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"Arctic-tecture": Teaching Sustainable Urban Planning and Architecture for Ordinary Arctic Cities

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Abstract

Arctic cities are often perceived as exceptional and uniquely challenged by extreme conditions, leading to their treatment as special cases in urban planning and development. However, this perception overlooks the reality that Arctic cities share similar issues common to many small and medium-sized urban centers globally, such as mobility, climate adaptation, and aging populations. By recognizing Arctic cities as ordinary cities, we can better address their needs and foster effective solutions. This article reflects on the results of a fourth-year Master-level course in Sustainable Urban Development, where students researched urban sustainability aspects (e.g., mobility, green infrastructure, energy, public spaces) in northern regions of Finland, Sweden, and Norway. It analyzes pedagogical approaches, highlighting challenges in integrating sustainability perspectives into architecture and planning curricula. Findings hold relevance for educators seeking to address similar challenges in the Arctic or other ordinary cities worldwide, contributing to more resilient and sustainable urban development across diverse environments.

Keywords

architecture education; Arctic cities; pedagogical approaches; sustainable urban development; urban planning

1. Introduction

Arctic cities face significant challenges due to their extreme weather conditions. Addressing these challenges requires innovative architectural and planning solutions, which are part of the education system (Antonini et al., 2021; Korobar & Siljanoska, 2016). However, treating Arctic cities as exceptional due to their extreme environment often results in overlooking these common urban challenges, thus hindering effective solutions

(Berman & Orttung, 2020; Heininen et al., 2020). Recognizing that Arctic cities face similar issues to other small and medium-sized ordinary cities globally—such as mobility, climate adaptation, and an aging population—allows for more inclusive and practical strategies. This perspective encourages the development of solutions, e.g., in urban planning education, that address the shared urban challenges of Arctic cities and other regions.

To address these issues, this research investigates the following question: How can pedagogical approaches effectively integrate Arctic sustainability perspectives into architecture education, particularly in urban planning? This article examines this question through a case study of a fourth-year course in the architectural engineering curriculum in Sweden. This course is in synergy with a research project funded by the Arctic Five, an alliance of five Nordic universities located in or near the Arctic region, focusing on implementing Sustainable Development Goals (SDGs) in Arctic cities. We nicknamed the project "Arctic-tecture," a playful merge between Arctic and architecture, to exemplify the challenges of adapting a well-established architecture curriculum to the fluid nature of environmental and social issues in the Arctic.

The course, Sustainable Urban Development, is offered as a part of the urban planning major at Luleå University of Technology. While it addresses a broad view of sustainable development, a unique aspect of this course is its focus on urban planning issues in the Arctic. Another main focus of this course is to teach students the challenges of implementing the global SDGs in smaller cities of the Arctic. Unlike other regions where urban challenges are similar to those in other parts of Europe (e.g., densification, mix-use development, heat islands, population increase, urban sprawl, etc.), Arctic municipalities face distinct challenges such as aging population, urban shrinkage, and transportation connectivity in sparsely populated areas. For instance, the population density in the Norrbotten region in the north of Sweden is three inhabitants per square kilometer compared to 376 in Stockholm. Additionally, between 2020 to 2023, the annual population change in Norrbotten decreased by 0.15% while in Stockholm it increased by 0.87% (SCB, 2023). In 2023, the average age in Stockholm region was 40.2 years, whereas in Norrbotten it was 44.6 years (SCB, 2023).

This article is structured as follows: In the next section we elaborate on the relevance of Arctic transformations for architecture and planning pedagogy. Section 3 outlines the chosen pedagogical framework and methodology. Section 4 delves into the Sustainable Urban Development course components and analyzes their effectiveness as a case study. Section 5 presents research findings, and Section 6 concludes with reflections on key challenges and future directions.

2. Transformations in the Arctic: Relevance for Architecture and Planning Pedagogy

The Arctic region, known for its extreme environment and rapid changes due to climate change, presents challenges and opportunities for architectural design. However, Arctic cities are often treated as exceptional cases, focusing excessively on their extremities and overlooking that they share many issues with other small and medium-sized cities globally. This perspective hinders the development of effective solutions to problems such as limited mobility, less concerns about climate adaptation, and aging populations. Integrating these considerations into architectural education will prepare students to design resilient, sustainable, and culturally sensitive structures that address both universal and region-specific urban challenges.

Within the past decade, the Swedish focus on the Arctic has intensified, coinciding with large-scale transformations in the Swedish resource sector under the "green transition" banner (Rizzo et al., 2024). This

transformation is marked by several significant milestones, including the ongoing relocation of Kiruna city (ongoing since 2004) to a new site due to land deformations caused by underground mining (Carrasco, 2020; Sjöholm, 2016). A similar process is underway in the nearby Malmberget district of Gällivare (Hidman, 2018). Additionally, the first large Facebook datacenter in Europe was established in the city of Luleå to benefit from the nearby green hydropower-generated electricity and cold temperature for cooling. Skellefteå, too, houses the largest battery factory in Europe (ongoing since 2018). Complementing these developments is the rising tide of international tourism in the Swedish Arctic.

However, this rapid change triggered by industrial transformation, climate change (evident in permafrost thaw, rising temperatures, and increased precipitation; Chapman, 2018; Robinson et al., 2006), and geopolitical shifts (e.g., the abandonment of the planned North-East Russian Passage in favor of Canada's North-West Passage due to the Ukraine conflict) presents a complex picture. While investment opportunities emerge for a shrinking local population, tensions resurface concerning the historical colonization and dispossession of the Indigenous Sápmi population (Normann, 2021). Further anxieties arise amongst the predominantly white society, fearing marginalization within the public and private sectors driven by the imperative to attract 100,000 new inhabitants to bolster the competitiveness and profitability of the Swedish resource sector. Climate activists, including Greta Thunberg and associated movements, also raise their voices amidst these transformations.

Sustainable development, a dynamic concept aiming to enhance quality of life, demands consideration of economic, social, and environmental aspects (Deakin et al., 2002; Dempsey et al., 2012; Hastrup, 2013; López Chao et al., 2020). Higher education increasingly links these dimensions in design and planning fields, emphasizing contextual relevance. This research specifically explores the pedagogical challenges of integrating Arctic sustainability perspectives into architecture and urban planning education. While architecture education boasts a long tradition of human-centered sustainability that is evident in early ecological studies (Bassas et al., 2020; McHarg, 1969), the climate crisis necessitates acknowledging a more intricate human–nature relationship. This compels collaboration between technical disciplines like architecture and scientific fields (biology, climatology) alongside humanistic ones (history and urban planning). The Arctic, considered the "urban frontier," exemplifies this complex entanglement. Here, human-induced impacts on nature are stark and rapid, with accelerated infrastructure degradation due to permafrost thaw (Hjort et al., 2022) exceeding the pace observed in temperate or tropical regions (Berteaux et al., 2004).

Teaching architecture and urban planning in the Arctic means incorporating elements of social and environmental justice in design disciplines (Park et al., 2022). From an urban ecology point of view, architect and educator Maria Kaika (2005) studies the interrelationship between water infrastructure policy and urbanization in Greece and England. In her research, water is treated as a fabricated resource rather than a natural one, that is inseparable from human intervention. This perspective is especially beneficial because it provides a clearer understanding of the role that urban infrastructures play in facilitating the commodification of natural resources. Kaika (2005, p. 33) argues that this fetishization of urban infrastructures aims at "being carriers of the modernist promise of participating in the phantasmagoric new world of technological advancement and progress; a world in which human freedom and emancipation resides in connecting to technology."

From a pedagogical point of view, there is the need to use methods and approaches that activate students' critical thinking in architecture and urban planning problem setting (Von Hauff & Nguyen, 2014). Particularly, it becomes central to localize (the concept of) sustainability in the Arctic. This involves understanding the peculiar characteristics of Arctic society and environment and critically situating sustainable architecture within this context. Moreover, there is a need to enable collaboration among students to co-define sustainability for the objectives of their course and to find suitable course tasks and deliverables. By treating Arctic cities as ordinary cities facing common urban challenges, educators can foster more effective and transferable solutions that benefit both Arctic and other regions with unique climate-related issues.

3. Pedagogical Framework

University curricula in urban-related fields should prioritize empowering students as independent learners, equipped with the knowledge and skills to address the complexities of urban development (Barth et al., 2007). Pedagogical principles are intended to form a foundation that stimulates continuous pedagogical growth and promotes active collaboration among university colleagues and across disciplines (Alejandro & David, 2018). In particular, this article focuses on three principles for effective learning in urban design and planning courses: active cognitive processing, assessment for learning, and knowledge-enhancing feedback (Gedda & Wikberg-Nilsson, 2013). These principles provide a framework (Figure 1) for understanding the pedagogical approaches utilized in architectural and urban planning education for sustainable urban development. They also align with the need for urban planners to synthesize knowledge from diverse fields, recall past concepts, and apply them to new complex scenarios.

Active cognitive processing emphasizes that students must deeply engage with course materials to achieve the fundamental abilities and knowledge to meet the learning outcomes. It requires that students integrate prior knowledge from various disciplines while adapting to the evolving challenges of urban development. While listening, reading, and note-taking are essential, active learning activities like collaborative projects, simulations, and discussions foster the critical thinking and adaptable problem-solving needed by urban

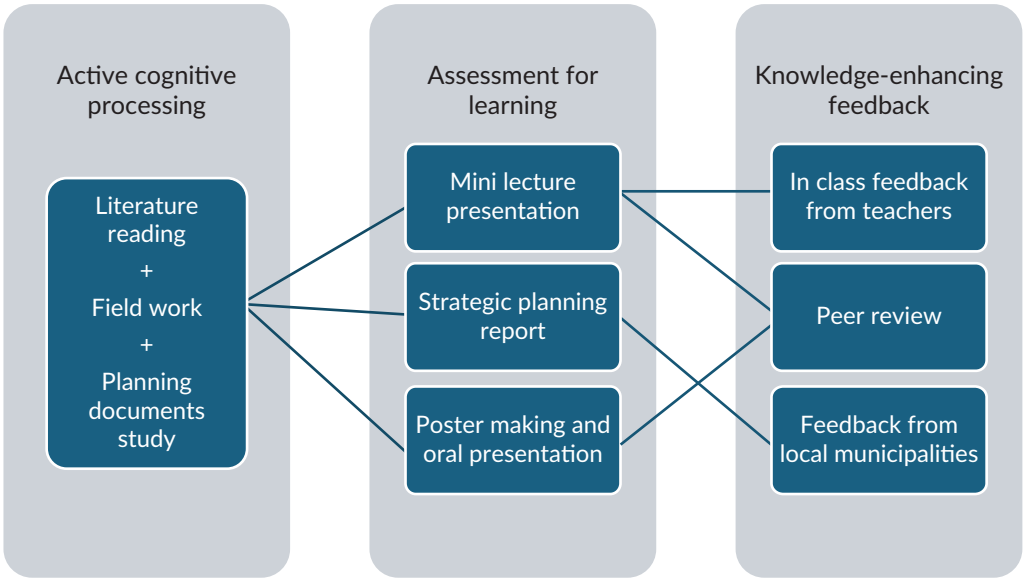


Figure 1. Pedagogical framework.

planners. To equip students with these essential skills, we employ active cognitive processing through a comprehensive array of elements, designed to provide opportunities for reflection and knowledge application across diverse contexts (Gedda & Wikberg-Nilsson, 2013). Within our teaching group, we have implemented several strategies in architectural education to foster such active cognitive processing (Table 1).

By integrating these actions and elements into our educational framework, we aim to create a dynamic and engaging learning environment that supports active cognitive processing. This approach not only enhances students' essential skills but also prepares them for professional success by fostering critical thinking, collaboration, and practical application of knowledge.

Among this active cognitive processing, assessment plays a crucial role in shaping student learning. By strategically selecting assessment methods, educators can guide students' efforts and focus their attention on essential skills and knowledge. Research on assessment's influence demonstrates that the form, frequency, and level of assessments significantly impact teaching practices and student learning outcomes (Rust, 2002). Additionally, types of assessment influence students' time management, their perception of the importance of the course material, and their capacity for self-evaluation (Gibbs, 2010). For example, Gratchev (2023) found that compared to a single in-depth final exam, multiple brief assignments with ongoing feedback promote student engagement and improve long-term knowledge retention.

University degrees serve as proof that students have acquired a specific body of knowledge and developed a specific set of skills. Assessments must be carefully designed to ensure validity in relation to both the intended learning outcomes of courses and broader program goals. We apply different forms of assessment to assure

Table 1. Actions consider the encouragement of active cognitive processing.

Elements	Actions
Collaboration for design activities	We organize the Teaching Progression Day to cultivate connections and collaborations across different courses and to refine course contents tailored for design activities.
Delivery forms	A variety of instructional methods are utilized, including written seminars, traditional lectures, and peer discussions. This multimodal approach ensures that students can absorb and interact with the material in multiple ways, catering to different learning styles and promoting a deeper understanding of the content.
Technical tools	The Canvas platform is used for organizing teaching activities, ensuring that all resources and assignments are easily accessible. For online guest lectures, we utilize Zoom and Microsoft Teams, allowing students to interact with industry professionals and gain insights from diverse perspectives, regardless of geographical constraints.
Course activities	Our curriculum includes a wide range of activities such as seminars, labs, studios, tutorials, debates, group discussions, role-plays, field trips, and oral presentations. These varied formats provide students with numerous opportunities to apply their knowledge practically, engage in critical thinking, and participate actively in their learning journey.
Forms of assessment	We employ diverse assessment methods to effectively evaluate student learning. These include written work (essays), quiz questions, posters, oral presentations, and report writing.

the quality in education, known as constructive alignment, calling for all tasks, activities, and assessments to support and build upon one another in a progression that aids students in achieving course goals. To ensure constructive alignment, our teaching and learning activities are carefully crafted to support the development of the knowledge and skills defined in the intended learning outcomes. The assessment plan is an integral part of each course and is designed to be accompanied by knowledge-enhancing feedback. For instance, we employ the portfolio method or workbooks, and in courses with a final exam, we incorporate smaller assignments or quizzes to gradually build and refine students' knowledge and understanding in preparation for the exam.

We create opportunities for students to demonstrate their knowledge through collaborative projects with stakeholders in the field, emphasizing the application of knowledge and skills to real-life situations. This approach not only enhances learning but also ensures that tasks cannot be easily copied or completed by someone other than the specific student being assessed, thereby maintaining academic integrity.

Another crucial element for cognitive processing and knowledge growth is the promotion of knowledge-enhancing feedback. This feedback encourages critical self-reflection, identifies knowledge gaps, and promotes continuous learning (Dochy et al., 1999; Evans, 2013; Yan & Carless, 2022). Throughout a course, opportunities should be provided for students to receive, apply, and provide feedback (Brown, 2020). Traditional end-of-course feedback in the form of grades and comments offers limited potential for students to implement new knowledge, potentially discouraging further engagement with the material. Timely and frequent provision of knowledge-enhancing feedback is essential for both students and educators to monitor progress and understanding. Tasks and activities should incorporate clear criteria for success and frameworks for constructive feedback to support this process.

Feedback in our teaching takes various forms, including automated responses to online assessments, teacher-to-student, teacher-to-group, and student-to-student interactions (Evans, 2013). Feedback yields the greatest impact when it is timely, personalized, specific, and perceived by students as encouraging and useful (Nicol et al., 2014). We, as educators, consider the most appropriate feedback type for specific learning activities and course stages. Additionally, cultivating students' ability to offer constructive criticism to their peers is a valuable skill throughout both their professional and academic careers. By actively incorporating student feedback, we can continuously refine teaching and learning activities to ensure alignment with intended learning outcomes.

While these pedagogical principles offer benefits across disciplines, they hold particular relevance within sustainability education. The complex and interconnected nature of sustainability challenges demands that students develop the capacity to navigate diverse knowledge domains, integrating ecological, economic, and social perspectives. Active cognitive processing, with its emphasis on prior knowledge application and adaptability, lays the groundwork for this holistic understanding. Sustainability problems are rarely static; thus, emphasizing reflection throughout the learning process mirrors the real-world need for continuous adaptation and course correction. Formative assessment, embedded with knowledge-enhancing feedback, allows students to iteratively improve their sustainability analysis and proposed solutions. Therefore, tertiary education with an active teaching and learning environment prioritizing these pedagogical principles nurtures the critical thinking and adaptability essential for tackling sustainability issues, especially within the rapidly evolving Arctic landscape.

Furthermore, sustainable development inherently prioritizes collaboration. Active collaboration in design and planning activities directly reflects real-world sustainability projects requiring input from diverse stakeholders, including scientists, policymakers, and local communities (Wheeler, 2013). The need to integrate multifaceted perspectives necessitates effective communication, negotiation, and an awareness of power dynamics. The Arctic region specifically demands a collaborative approach, balancing the push for resource-based economic development with the need for environmental responsibility and the rights of Indigenous communities. Consequently, the pedagogical principles discussed here become essential tools in empowering students to become effective contributors to multidisciplinary teams and facilitators of sustainable practices, particularly within the sensitive social and ecological context of the Arctic. We highlight these principles as the foundation for the specific study outcomes in our Architecture Engineering grogram. The case study we undertake is the Sustainable Urban Development course, cultivating the necessary skills for future sustainability researchers and planners.

4. Case Study

4.1. Sustainable Urban Development as a Key Program Course in North Sweden

The Swedish Arctic, characterized by its unique environment and rich natural resources, faces a complex nexus of sustainability challenges amplified by a rapidly changing climate. These changing conditions have been identified by the Nordic Council of Ministers (Rasmussen, 2011) which highlights the faster rate of Earth's global warming in the Arctic. Globalization is also one of the trends, especially the extractive industries and broader exploitation of natural resources like forests and ecosystem services for the travel and tourism sector (Flaquer, 2023; Rizzo & Petruccioli, 2023). This has led to significant changes, including permafrost thaw, altered precipitation patterns, shifts in vegetation zones, and the change of socio-demographic structure (Callaghan & Jonasson, 1995; Jungsberg et al., 2016). Another notable effect is that young people from northern areas move to larger towns and cities in the south to seek various educational and work opportunities. This leads to shrinking towns and villages, an older population, increased unemployment amongst young people, and a lack of entertainment and cultural identity (Corbett, 2007). These transformations, coupled with ongoing resource development pressures, create a complex landscape for sustainability planning. Despite these pressing challenges, the Swedish Arctic holds potential opportunities fueled by the worldwide push towards a green transition (Söderholm, 2020). It creates a uniquely demanding context for involving sustainability perspectives in higher education. These trends are similar in Finland and Norway (Khan et al., 2021; Lipiäinen et al., 2022).

In higher education, these challenges and opportunities must be addressed with the complexities of mitigating the detrimental impacts of climate change and historical resource exploitation while responsibly harnessing the potential of the green transition. This demands a pedagogical approach that fosters systems thinking, enabling students to analyze the interconnected ecological, economic, and social consequences of development actions. Most recently, architecture education in the north of Sweden is considering these challenges in the design and implementation of the energy transition in the Arctic region. While many are positive about the opportunities such an influx of investments can bring to a shrinking local population, others are concerned with the impacts of such a change on local identity (Fjellborg et al., 2022; Ojala & Nordin, 2015). In the Architectural Engineering program at Luleå University of Technology, the aim is to develop courses with unique perspectives into social and environmental sustainability, such as dealing with

climate mitigation and adaptation and urban attractivity. This approach is particularly reflected in the results of a fourth-year master course, Sustainable Urban Development.

4.2. Course Content and Structure

The United Nations' focus on Education for Sustainable Development highlights the urgency of embedding sustainability across all educational levels (Buckler & Creech, 2014). As stated in the influential World Commission on Environment and Development report, achieving sustainability demands that everyone takes "wider responsibility for the impacts of decisions" (Brundtland, 1987, p. 56). Higher education plays a crucial role in preparing future leaders to address these challenges (Fokdal et al., 2020). Therefore, universities are expanding their sustainable development curricula across disciplines, considering environmental, economic, and societal impacts, with particular emphasis on integrating sustainability into planning and design.

Our Sustainable Urban Development course focuses on these critical issues within the context of the rapidly changing Arctic region. Within a study period of eight weeks, students (both Swedish and international) explore the interplay of built structures, transportation networks (public, private, and active transport), green spaces, and their collective impact on sustainable living. Active learning and engagement with real-world Arctic planning challenges are prioritized (Fokdal et al., 2020), enabling students to develop holistic solutions. The course's overarching goal is to empower students to analyze and apply urban development theories in the Arctic, addressing complex social, ecological, and economic challenges posed by climate change and evolving resource development patterns.

This course examines the application of sustainability theories in urban planning, specifically within the context of the Nordic Arctic region (Figure 2). Students gain a foundational understanding of the Arctic's unique characteristics and the challenges of sustainable living in this context. Key course competencies

Figure 2. Nordic Arctic region. Source: Combeaux et al. (2022, p. 8).

include describing the concept of sustainability, analyzing relevant national and international agreements, defining objectives for sustainable urban development, and critically evaluating the social, ecological, and economic dimensions of urban projects in the Arctic.

The course structure blends theoretical foundations and practical application. Four core aspects are explored: green and blue infrastructure, urban areas, renewable energy, and sustainable mobility. Students collaborate in small groups to research and present mini lectures on these topics, supported by a curated reading list. This process fosters active learning and prepares students for in-depth discussions. Simultaneously, students engage in a project assignment grounded in real-world Arctic planning scenarios. This project emphasizes analysis, problem-solving, and the development of comprehensive proposals presented in various formats.

In the project assignment, students were divided into groups, focusing on writing a strategic planning proposal, based on the literature studies, analyzing how the case study area in the Arctic region functions today and proposing planning measures for future sustainable development. The proposal should address both short-term and long-term development phases, including housing, services, infrastructure, cultural and green structures, etc., and relate to the Agenda 2030 SDGs. The analysis addresses the case study area, regarding its urban structure, urban areas, renewable energy, and sustainable mobility.

5. Results

The investigation into Sustainable Urban Development within the Arctic regions of Norway, Sweden, and Finland underscores the critical importance of planning for sustainable communities underpinned by the principle of sustainable development. Sustainable development, which seeks to meet the current generation's needs without compromising future generations' ability, is pivotal in guiding municipal strategies across these regions. Our findings reveal that active cognitive processing, various assessments for learning, and knowledge-enhancing feedback—our three core pedagogical principles—were instrumental in achieving the course's learning outcomes.

The course divided 15 master-level students into three groups, each tasked with addressing sustainability in one of the Arctic regions. Through literature review, data collection, analysis, and field trips, students engaged deeply with the subject matter, embodying the principle of active cognitive processing. Each group conducted the research on a specific part of the Arctic region, namely Finnish Lapland (Finland), Troms og Finnmark (Norway), and Swedish Norrbotten (Sweden). Their objective was to understand the development goals of each region and how these goals connect with the global SDGs in Agenda 2030, comparing the similarities and differences among them. Their presentations to local stakeholders not only facilitated real-world engagement but also provided a platform for immediate, knowledge-enhancing feedback, further refining their understanding and proposals.

5.1. Active Cognitive Processing

Active cognitive processing, a fundamental principle of effective learning, encourages students to deeply engage with course materials and connect new information to their existing knowledge. In this course, students in each group conducted extensive research using provided literature, independent search for reports and municipality documents on Arctic development strategies and visions within Finland, Norway,

and Sweden. This pedagogical principle proved pivotal in empowering students to adeptly navigate the multifaceted and interlinked challenges endemic to these regions. Through this rigorous inquiry and understanding of the contextual dynamics, students were proficient in discerning the shared challenges inherent in the development strategies of each region. This was shown as visions in their strategic planning proposals for tailored strategies addressing both short-term and long-term development objectives (Figure 3).

In Finnish Lapland, students were confronted with the task of increasing population sustainability while leveraging renewable energy sources. They critically analyzed the region's unique environmental conditions, societal needs, and potential for green energy, leading to proposals that balanced ecological integrity with human development. This deep dive into the specifics of Lapland's context required students to synthesize diverse knowledge areas, from ecological science to social policy, demonstrating the principle's effectiveness in fostering a holistic understanding of sustainability. The strategic vision for Finnish Lapland involves expanding towards the larger cities in the northern region, beginning with Rovaniemi and extending to Inari and Muonio. Currently, Rovaniemi stands as the largest city in Finnish Lapland, boasting established connections to the southern parts of the country. Inari, situated amidst seven national parks and adjacent to a large lake, holds significant potential for attracting both tourists and new residents. The long-term plan, spanning the next 30 years, includes Muonio as a key focus for development. This selection is strategic due to Muonio's location on the Swedish border, its proximity to Norway, and its surrounding national parks. Additionally, the presence of undeveloped areas offers opportunities for the construction of wind farms, further enhancing the region's appeal and sustainability.

Norway's Troms og Finnmark presented a different set of challenges, characterized by dramatic topography and a sparse population. Here, students explored innovative solutions for sustainable mobility and community resilience, considering how to maintain the delicate balance between development and the preservation of natural landscapes. By engaging with this complex scenario, students developed proposals that were sensitive to the unique needs and opportunities of northern Norwegian communities, reflecting an advanced level of understanding and application of sustainability principles. They considered Troms og Finnmark a thriving region on the rise. Within its winding fjords and vast nature, they identified a strong network of tightly knit

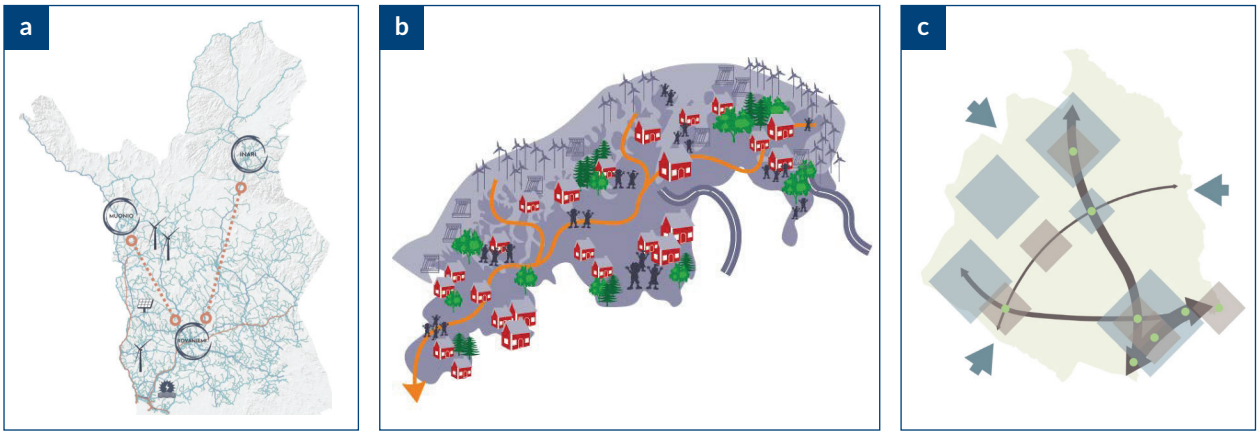


Figure 3. Visions of three countries in the Arctic region. Sources: a. Finland (Gideonsson et al., 2022, p. 11); b. Norway (Combeaux et al., 2022, p. 10); c. Sweden (Ravlic et al., 2022a, p. 4).

communities. The future for energy production should be greener than before, but within the capacity it has. The development of sustainable industries should support both nature and the people, standing side by side to ensure that Troms og Finnmark is a region connected to the Nordic Arctic.

In Sweden's Norrbotten, the emphasis on inclusivity and equity within the framework of sustainable urban development has prioritized the social dimensions of sustainability. This approach has explored how urban planning can enhance community cohesion and accessibility, particularly in regions characterized by significant geographic and demographic diversity. The investigation highlights the necessity of incorporating human factors into sustainability efforts. Norrbotten is seen as a hub of connectivity, collaboration, and innovation. The aim is to cultivate new ideas, improve resource utilization, and harness cleaner energy sources to overcome existing challenges. The vision includes creating novel spaces and working methods that challenge the status quo, striving for better internal connectivity within Norrbotten. Cities will remain green, contributing to micro-climatic environments that support the ecosystem. The nearby wilderness will continue to provide resources, inviting people to engage with nature, offering work, food, materials, health, and happiness.

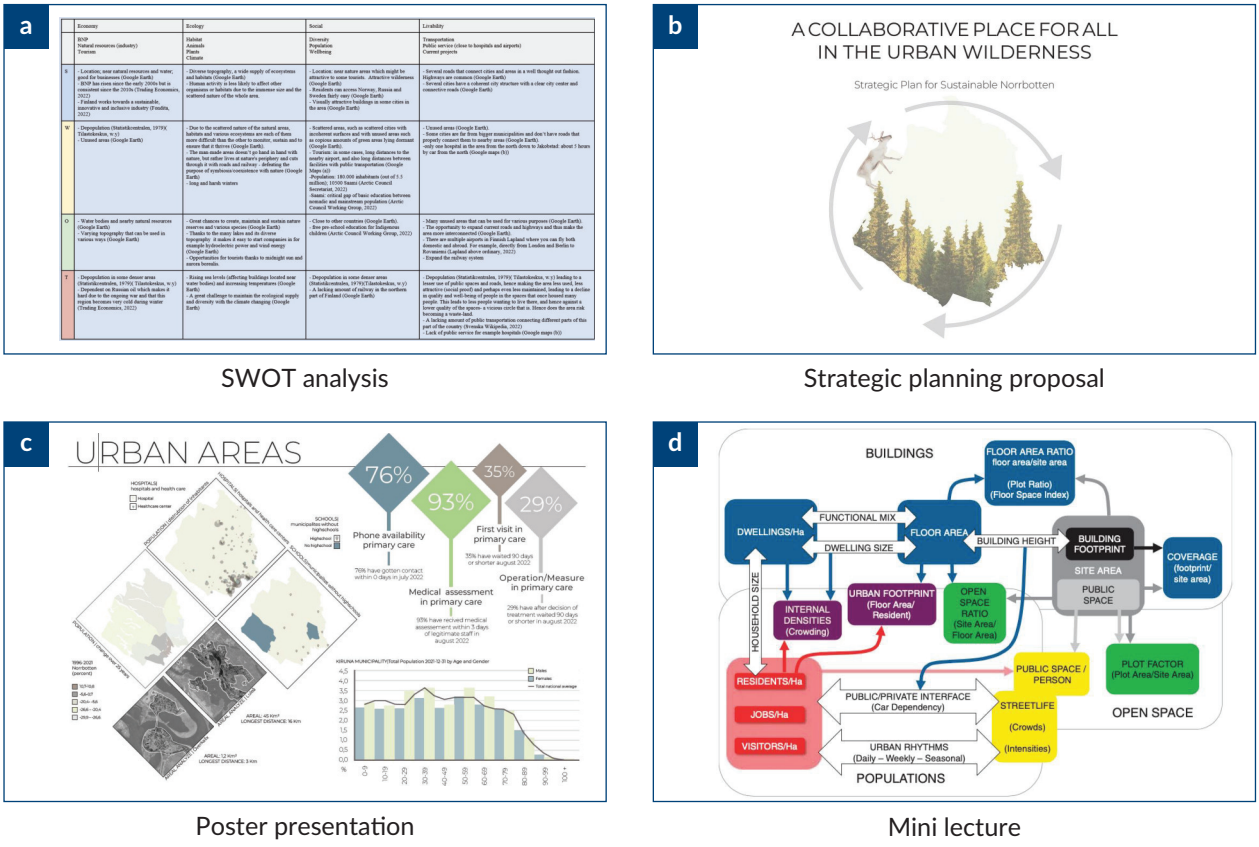
5.2. Various Assessments for Learning

The approach of assessment for learning, which prioritizes the use of assessment as a means to enhance learning rather than merely for evaluation, was instrumental in enriching students' comprehension of sustainability within the Arctic regions. The course applies this principle by integrating feedback mechanisms and reflective practices into the assessment framework, thereby ensuring that assessments serve as a continuous learning process.

A distinctive aspect of assessing students' learning outcomes involves group presentations on principal sustainability subjects. Recognizing the broad and general nature of the sustainability concept, the course narrowed its focus to specific areas such as mobility, green and blue infrastructure, energy, and public spaces. This focused approach helped to narrow down the scope of sustainable urban development, making the concept more tangible and manageable for students.

Various types of assessment have been applied in this course (Figure 4). The mini lecture presented by students were anchored in literature reviews of each topic, contextualized within the Arctic settings. This process significantly enhanced students' analytical capabilities and their ability to bridge theoretical concepts with practical applications. Additionally, the requirement for a planning proposal assessed students' proficiency in identifying and addressing problems. These proposals had to be articulated through formal writing, complemented by visual aids such as maps and diagrams to underscore key information.

Consequently, the synergy between oral presentations and written documents served not only to showcase students' written and verbal communication but also to test their in-depth understanding of the topics at hand. This combined assessment approach ensured that students were not merely evaluated but actively engaged in a learning process that reinforced their knowledge and skills in sustainable urban development within the Arctic context.



SWOT analysis | Strategic planning proposal

Poster presentation | Mini lecture

Figure 4. Various types of assessment. Sources: a. SWOT analysis (Gideonsson et al., 2022, p. 18); b. Strategic planning proposal (Ravlic et al., 2022b, p. 1); c. Poster presentation (Ravlic et al., 2022a, p. 1); d. Mini lecture (Dovey & Pafka, 2014, p. 70).

5.3. Knowledge-Enhancing Feedback

Knowledge-enhancing feedback, designed to bridge the gap between existing knowledge and the learning objectives yet to be achieved, played a crucial role in the educational experience of students. This principle fostered a dynamic educational environment, enabling students to actively incorporate feedback to refine their understanding and enhance their project proposals. Within this course framework, students were exposed to three distinct types of feedback, each serving to deepen their engagement with the subject matter and broaden their perspective on sustainability.

During course presentations, students encountered feedback from peers in opposing groups. This peer-to-peer interaction encouraged a critical exchange of ideas, wherein students from other groups posed questions and offered insights, thereby enriching the discourse on the presented topics. This form of feedback not only facilitated a deeper understanding of the subject but also introduced new perspectives and ideas into the conversation. They received immediate feedback from lecturers, drawing upon their extensive knowledge and experience in teaching and researching sustainability in Arctic contexts. Lecturers posed targeted questions to students with the aim of deepening their understanding and addressing any uncertainties. This immediate expert feedback was invaluable in clarifying complex concepts and guiding students towards a more nuanced comprehension of sustainability.

The most effective yet challenging one was the feedback students received from planners within local municipalities during field trips. In this course, students presented their research outcomes at both Haparanda and Tornio municipalities, Sweden. Practitioners, well-versed in local policies and the practical challenges of sustainable development, offered insights that bridged theoretical knowledge with real-world applications. Their feedback grounded students' understanding of sustainability in the tangible realities of regional planning, thereby enhancing their problem-solving and critical thinking skills.

This multilevel feedback system significantly enriched students' learning experiences, offering them a thorough understanding of sustainability that transcended textbook knowledge. By engaging with feedback from peers, academics, and practitioners, students were equipped to critically analyze and address the complex challenges of sustainable development in the Arctic regions, thereby fostering a more holistic and practical approach to learning.

The challenges and difficulties encountered in applying these pedagogical principles to higher education for learning sustainability address the complexity of teaching and learning in this domain. Each region presented unique challenges that required students to engage deeply with the material, critically assess their work, and incorporate feedback to enhance their understanding and proposals. The importance of these principles lies in their ability to foster a learning environment where students are active participants in their education, equipped with the skills and knowledge to address the pressing sustainability challenges of our time. Through this approach, sustainability education can move beyond theoretical knowledge, preparing students to contribute to sustainable development efforts in the Arctic and beyond.

6. Discussion and Conclusion

We started this article with the research question: How can pedagogical approaches effectively integrate Arctic sustainability perspectives into architecture and urban planning education? Addressing this involves navigating unique pedagogical challenges and seizing opportunities specific to the Arctic context. These include crafting curriculum content that is both engaging and relevant to the Arctic, overcoming students' preconceived notions about the Arctic, ensuring interdisciplinary collaboration, providing experiential learning in remote and harsh environments, and incorporating Indigenous knowledge and perspectives effectively into the curriculum. A significant pedagogical challenge is the tendency to view Arctic cities as exceptional or extreme cases. In reality, these cities face many of the same issues as other small and medium-sized urban areas, such as mobility, climate adaptation, and aging populations. Treating Arctic cities as exceptional can lead to inadequate solutions to their common urban problems.

However, these challenges also present opportunities. By exposing students to the real-world issues and diverse perspectives of Arctic environments, educational programs can foster a deeper understanding of sustainability. The Arctic context is ideal for developing innovative teaching methods that emphasize active learning, critical thinking, and problem-solving. For instance, students can engage directly with the unique ecological and social conditions of Arctic regions, which enhances their ability to address complex sustainability issues. The distinct environmental and social dynamics of the Arctic also offer a rich setting for interdisciplinary collaboration. This collaboration is crucial in tertiary education in urban planning, as it allows students to integrate knowledge from various fields such as engineering, environmental science, sociology, etc. For example, students working on projects that tackle the challenges of sustainable development in the

Arctic—like designing energy-efficient housing or improving transportation networks in sparsely populated areas—must draw on multiple disciplines to create effective solutions. This interdisciplinary approach not only broadens their knowledge base but also enhances their teamwork and communication skills.

Our course implementation highlighted several considerations necessary for successful sustainable development education. These include the emphasis of the need for contextual awareness of sustainability issues, well-structured learning environments, a wide range of reading resources, robust institutional support, and dynamic communication and feedback mechanisms with communities and public sectors. The broad and general nature of sustainability, encapsulated in the United Nations' 17 SDGs, poses educational challenges that require a comprehensive and context-specific approach.

A dual strategy was demonstrated to apply this approach: combining literature review and presentation to introduce broad theoretical dimensions of sustainability, and engaging students in real-world projects to apply these concepts in the Arctic context. This methodology facilitated direct observation, data collection, and reflective practice, enabling a deep understanding of sustainable urban development within urban planning. By engaging with stakeholders such as planners from local municipalities, students developed a nuanced understanding of sustainability that transcends traditional academic boundaries. This approach is critical for preparing future leaders in sustainable development, capable of addressing the complex challenges posed by climate change and societal shifts.

However, even when applying the aforementioned methods in the teaching and learning process, sustainability remains a vast concept that encompasses multiple aspects and involves various societal roles. Several challenges were encountered in our course. One significant challenge was the difficulty in maintaining ongoing engagement with local municipalities throughout the course. Often, municipality stakeholders have limited time and resources to commit to educational collaborations, which can hinder the depth of students' projects and their practical relevance. Additionally, the remote and sparsely populated nature of Arctic regions can make fieldwork and data collection logistically challenging and costly. Another challenge was balancing the broad theoretical dimensions of sustainability with the specific, localized issues of Arctic urban development. While the dual strategy of literature review and real-world projects aimed to bridge this gap, some students found it difficult to integrate these two aspects effectively within the limited duration of the course. Furthermore, the breadth of sustainability as a concept requires that students must engage in extensive literature reading and comprehend local context intricacies, which can be overwhelming.

A critical setback we realized in this course was the difficulty in conducting longitudinal studies to assess the long-term impacts of the course on students' careers and further studies. While immediate feedback through evaluation surveys of the course provides some insights, a detailed approach to tracking and analyzing students' outcomes over time is lacking. To truly understand and improve the educational impact of sustainability courses, a more thorough approach to tracking and analyzing students' outcomes is needed. This includes not only immediate feedback but also longitudinal studies to assess how specific courses influence career paths and lifestyle choices over time.

In conclusion, teaching sustainability-related topics in urban planning is crucial and challenging. Arctic sustainability provides a valuable lens through which students could explore and understand the complexities of sustainable development. Recognizing that Arctic cities face similar issues to other

small and medium-sized urban areas helps shift the focus from their perceived extremities to their common urban challenges. The application of active cognitive processing, assessment for learning, and knowledge-enhancing feedback within this context not only enhances students' learning experiences but also prepares them to contribute to the global sustainability discourse. As the world continues to face the pressing challenges of climate change and sustainable development, educational approaches like those employed in this course will be crucial for equipping future generations with the necessary knowledge, skills, and perspectives. It is essential to recognize and address the challenges and setbacks encountered to continually improve and adapt pedagogical approaches for better outcomes.

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Conflict of Interests

The authors declare no conflict of interests.

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