement (Gohari et al., 2020; Temeljotov Salaj et al., 2020). Nordic countries' recent smart city projects prioritize the improvement of citizens' quality of life and their empowerment to actively participate in city governance (Anttiroiko, 2016; Berntzen & Johannessen, 2016; Simonofski et al., 2019). Some examples of this are the feedback and data collection through the use of online surveys (Johansen et al., 2022; Temeljotov Salaj et al., 2020). Participatory budgeting is employed to enable co-management of green spaces, while collaborative maps are used to foster community building. Research shows that the highest degree of public participation can only be achieved in the implementation phase of smart cities projects if higher ambitions were documented in the early strategic plan (Senior et al., 2021) (Fig. 1).

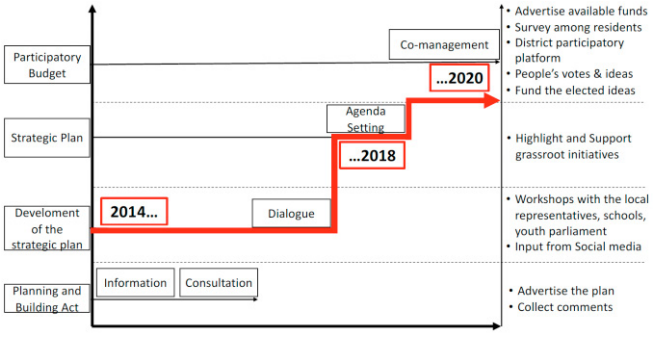

Fig. 1 Degrees of citizen participation at each stage of the Hovinbyen project (Source: Senior et al. 2021)

This paper aims to operationalize parts of the "age-ready cities" framework with a practical example of creating multigenerational "spaces" while also catering for making technology work for age-readiness.

We address the following research question:

How can students' innovations help cities to develop towards age-readiness by engaging older adults?

We present the results of experimental research conducted during a project-based learning course at the Norwegian University of Science and Technology (NTNU) in Trondheim, Norway between 2021 and 2022.

2. PROJECT-BASED LEARNING FOR STUDENT INNOVATION

In order to prepare students for the professional life, the Experts in Teamwork (EiT) course was created for master students at the NTNU. The students are organized in interdisciplinary teams working on a real project (Larsen, 2012). In the EiT course "From Users to Creators", students were tasked with developing digital innovative solutions for empowering citizens to become co-creators of smart and sustainable cities. At the start of the semester, students were introduced to different ongoing urban transformation projects that they could use as a starting point to define the objectives of their solutions and work in a real-life context with access to project documents and key stakeholders. The students were supervised by a team of academics including one professor in Urban Facilities Management, one professor in Project Management and a doctoral candidate. In addition, they were mentored by stakeholders from the urban transformation projects in which the solutions were to be implemented.

2.1 Challenges in sustainable urban transformation

Two cases were presented by the municipalities and urban developers: the development of Fjordbyen in Lier, and Furuset in Oslo.

The municipality of Lier has a population of just over 27,000 people. Located approximately a 30-minute drive from the Norwegian Capital of Oslo, Lier is situated economically as a part of the greater Oslo areas (as is the case with its the municipality of Drammen, in which part of the Fjordbyen project is also located) however it is administered and governed as its own municipality (Collins et al., 2021).

Fig. 2 Fjordbyen project (source: Fjordbyen Lier og Drammen)

The Fjordbyen project is located on the shoreline in the Oslo Fjord, it will be a new urban area under both the Lier and Drammen municipal authorities. It is planned for at least 16000 new residents and 16000 jobs in this zero-emissions urban area with green and future-oriented ambitions (Collins et al., 2021; Fjordbyen Lier og Drammen, 2021). The project in its current form started in 2011 and the first construction work was initiated in 2019 Fjordbyen will feature a small artificial island, a marina, parks for recreation and a maritime hub. The project is publicly owned and led by Eidos, a public-private partnership between Lier and Drammen municipalities and the biggest private landlords in the area. Consultant companies are hired for diverse missions, one of them being the implementation and analysis of a participatory process with the local population. While the public-private partnership was established to propose and lead the preliminary plan, the final decisions are made by the Lier municipality alone. The results of survey in Lier among 2407 participants asking about the development focus of Fjordbyen showed interesting results, among others the need for: hiking trails for walking and running within the area, access to open green areas for leisure; parcel gardens and local agricultural land; access to the forest; Neighborhoods suitable for children and elderly; interest for outdoor cultural activities, meeting places and sport activities.

Furuset, is an eastern suburban area of Oslo, characterized by a high multi-cultural background population with residents of 140 different nationalities.

Fig. 1 Furuset area (source: Oslo Kommune)

It has been selected by the Oslo municipality as a “role model area” in the FutureBuilt program, which aims to develop sustainable, climate-neutral urban areas with high-quality architecture (FutureBuilt, 2019). The program is governed by a broad partnership that plans to create 50 role model projects by 2020, with a minimum of 50% reduction in greenhouse gas emissions. Furuset comprises around 3,800 residential units, mainly apartment blocks, and 1,500 workplaces (Ekne Ruud et al., 2020). In addition to its good transport connections, including two metro stations and four bus lines, the neighborhood offers a range of shopping and service facilities, as well as social infrastructure such as an ice stadium, school, library, and kindergarten. The revitalization of Furuset aims to upgrade the physical infrastructure of the neighborhood, which consists of many buildings from the 1970s, and transform it into a modern area with high environmental ambitions. The goals of the revitalization include creating attractive urban spaces, enhancing the green infrastructure with blue-green connections, providing diverse and plentiful residential options, and improving transportation efficiency.

3. STUDENTS’ SOLUTIONS

Based on the characteristics and challenges presented by the Fjordbyen and Furuset representatives, students prepared many innovative solutions, focusing on creating multigenerational spaces (digital and physical) and making technology work for age-readiness. This section presents a selection of the solutions presented by the student teams and divided between digital solutions and mixed digital/in-person solutions.

3.1 Digital solutions

3.1.1 Team "FjordbyAppen"

The group consisted of students with background in Civil engineering and Information technology, Real estate development, Psychology, Civil and Environmental Engineering and Urban Development. They prepared a quick-voting app to rate different solutions proposed in an urban development project.

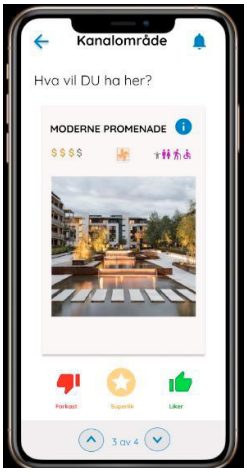

Fig. 2 "FjordbyAppen"
(source: Students Team)

The goal is to empower people to make informed choices by providing sustainability scores of the different solutions based on social, economic, and environmental indicators. After developing the app, they tested it and made design iteration, based on the opinion of various group of people: young, active (employed, families), retired and investor. For older adults, it was important to be easy to use and readable.

3.1.2 Team "Bybøddy

The students’ profiles in this group were from Civil and Environmental Engineering, Industrial production, Material technology, Urban development, and Geography. The main problem they addressed was that Lier municipality has been successful in involving its own residents in the development of Fjordbyen but has not reached out to all potential new residents (outside Lier). So, their product was developed on

the principle of ‘What would a person from Horten, Oslo or other places in the country think is attractive to move here?’

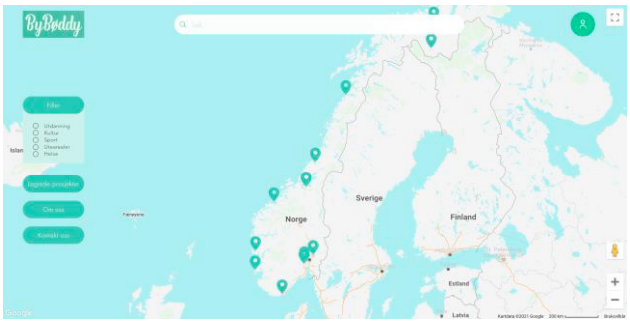

Fig. 3 "ByBøddy" (source: Students Team)

The product is an online platform to connect all urban development projects seeking citizen participation at the national level to open participatory process to people across municipal borders and create learning experiences.

3.2. Mixed digital/in-person solutions

3.2.1 Team “FUTUREset”

Students from Economy and administration, Physioterapist, Sustainable energy, Geography, Energy and environment and Civil and environmental engineering programs prepared a product FUTUREset platform.

Fig. 4 "FUTUREset" (source: Students Team)

The product focuses on engaging the local citizens to develop an attractive urban place together. The platform is in a form of an interactive screen that can communicate in the desired language and facilitates users with disabilities. The screen extracts and categorizes information from the user. It can be used as a simple survey but also accepts written, audio and visual contributions. The FUTUREset screens are distributed as both mobile and stationary public displays options. The stationary screens are mounted at strategically selected locations in the neighborhood and are adjustable in height for wheelchair users, while the mobile screens seek out selected institutions with a high level of activity.

3.2.2 Team “ByBilen”

This idea was developed by a team with Cybernetic and robotics, Civil and Environmental engineering, Urban development, Business and management, and Machine engineering backgrounds. The product is an expandable and itinerant truck with fixed technical and practical solutions that enable visualization and sharing of ideas for how the district can be developed. Traditional physical spaces for participation can be located where people usually gather (e.g., main square, city hall) but it not always easy to pick a location that everyone in an area will relate to. By being completely mobile, the ByBilen (City Automobile in English) offers the opportunity to go where different citizen groups are and thereby vary the population segment that can participate in a project.

Fig. 7 "ByBilen" (source: Students Team)

3.2.3 Team “ToolBoxen”

A generator composed of four developed methods and tools for public participation was prepared by a team consisting of students with backgrounds in Urban development, Data technology, Property management, Civil and environmental engineering, and Psychology. The idea is that the project leaders provide information about their project in the generator and based on this data, they receive suggestions for recommended participation methods and tools. The participation methods proposed by the generator are Survey, the café method, People-tracks, and Digital services. Survey is a participatory method used to obtain information from individuals. The information collected relates to predetermined questions with the intent to reveal the population's attitudes, perceptions, and actions. The café method is an event that can take place either in an actual café, or in a venue that is set up to resemble a café. On each table is a question or issue the group will discuss with the help of a facilitator for a set amount of time.

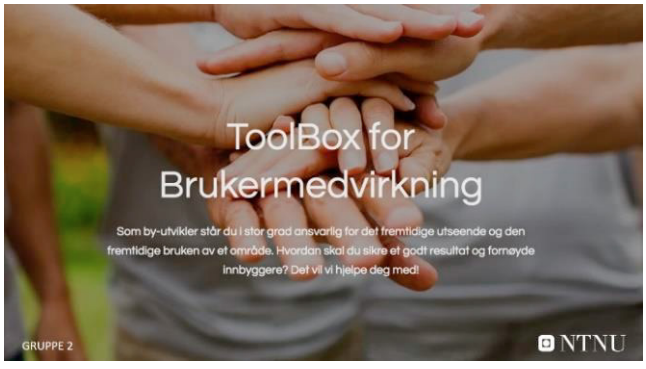

Fig. 8 "ToolBox" (source: Students Team)

Once the time is over, the group goes to the next table to discuss a new topic. In addition, the website contains information about pre- and post-work. The people-tracks is a mapping method that provides spatial insight into the population's needs and wishes in their local environment (Doga, 2019). The method uses analog and digital tools which makes it especially relevant in a multigenerational context. The digital services present a compilation of innovative e-participation tools and devices such as Virtual Reality, gaming and OpenCities Planner, a web-based 3D visualization platform with an interactive dialog function for citizens to submit comments and ideas to specific projects and plans (Norkart, 2021). All methods presented in the generator include a step-by-step implementation guide as well as direct links to the relevant actors and service providers in the area. An important preliminary work is the implementation of a stakeholder and site analysis before the generator is used. This ensures that the developer can take into account the site's unique characteristics, in combination with the generator's method proposal.

4. DISCUSSION & CONCLUSION

This paper discusses the "age-ready cities" framework methodology from the perspective of involving students into the process of creating possible solutions for and by older adults. The main research question *How can a student city develop towards age-readiness by engaging older adults?* was discussed from the perspective of creating multigenerational spaces, making technology work for age-readiness, challenges of older adults in smart city development, and participatory approaches. There is a need for improvement of the quality of life for the citizens by stimulating and facilitating their synergistic participation in transformation processes and contributing to smart city development (Simonofski et al., 2019). It is also acknowledged that technological innovation could help in creating individual and social wellbeing, especially as a supportive tool for seeing the benefits of "sharing is sustainable" and collaborative actions for social sustainability (Temeljotov Salaj & Senior, 2021). As stated by Drobne & Bogataj (2017), by activating all generations in creative processes, a stronger attachment to the place can be reinforced, and willingness to invest in better living conditions can be fostered.

Improving service quality demands participatory and synergetic processes that draw attention to the social and managerial aspects of the built environment. The challenge lies in technology and service transformation, as well as transparency of impacts to enhance operational efficiency. The more values a service contains, the better users engage with them.

All solutions presented by the students included one or more dimension of the age-ready cities framework. FjordbyAppen uses a sustainability scoring system for each project proposal on which users can vote. The social impact is displayed using icons symbolizing different societal groups (e.g., children, wheelchair users, older people). Showing for example how the use of different pavement materials might affect wheelchair and Zimmer frame users. ByBøddy proposes an online platform with a simple and intuitive interface where users can access information regarding different ongoing projects at the national level and give input to those, they might deem relevant. The projects displayed on the map can be filtered according to the type of infrastructure. This is an interesting approach as most participatory processes usually focus on targeted user groups in the local environment rather than seeking for the participation of a potential user profile. In the case of a nursing home project for example, older residents might have valuable input to give regardless of where they are in the country. The FUTUREset solutions combines interactive screens that follow the rules of universal design, including adjustable height, voiceover commands for visually impaired and multiple language settings. Similarly to the FjordbyAppen, information regarding impact on different societal groups is displayed using simple icons. Users can give input to the projects using a variety of functions like voice recording, typing, drawing, or uploading photos which also extends the inclusivity of the technology. ByBilen is inspired by a solution already well-deployed in the health sector (e.g., mobile healthcare units and vaccine stations) and allows municipalities to get the participation of publics exactly where and when they are available. The computers installed in the truck can be used to assist people in accessing essential administrative online portals.

In conclusion, this study demonstrates the potential for involving students in the transition towards age-ready cities, with a focus on multigenerational spaces, technology, and participatory approaches. The solutions proposed by the students aligned with the age-ready cities framework and included innovative ways of engaging citizens and collecting input. While the study was conducted in a specific context, the results can be applied to different cases and contexts as the challenges of creating age-ready cities are universal. The study highlights the importance of participatory and synergetic processes for improving service quality and the need for technological innovation to support social sustainability. This study provides insights into the potential of engaging students in creating age-ready cities and highlights the importance of considering the needs and capabilities of older adult users in the design of technological solutions. Further research will focus on large-scale user testing of the prototypes and comparing them to other existing solutions.

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REFERENCES

Aghdam, A., Birungi, C., Duncan, D., Ghosh, P. K., Kalra, R., Mareels, I., Marimuthu, R., & Pasik-Duncan, B. (2022). Diversity & Inclusion in Universal Access to Technology – A Perspective. *IFAC-PapersOnLine*,

55(39), 123–128. https://doi.org/10.1016/J.IFACOL.2022.12.022

Anttiroiko, A. V. (2016). City-as-a-platform: The rise of participatory innovation platforms in finnish cities. *Sustainability (Switzerland)*, *8*(9). https://doi.org/10.3390/su8090922

Berntzen, L., & Johannessen, M. R. (2016). The Role of Citizen Participation in Municipal Smart City Projects: Lessons Learned from Norway. In J. R. Gil-Garcia, T. A. Pardo, & T. Nam (Eds.), *Public Administration and Information Technology* (Vol. 11, pp. 299–314). Springer. https://doi.org/10.1007/978-3-319-17620-8_16

Bogataj, D., Rogelj, V., & Salaj, A. T. (2021). Social Infrastructure supporting Ambient Assisted Living in a Smart Silver City: Literature Review and Research Agenda. *IFAC-PapersOnLine*, *54*(1), 942–947. https://doi.org/10.1016/J.IFACOL.2021.08.111

Collins, D., Senior, C., Jowkar, M., Temeljotov Salaj, A., & Johansen, A. (2021). From the North Country: The Citizen Centered Journey towards Sustainable Smart Cities in the Norwegian Context. *Cities in a Changing World: Questions of Culture, Climate and Design Online AMPS PROCEEDINGS SERIES 24.2*, 154–160.

Das, M. B., Arai, Y., Chapman, T. B., & Jain, V. (2022). *Silver Hues: Building Age-Ready Cities*. https://openknowledge.worldbank.org/handle/10986/37259

Das, M. B., Arai, Y., & Kim, Y. (2022). Building Age-Ready Cities. *The World Bank*, 11–14. https://www.worldbank.org/en/news/opinion/2022/06/13/building-age-ready-cities

Doga. (2019). *METODEVELGER | DOGA*. https://doga.no/verktoy/folketrakk

Drobne, S., & Bogataj, M. (2017). The impact of public investments in facilities on the potential housing market for older persons. *Facilities*, *35*(7–8), 422–435. https://doi.org/10.1108/F-09-2016-0091/FULL/PDF

Ekne Ruud, M., Andersen, B., Berge, S., Margareta Dalseide, A., Dyrendahl Staven, H., Mamelund, S.-E., & Skogheim, R. (2020). *Spenninger og harmoni-Sosiokulturell stedsanalyse for Furuset*. https://alnainvolverer.no/uploads/63b5bbd1-79ce-451c-9ca5-453c3237ea4c/project_file/file/808726cd-9261-41a1-ae61-d4bfa605b6f1/Sosiokulturell_stedsanalyse_for_Furuset_2019.pdf

Fang, M. L., Sixsmith, J., Hamilton-Pryde, A., Rogowsky, R., Scrutton, P., Pengelly, R., Woolrych, R., & Creaney, R. (2023). Co-creating inclusive spaces and places: Towards an intergenerational and age-friendly living ecosystem. *Frontiers in Public Health*, *10*, 5074. https://doi.org/10.3389/FPUBH.2022.996520/BIBTEX

Fisk, A. D., Czaja, S. J., Rogers, W. A., Charness, N., Czaja, S. J., & Sharit, J. (2020). Designing for Older Adults : Principles and Creative Human Factors Approaches, Second Edition. *Designing for Older Adults*. https://doi.org/10.1201/9781420080681

Fjordbyen Lier og Drammen. (2021). *Områdeplanen er levert til Lier*. https://fjordbyenlierdrammen.no/

FutureBuilt. (2019). *FutureBuilt Program*. https://www.futurebuilt.no/

Gohari, S., Ahlers, D., Nielsen, B. F., & Junker, E. (2020). The Governance Approach of Smart City Initiatives. Evidence from Trondheim, Bergen, and Bodø. *Infrastructures 2020, Vol. 5, Page 31*, *5*(4), 31. https://doi.org/10.3390/INFRASTRUCTURES5040031

Grum, B., & Kobal Grum, D. (2020). Concepts of social sustainability based on social infrastructure and quality of life. *Facilities*, *38*(11–12). https://doi.org/10.1108/F-04-2020-0042

Hsiao, H., Tseng, J. T., Hsu, Y. J., Chen, T., Wang, Y. W., & Kuo, T. (2022). Effects of Design-Thinking Intergenerational Service-Learning Model on College Students: A Pilot Study in Taiwan. https://doi.org/10.1177/10497315221146189

Johansen, A., Collins, D., Temeljotov-Salaj, A., & Hagehaugen, G. (2022). Down by the Fjord: successful public and private collaboration in a Neighbourhood redevelopment project. *Management, Procurement and Law*, *(*1–10. https://doi.org/10.1680/jmapl.22.00011

Larsen, B. B. (2012). *11 years of Experts in teamwork at NTNU*. 9–11.

Nedeljko, M., Bogataj, D., & Kaucic, B. M. (2021). The use of ICT in older adults strengthens their social network and reduces social isolation: Literature Review and Research Agenda. *IFAC-PapersOnLine*, *54*(13), 645–650. https://doi.org/10.1016/J.IFACOL.2021.10.524

Norkart. (2021). *OpenCities Planner - Unike muligheter for samspill*. https://www.norkart.no/planoggeodata

Rogers, W. A., & Mitzner, T. L. (2017). Envisioning the future for older adults : Autonomy , health , well-being , and social connectedness with technology support. *Futures*, *87*, 133–139. https://doi.org/10.1016/j.futures.2016.07.002

Senior, C., Jowkar, M., Temeljotov-Salaj, A., & Johansen, A. (2021). Empowering citizens in a smart city project one step at a time: A Norwegian case study. *2021 IEEE European Technology and Engineering Management Summit, E-TEMS 2021 - Conference Proceedings*, 10–15. https://doi.org/10.1109/E-TEMS51171.2021.9524892

Simonofski, A., Vallé, T., Serral, E., & Wautelet, Y. (2019). Investigating context factors in citizen participation strategies: A comparative analysis of Swedish and Belgian smart cities. *International Journal of Information Management*, *September*, 102011. https://doi.org/10.1016/j.ijinfomgt.2019.09.007

Temeljotov Salaj, A., Gohari, S., Senior, C., Xue, Y., & Lindkvist, C. (2020). An interactive tool for citizens' involvement in the sustainable regeneration. *Facilities*, *38*(11–12), 859–870. https://doi.org/10.1108/F-09-2019-0099

Temeljotov Salaj, A., & Senior, C. (2021). Co-creators of wellbeing - smarter engagement of older residents. *IFAC-PapersOnLine*, *54*(13), 669–674. https://doi.org/10.1016/J.IFACOL.2021.10.528