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Current Practices in Hygrothermal Design Education: Evidence from Nordic–Baltic Building Physics Curricula

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Abstract. Achieving a resilient and zero-emission building stock requires advanced knowledge in hygrothermal design. Educating in new and complex approaches to the design and construction of future-proof, durable, sustainable, and energy-efficient structures are important to equip professionals navigating and overcoming current challenges. This article provides an overview of the state-of-the-art building physics education in the Nordic and Baltic countries, with a focus on the design and technological aspects of building envelopes. The study analyses the content and scope of relevant courses, prerequisite structures, teaching methods, integration of digital tools, and progress in the field. The analysis aims to enhance inter-university cooperation in building physics education. The results indicate that Nordic and Baltic universities provide a strong foundation in the building physics basics, adequately preparing students for the

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design and calculation of thermal transmittance and hygrothermal performance, especially in aspects of water vapour diffusion and heat transfer. However, advanced topics in building physics, the design of building envelope structures for new and renovated buildings, and moisture safety during construction, are taught in fewer universities and to fewer students, which result in a shortage of specialists in these areas. Without sufficient knowledge, skills, and experience in hygrothermal design, building envelope structures may perform poorly in the future climate, or design documentation may lack sufficient details. To achieve a zero-emission, climate-resilient building stock, it's crucial to enhance current curricula in building physics. Integrating science and modern testing methods into design and construction is a key aspect to expanding students' knowledge of advanced building physics and envelope structures.

1. Introduction

The urgent need to decarbonise the building stock [1,2] places new and challenging demands on the design, construction, and renovation of future-proof and sustainable buildings [3]. Consequently, EU policies are increasingly integrating environmental sustainability requirements into the regulations [4]. The revised EU Construction Products Regulation [5] requires products to be designed for enhanced durability, resilience, recyclability, and repairability, supporting the EU's green and digital transition objectives. Achieving environmental goals like climate change adaptation, mitigation, and transitioning to a circular economy poses challenges for building design, especially building envelopes. Effective teaching of building physics is essential for preparing future professionals to tackle these demands.

The requirement of applying building physics knowledge to the construction sector is highlighted by the cases of moisture damage in European buildings [6,7]. In Sweden, 85% of these moisture damages were linked to challenges with the building envelopes. Moisture damage caused by various reasons, including elevated humidity, deficient thermal comfort, condensation, rising damp, and discolouration was detected in components built during any period and occurred independently of time [8]. In Norway, 75 % of building defects are linked to the building envelope [9], related mainly to moisture, caused by sources such as precipitation, including wind-driven rain, condensation of humid indoor air, or built-in moisture [10]. According to a 2022 report from surveys of EU citizens [11], nearly one in ten occupants in Nordic countries report dampness and mould issues, more frequently than concerns about insufficient daylight or cold indoor conditions.

Many of these challenges are still under investigation and development in the Nordic-Baltic region, including: outdoor ventilated cold attics [12,13], compact roofs [14], structures in contact with the ground [15,16], drying of structures [17,18], thermal bridges [19], ETICS [20,21], and air leakages in the building envelope [22–24]. Many of the challenges are new compared to decades ago. Regulations demand more energy-efficient and zero-emission buildings, which require decreased heat loss through the building envelopes for new buildings [25] and renovation of existing ones [26]. Increasing the thermal insulation thickness of the building envelope without changing other parameters may increase the risk of mould growth and the drying-out period [27,28]. Additionally, new challenges have arisen due to the use of new materials, like: cross-laminated timber [29–32], aerogel-based materials [33,34], nano insulation materials [35], phase change materials [36], mortar-based thermal insulation [37], magnesium oxide boards [38], bio- and nature-based insulations [39,40], earth-based structures [41], building integrated photovoltaic panels [42,43], interior insulation [44–48], 3D-printed materials/components [49],

and so forth. Additionally, as shown by Caniato et al. [52], in the context of green timber buildings, designers' expectations regarding building physics performance are influenced by personal beliefs, knowledge gaps, and expectations, a situation that could be improved through deeper, broader, science-based education on the matter. Last but not least, the future pressure imposed by climate change on building durability and moisture damage complicates the design of durable and resilient structures [50,51], due to the increase in heavy precipitation in the area [53].

Building physics has progressed over the past 30 years, driven by advanced computational tools that enable detailed modelling of heat and mass transfer in buildings and their close environment. These developments enhanced experimental research, combining numerical–experimental approaches and standard practices. This results in better buildings and improved practices in design, construction, and maintenance through continuous education and professional training. However, rising demands for indoor environmental quality, reduced negative environmental impact, new and innovative materials and envelope systems, and climate change introduce new challenges for building physics design. Keeping building physics education up to date is key to preparing for tomorrow's demands.

Research in building physics focuses on the interplay of building materials, components, and assemblies, exploring transport mechanisms such as heat, air, moisture, solar radiation, acoustics, and radon. Numerous international conferences and scientific journals cover various topics in this field, alongside a range of university-level textbooks, from specialized to comprehensive. However, research on teaching and education of moisture-related building physics remains scarce. In curriculum development, related examples can be found in building science [54], climate change [55], and building energy performance [55,56]. In teaching, various simulation tools are commonly used to generate learning, but the teaching must take into account that the tools are not always used in practice [57], The tools contain limitations [58] and the results from different users can vary [59].

The above description highlights that many old challenges remain unresolved, while numerous new ones are emerging due to advancements in materials, products, and technologies, as well as future climate change. This highlights the importance and relevance of educating professionals in the hygrothermal design of building envelope structures. Thus, this article aims to provide an overview of the current state of education in hygrothermal building physics in the Nordic-Baltic countries in 2024-2025, with a particular focus on building envelope design. As this is the first comparison of its kind, the overview is merely factual, offering empirical evidence to guide future development and collaboration.

2. Methods

This study adopts a qualitative, expert-driven approach to survey and compare higher-education courses in hygrothermal building physics across the Nordic–Baltic region, within civil engineering and architecture programs. The analysis draws on the expert knowledge of the authors, who are academic staff directly involved in teaching and curriculum development at the participating universities. Information on course content and structure was collected and discussed through both survey in structured information template and joint expert meetings, enabling a systematic comparison across institutions. Through iterative discussions and consensus-building, strengths, gaps, and opportunities for future development and collaboration in hygrothermal building physics education were identified.

Data was collected from 11 universities across seven countries: Kaunas University of Technology (KTU), Lithuania; Riga Technical University (RTU), Latvia; Tallinn University of

Technology (TalTech), Estonia; Aalborg University (AAU) and Technical University of Denmark (DTU), Denmark; Aalto University (Aalto), Oulu University (Oulu) and Tampere University (TAU), Finland; Chalmers University of Technology (Chalmers) and Lund University (LTH), Sweden, and Norwegian University of Science and Technology (NTNU), Norway.

The data collection focused on gathering information on course contents and structure. First, the scope of the analysis was defined to include higher-education courses that explicitly address hygrothermal building physics-related contents. The analysis covered courses offered at bachelor's and master's levels within civil engineering and/or architecture programmes. The data collection was structured by dividing the courses into three categories, according to their content:

- Hygrothermal building physics: basics and advanced courses;
- Hygrothermal design of building envelope: new buildings and renovations;
- Moisture safety during the construction process: new buildings and renovations.

Each contributing author was asked to identify relevant courses at their institution that met these criteria. Data were collected from the formal sources (course descriptions) and sorted using a structured information template to ensure consistency across institutions. Quantitative data included course title, aim, position (year) within the program, study forms and load (lectures/theory, exercises, practices/laboratory work, individual work), method of teaching (ex-cathedra, including online teaching, online tutorials, and other teaching methods), number of students, distribution of time to different topics, prerequisites, learning outcomes, assessment, study literature, graduation, amount of work, course contents (coverage of heat, air, and moisture transfer phenomena, the relative emphasis placed on different envelope performance aspects).

The gathered data were analysed in the form of reflections on strengths, weaknesses, opportunities, and threats (SWOT) from the perspectives of teachers and students, the latter group by including data collected from students' annual feedback and national surveys. Both quantitative and qualitative input were used to support the experts' discussion, the identification of common challenges and opportunities for future development, and inter-university collaboration in hygrothermal building physics education.

3. Results

3.1 Overview of courses

Figure 1 presents relationships between courses and position in the curriculum. Basic courses are prerequisites for admission to advanced and specialised courses.

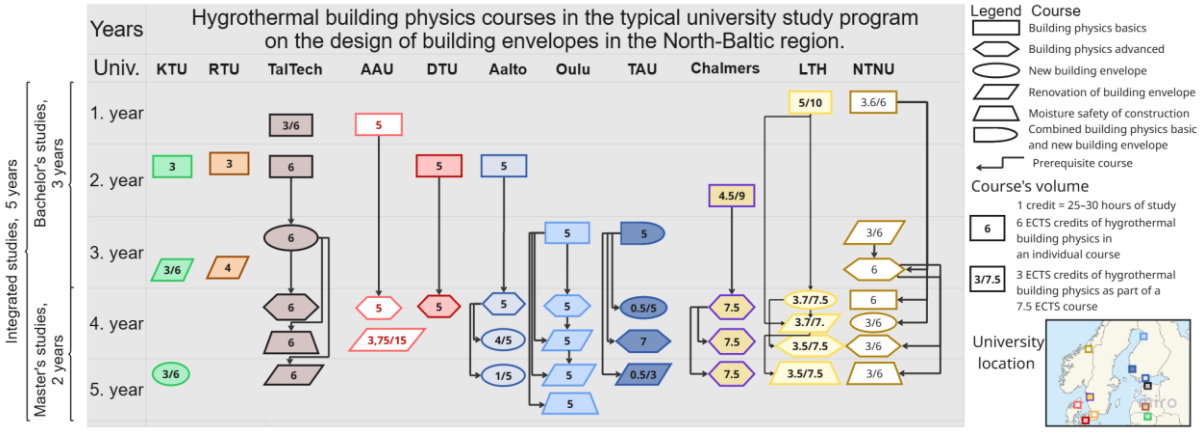

Figure 1. Relationships between courses and their positions in the study program.

Only courses and course sections that include heat, air, and moisture transfer theory and practice, design of new building envelopes and renovations from the perspective of hygrothermal behaviour, and moisture safety in construction work were included in the study. However, the analysis and the figures presented in this work should be intended as a preliminary overview of the discussions, which will be developed further in the next steps of the study.

3.2 Building physics basic course

Across universities, the compulsory bachelor-level hygrothermal building physics course shows only minor variations. It typically provides civil engineering and architecture students with fundamental knowledge of heat, air, and moisture transfer in buildings (sometimes also solar radiation, acoustics, and radon contamination). After completing the course, students are expected to understand the underlying physical principles, analyse building envelope structures using suitable methods, assess steady-state performance against regulations and sustainability goals, and apply this knowledge in integrated design. A few universities additionally expect students to perform analytical nonstationary and multidimensional heat transfer calculations, while only one explicitly includes using numerical tools for hygrothermal simulations.

Hygrothermal building physics basic education was reported to be offered at 90% of the studied universities. In 9 universities, the subject is covered in a dedicated, stand-alone course, typically titled *Basic/Introduction to Building Physics* or T*hermodynamics and Fundamentals of Heat Transfer/Thermal Building Physics/Heat Transfer in Building Construction*. In one institution, the subject is taught within a larger course in *Building Technology.* In terms of distribution of time to different aspects of building physics, the building physics basic course primarily focuses (≈ 50%) on topics related to heat loss and thermal performance. It includes discussions on moisture transfer mechanisms and storage (≈ 20 %), with calculations mostly limited to one-dimensional and steady-state conditions. Two-dimensional thermal calculation is used to calculate linear thermal transmittance and criticality of thermal bridge in 44 % of universities, mostly by using the software LBNL Therm [60] (freeware). In some universities, an introduction to acoustics and daylighting is also included. Within the bachelor's program, the building physics basic course is often given on the second or third year, offering 2.5 to 6 credits. Theoretical calculations were included in the course across all universities, while only one complements it with practical measurements. In general, building physics basic courses emerge as compulsory, large-scale courses, with an average number of students of 120, and a maximum of up to 300 students. The percentage of successful graduates is around 80 %. Teachers' teaching experience in building physics-related topics varied between 5 to >20 years.

The SWOT analysis shows that teachers view the high student–teacher ratio as a major weakness, limiting individual feedback, deeper explanations, and practical examples. At the same time, they see strong opportunities to use the basic course to highlight the societal relevance of building physics—driven by climate goals, moisture safety, and regulations—and to strengthen teaching through interactive methods, interdisciplinary collaboration, and shared material development across universities. Students report clearly understanding the importance of building physics for their studies and future work. They appreciate clear learning objectives that connect theory to materials, construction solutions, and building requirements, as well as well structured courses, expert teaching, hands on tasks, and support from teaching assistants and digital platforms. Identified weaknesses include the demanding nature of the material—especially in courses covering many topics—and the wide variation in students' prior knowledge. Students also see room for more practical examples and interactive teaching. One institution additionally

noted a market-related challenge: some company managers still do not recognise the importance of building physics in modern construction.

Feedback from teachers and students highlights three major opportunities to improve basic building physics courses: clearer links to specialisation tracks and professional careers; increased use of interactive methods such as case studies, simulations, laboratories, practical exercises, and calculation examples; and broader use of digital tools for calculation and visualisation. Strengthening interdisciplinary collaboration, modernising assessment and feedback, and updating teaching materials with international partners and national industry practice are also important steps. Key threats include declining attendance and engagement, students copying assignments, and limited time to fully grasp core concepts. Expectations for more interactive teaching may lead to dissatisfaction if courses are not updated. More broadly, insufficient basic competence increases the risk of design and construction errors, weakens the course's standing in the curriculum, and reduces companies' competitiveness due to a lack of qualified specialists.

3.3 Building physics advanced course

In most cases, the advanced master's level hygrothermal building physics course was found to have the following characteristics. The advanced course aims to provide a deeper understanding of heat and mass transfer in buildings, together with an introduction to different 1D–3D numerical methods, software relevant for analysing and supporting building envelope design and problem-solving approaches. The software used for numerical simulations includes Delphin, Therm, COMSOL Multiphysics, WUFI Pro, WUFI 2D, Simulink, Contam, and custom calculation tools using MATLAB or Python. Based on learning objectives, these courses should equip students with the ability to analyse, model and simulate complex, dynamic heat, air and moisture processes in building envelope structures, to diagnose and design building envelope assemblies under varying climatic and operational conditions, to critically evaluate numerical results and regulatory performance, and to apply this knowledge professionally in sustainable, multidisciplinary building design, assessment and research contexts.

Hygrothermal building physics advanced education is offered at 80 % of the surveyed universities (8/11), with about 65 % (7/11) providing it as a stand-alone course. Course titles vary widely, including *Hygrothermal Modelling, Heat and Mass Transfer in Buildings, Building Physics Advanced, and HAM Transfer* (analytical/numerical modelling). Moisture plays a larger role than in basic courses, accounting for roughly 40 % of teaching time. Typical topics include boundary conditions, mould-growth models, hygrothermal design, measurements, and moisture-damage prevention. Within master's programmes, advanced courses are usually taught in year 1 or 2, with one university offering it already in the third bachelor year. Course size averages around 5.5 credits (range 5.5–7.5 credits). Courses may be mandatory or elective, typically attract about 40 students, and have an average pass rate above 75 %.

SWOT feedback shows that advanced building physics courses benefit from being elective in many programs, leading to highly motivated and engaged students. The subject, teaching quality, and lecturers are generally well appreciated, and interactive elements (e.g., Kahoot questions) receive positive responses. Close involvement of industry professionals as supervisors or examiners is another strength, providing a realistic context, networking opportunities, and better alignment with practice. Challenges include students' varied educational backgrounds, which create uneven starting levels, and perceptions that the course can be overly theoretical. Students request more applied examples, clearer solutions, and less demanding exercises. In some cases, outdated or low-relevance content reflects limited updating of course material.

Teachers value the course as a good source for identifying master's thesis candidates. Students see further improvement potential in modernising materials, increasing practice-oriented activities, and enhancing feedback and assessment. Additional opportunities lie in developing and sharing teaching resources with international academic partners and industry. A key threat is the tension between the course's high theoretical demands and increasingly tight study-time constraints for students.

3.4 Design of building envelope for new buildings

Only two universities, out of eleven, offer a stand-alone course on building-envelope design for new buildings. These courses introduce civil engineering and architecture students to basic design criteria, common envelope solutions, and how to select optimal layer assemblies based on performance requirements. In two additional universities, the topic is embedded in courses such as basic building physics, building technology, or energy performance of buildings, and most institutions cover at least some core concepts within their building physics curricula.

Standalone courses are taught either in the third bachelor year or the second master's year, titled *Building Envelope Structures and Building Energy Demand Modelling*, each worth 6 credits, and are compulsory within related programmes. At another institution, the topic is extensively integrated into a mandatory third-year bachelor's course in building physics, corresponding to about 2.5 credits.

On average, courses concentrate 45 % of teaching time on heat loss (thermal transmittance, linear thermal transmittance, thermal bridges, etc.), ~40% on moisture performance, and ~15% on air leakage and other topics related to the building envelope. Typical prerequisite courses are basic building physics and building materials. The building envelope is designed based on basic moisture-safety design rules (wind-driven rain protection of façades, water protection of structures in contact with soil, roof eaves, plinth heights, etc.) and calculating hygrothermal performance based on moisture diffusion and heat conduction (EN-ISO 13788 [61]). The courses range from large scale (100 students/course) to small scale (15 students/course).

Students appreciated the professionalism, dedication, and ability of the lecturers to deliver complex topics. They valued the feedback on course projects, the supportive and motivating atmosphere of a good learning environment during practice sessions, and the encouragement to ask for questions and clarifications. In one course, students appreciated the flexible learning options, such as distance participation in lectures, and the prerequisite subject (basic building physics), which acted as a motivating and quality-assuring filter in the curriculum. Students expressed a desire for more practical examples, particularly regarding the connections of building envelopes in both lectures and practice sessions, along with a clearer emphasis on the most critical aspects and core contents of the course. Furthermore, there was a call for a more flexible approach to learning and assessment that accommodates working students and distance learning opportunities, while avoiding unannounced graded in-class assessments. In one university, the course is mandatory for bachelor's degree architecture students. While designing a new building envelope is central to architects' future work, architecture students encounter significant challenges with this topic.

3.5 Design of building envelope for existing buildings – renovation of building envelope

The course on design of building envelope for existing buildings aims to equip students with the skills to plan the service life of a building, assess the need for further surveys, and evaluate and select suitable renovation and repair solutions, including service systems and moisture damage repairs. Three out of eleven universities offer a separate course in building renovation, while one

university incorporates this topic into other courses. These building renovation courses can be either elective or compulsory and are primarily targeted at civil engineering students at the master's level, offering 5 to 7.5 credits. The titles of the courses range from *Structural renovation orRenovation of buildings, to Moisture damage remediation design, and Transformation of existing buildings.*

Additionally, three universities provide dedicated courses focused on pre-renovation building condition assessments. The learning outcomes for these courses enable students to plan, conduct, interpret, and evaluate moisture and indoor air condition investigations; apply and assess the reliability of various measurement methods; analyse air, heat, and moisture-related phenomena affecting indoor environments; evaluate the impact of damages and exposure conditions on the urgency and scope of maintenance and retrofit measures; and calculate airflow, air pressure distribution, and the criticality of thermal bridges. The courses are titled: *Indoor environmental investigations, Building health and indoor environment, and Energy, air movements, and moisture in rebuilding and administration.* They are usually offered at the master's level as elective courses focused on pre-renovation building condition assessments. Two of them are provided as separate courses (5-7.5 credits), while one is part of a wider course (0.5 credits out of 3).

Students and companies viewed courses as highly relevant and engaging, offering both practical and theoretical insight into surveying and renovating existing buildings. Students especially valued the strong "learning by doing" approach, with site visits, real examples, and solution-oriented theory linking technical knowledge to real constraints such as cost and user needs. The course builds key competencies in assessing existing buildings, integrating traditional and modern methods, and producing safe, sustainable renovation solutions, while also preparing students for research and thesis work. The main weakness is the heavy project workload, which limits depth despite supporting learning goals. Other challenges include limited access to equipment, weather-dependent surveying, uneven topic emphasis, limited hands-on experience for students without construction backgrounds, and insufficient integration of architectural perspectives. Opportunities include more recorded and hybrid teaching, expanded hands-on practice, additional drawing-based and real renovation case exercises, and stronger involvement from authorities and practitioners. Improved group-work organisation, a clearer architectural role in technical renovation design, and exploring tools like AI for typology analysis were also highlighted. A key threat is that the large, partly theoretical workload may crowd out practical learning, while the increasing complexity of renovation—especially in post-WWII housing—puts pressure on course content and requires careful balancing of depth across topics.

3.6 Moisture safety during construction

When a building envelope is designed to perform well during the whole service life, it should also be constructed ensuring moisture safety during the construction period. It is also important to teach how to guarantee the airtightness of the building envelope. According to the data collection performed in this study, only two out of 11 universities offer an independent course to educate on moisture safety during the construction period. At two other universities, this topic is partially included and handled as part of other courses.

The independent courses take place in the second year of master's studies, typically for 20 students, offering 5 to 6 ECTS credits. They are titled *Moisture safety in the building process* and *Moisture damage remediation design*, respectively. Courses can be compulsory or elective courses, depending on the master's programs. For instance, in one university, the course is mandatory for the master's program *Healthy Buildings* and elective for others, while it is elective for all programs in other university. As per the time allocation of the teaching, on average, about half of the courses

focus on moisture transfer and moisture performance, about 20 % of the time is devoted to air leakages and 20% to other topics, with a minor 10 % being left to heat transfer-related topics. SWOT analysis revealed that combining participants with different progress and background (master's level students as well as professionals already working in the construction sector) and teaching methods (challenge-based learning, working in teams, mutual assessment) of studies creates synergy. Practitioners involved bring interesting real-life cases to the table that extend knowledge and skills also for teachers. Three teachers with different backgrounds complete a wide spectrum of competencies that enrich the course.

4. Discussion

Based on the data collected from expert faculty members from higher education institutions and the discussions developed in the meetings on such data, the following challenges and opportunities have been defined.

Compulsory, hygrothermal building physics basic courses are designed to devote most of the teaching time to heat loss and thermal performance. Consequently, civil engineering and architecture graduates can reasonably be expected to calculate thermal transmittance values and estimate heat losses using steady-state or monthly methods. However, the well-documented performance gap in practice shows that actual building envelope performance often deviates substantially from design predictions, with measured U-values and total heat losses reported to be up to 60 % higher than calculated values [62–64]. This gap reflects the limitations of simplified approaches and the greater complexity of real building behaviour, which requires detailed knowledge of heat, air, and moisture transport mechanisms, as well as the influence of the latter two on heat losses and how buildings are used and operated. In the current educational landscape of the Nordic–Baltic region, such integrated hygrothermal knowledge is primarily delivered through advanced courses, typically offered only at the master's level. Consequently, graduates entering professional practice with a bachelor's degree may lack the competencies required to effectively address performance gaps in practice, unless these skills are subsequently acquired through professional experience or additional training.

Teaching the calculation of 2D heat transfer is not always covered in all compulsory building physics basic courses, meaning that a knowledge gap may exist in practice. The share of linear thermal transmittance is smaller, but the share increases in the case of highly insulated building envelopes [65]. Moisture performance calculations in compulsory building physics basic courses cover mainly diffusion. The diffusion, however, is only seldom the main reason for moisture damage, as convection and capillary forces can transport much more moisture [66,67].

Advanced courses present topics not covered in the basic course, but in much fewer universities and with much fewer participating students, meaning that a knowledge gap may exist in the design market in the field of multidimensional, transient heat, air, and moisture flow. As real building envelope structures are not one-dimensional or airtight and are exposed to driving rain and air flows as well as to highly variating boundary conditions, simple one-dimensional and steady-state calculations can never present the real performance.

The design of building envelope structures for new buildings is typically not offered as a separate course at most universities. Instead, it relies on knowledge of basic building physics, building technology, and building energy performance. This situation is comparable, for example, to the fact that the design of load-bearing structures relies on basic principles of material strength and structural mechanics, while specialised courses focusing on timber, steel, concrete, masonry, and foundation structures need to be taught in addition. Similarly, general economic knowledge

is not enough for construction economics either [68], and construction site management challenges cannot be solved by general project management knowledge [69,70]. In practice, there are distinct specialities also within various components and types of building envelopes. Thus, teaching only the basic theory is insufficient to cover all the necessary aspects for designing and constructing durable, long-lasting, and healthy building envelopes for a future zero-emission building stock.

Although methods for moisture safety during construction were developed 15 years ago [71], it has not been implemented in most civil engineering curricula in Nordic-Baltic courses. Often, moisture damage that occurs during construction or due to the drying out of constructional moisture are not considered in the construction schedule [72–76].

Without sufficient knowledge, skills, and experience in hygrothermal design, the result may be a poorly performing building envelope structure due to a lack of education, or the solutions may not be adequately detailed in the design documentation due to a lack of confidence in the design process. To meet the goal of a future zero-emission, climate-resilient, and durable building stock, there may be a need to further develop current study programs.

Finally, the SWOT analyses based on student and teacher feedback indicate a strong and consistent demand for more practice-oriented and hands-on learning from the students. They particularly emphasise the value of practical examples, design projects, drawing-based exercises, and real-life case studies, alongside an increased use of digital tools for calculating and visualising building physics principles. When these aims are achieved, graduates are better equipped to apply this knowledge in practice, which in turn enhances their attractiveness to future employers. From the teachers' perspective, key opportunities were identified in strengthening interdisciplinary collaboration across architecture and engineering disciplines, modernising assessment and feedback practices, and updating teaching materials through cooperation with international academic partners.

5. Limitations

This study provides preliminary results and an overview based on information gathered during the initial phase of a broader collaborative effort to advance education in hygrothermal building physics in the Nordic–Baltic region. Although at the early stage of the collaboration, most university representatives provided extensive information during the data collection process. However, a minor part of the data is still missing. This may have some influence on certain aspects of the current analysis, such as the reported average credit loads or the average distribution of teaching time across different topics.

This paper maps the current teaching situation at the Bachelor's and Master's levels, without considering future developments. It emphasizes the need for renewing professional competence in the architecture and civil engineering sector, focusing on:

- Content: new building materials (low-emission, nature-based), lightweight envelopes, durability, climate resilience, sustainability, design for disassembly;
- Type: BSc/MSc education vs. continuing education or combinations;
- Volume: micro-degrees (18-24 ECTS) or bite-sized courses (typically 1 ECTS);
- Method: digital tools, distance learning, challenge-based learning, interdisciplinary cooperation, general competencies.

Subjected to these limitations, the data presented are still considered valuable for the academic community and industry, aiming to strengthen the education in hygrothermal building physics for building envelope design. Based on the results reported here, the collaboration intends

to progress towards a more comprehensive and structured dataset, as well as to develop concrete recommendations for advancing teaching practices and structuring inter-university collaborations in the field of hygrothermal building physics.

6. Conclusions

In the Nordic-Baltic region, universities of technology provide strong foundations for education in the basics of building physics. Since the basic course is compulsory, students learn to design and calculate the thermal transmittance and hygrothermal performance of building envelopes, including aspects of water vapour diffusion and heat transfer.

Advanced-level building physics, design of building envelope structures for new and renovated buildings, and moisture safety of buildings are taught in fewer universities and to fewer civil engineering students, which may lead to an insufficient number of specialists in these fields. The teaching of architects in hygrothermal building physics for the building envelope is clearly smaller in scope and of lower complexity. Considering their role in the early-stage design of building envelope structures, the education of architects in building physics should be improved. Nevertheless, selected building physics topics are incorporated in miscellaneous courses at different universities to a varying extent, hence helping to provide building physics teaching at both basic and advanced levels within a holistic building perspective. Compared to the share of existing buildings in the building stock, the extent of their renovation needs and the need for growth in renovation volume, the education and training in renovation of the building envelope structures of existing buildings are clearly limited.

The authors found that the current analysis poses the basis for future collaborations, with a preliminary identification of key challenges and opportunities in higher education for building physics. The future steps of this collaboration are expected to significantly enhance inter-university collaboration in building physics education and would also benefit future exchange students through more structured and coordinated course offerings. In addition to the Nordic-Baltic region, a similar analysis is also expected to be useful in other regions.

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