STEM in Heritage: Procedures, Methods, and Teaching

Edited by

Jasna Vuković

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PREFACE

The edited volume *STEM in Heritage: Procedures, Methods, and Teaching* before you encompasses papers presented at the international conference *Teaching STEM in Heritage*. The conference was held in November 2022 at the Faculty of Philosophy, University of Belgrade as the final event of the Erasmus+ Strategic Partnership Project *STEM in Heritage Sciences (HERISTEM)*.

The volume explores the application, learning, and teaching of STEM in heritage disciplines, primarily in Southeastern Europe. The first chapter represents a summary of activities carried out a part of the HERISTEM Project, aimed at university students, staff, and young professionals, as well as the general public (Vuković). Several papers address issues related to STEM teaching: the representation of STEM within university cirricula in Europe (Novaković), within the subdiscipline of archaeology and the public (Cvjetićanin), and within the curriculum of the Conservation-Restoration study program (Korolija Crkvenjakov); the history of archaeozoology at the University of Belgrade (Dimitrijević et al.); relationships between design tools, research strategies, and university courses related to architectural heritage (Milovanović et al.); and relations between "hard sciences," i.e. STEM, and archaeology as a humanistic discipline (Babić). Issues related to various methods and their application in archaeological fieldwork, laboratory analyses, and data processing are also discussed in the volume: the construction of archaological heritage using remote sensing and geophysics (Mlekuž); the use and significance of geoarchaeology both in research and heritage management (French and Rajkovača); geoarchaeological sampling, soil micromorphology, and related laboratory procedures (Rajkovača); the history and current use and importance of GIS (Mori); the application of UAVs, geophysical surveys, laser scanning, and LiDAR in Bosnia and Herzegovina (Kaljanac and Hadžihasanović); and the benefits of using photogrammetry in archaeological documentation (Tresić Pavičić and Burmaz).

We would like to thank all of the contributors for their presentations at the Conference as well as their valuable articles, and the reviewers who read all of the papers promptly and shared their opinions. Out gratitude is extended to our Institution, the Faculty of Philosophy, for supporting the conference and this publication, as well as Tempus Agency for their help during the course of the HERISTEM Project.

Jasna Vuković

REVIEW OF ANALYTICAL TOOLS AND DESIGN APPROACHES IN ARCHITECTURAL HERITAGE HIGHER EDUCATION: SHARING HERSUS PROJECT EXPERIENCES

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Introduction

In higher education in architecture and urbanism, the theme of cultural heritage is traditionally encouraged within study programs and various educational extracurricular initiatives. In the context of multiple influences affecting the development and transformation of cities – such as climate change, green challenges, and social transformation – the problematization of heritage issues in the setting of the city and landscape becomes a priority topic. For this topic to have far-reaching implications in the practical sense, its integration into existing study programs as well as new study programs is of immense importance. The General Consideration of *UNESCO/UIA Charter for Architectural Education* (UIA 2017) highlights that architectural heritage education is essential for "understanding sustainability, the social context and sense of place in building design, and transforming the professional architectural mentality so that its creative methods are part of a continuous and harmonious cultural process" (Appendix X, UIA paper on Heritage Education, of UIA Education Commission Reflection Group 7, on Heritage Education, Torino 2008, cited in UIA 2017). Following this consideration, understanding heritage issues in the built environment within the framework of cultural and artistic studies in architectural education is listed as part of mandatory knowledge (UIA 2017).

Although the subject of cultural heritage is already deeply rooted in architectural education, it has grown in importance in the last decade, taking a priority position in architectural education, practice, and policy. Within this context, a number of authoritative networks and bodies at the European level (both professional and educational) emphasize the role of heritage in creating a contemporary agenda of architectural action through declarations, charters, strategies, and policies. ACE's Policy Position on *Urban Regeneration: Renovating the Existing Building Stock* defines architectural heritage as "a capital of irreplaceable spiritual, cultural, social and economic value," and accordingly, advocates for the architectural profession's key role in the preservation of heritage through conservation and appropriate intervention (ACE 2016, 2). In the context of the European Conference for Architectural Policies, the vitality of architecture is explained through its connection with heritage – "Architecture is one of the layers of cultural heritage that speaks of who we are and where we are going, with a strong impact on creating the local and national identity" (Goagea et al. 2019). Moreover, research on architectural policies conducted between 2013 and 2020 revealed that built heritage is one of the ten priority thematic areas for achieving the objectives of architectural policies (Goagea et al. 2019). For the current architectural priorities established in accordance with the policy framework to be achieved, a research framework and new architectural strategies that promote circularity as one of the leading drivers of sustainable development must be developed. Consequently, the Statement of the Architects' Council of Europe (ACE 2019) on *Designing for a Circular Economy* indicates the need for introducing a cultural approach directed towards maintaining and re-using cultural heritage (ACE 2019).

Discipline of design and architectural heritage

Over the previous decade, there has been an immense growth of research and work on the principles of sustainability, particularly the preservation of cultural heritage in all domains and in the broadest sense. In this context, it is especially important to examine the relationship between the built environment and heritage in general, having in mind that recognizing and instilling built heritage values has become a critical theme in both the education and the practice of architects. As a result, a new profile of architects/urban designers is needed in the wider architectural field, and design education faces new challenges that demand fresh didactic perspectives and tools. A new professional profile, with specific technical, technological, socio-humanistic, and artistic skills is needed to respond to these challenges. Accordingly, a new profile of architectural educators is required, one who may be in charge of improving didactic methods

and tools in architectural design and heritage education. Therefore, it is necessary to emphasize the importance of critical thinking as well as the complexity of developing an adequate methodological framework for addressing sustainability and heritage in architectural higher education and the design discipline in order to enable future professionals to meet the expectations of 21st-century societies for a sustainable and value-based built environment in a variety of cultural settings.

Objectives and paper outline

The primary goal of this paper is to develop a methodological framework for addressing tools in the context of sustainability and heritage, thereby enriching curricula and broadening the scope of tools to be used in the design process. By defining the group of terms perceived as engaging learning contents (Notions, Heritage Types, Design Approaches, Design Actions, and Tools) with a focus on tools within various design approaches, the paper reconsiders the current educational framework (which includes, among other things, multiple scales, thematic scopes, course types), thereby contributing to the integration of three elements of research: value, method, and instrument. The specific objective of this paper is to analyze the relationship between tools and (1) research strategies, (2) spatial scales, and (3) educational frameworks and course types, to conceptualize them as supporting structures around which future curricula in architectural schools can be built, and as guiding frameworks for case study analysis in research and professional contexts. Following these objectives, two research questions arise: (1) what is the importance of tools in the analyzed domain of heritage and sustainability concerning high-quality standards of architecture and urban design higher education, and (2) what is the relationship between specific tools and research strategies, scales, and course types, i.e. what are the prerequisites needed to identify specific starting points and the role of specific tools.

The first part of the paper presents the research context. It provides insight into the Erasmus+ Strategic Partnership – Enhancing of Heritage Awareness and Sustainability of Built Environment in Architectural and Urban Design Higher Education (HERSUS) and HERSUS Intellectual Output 3. The second part of the paper presents a research framework for establishing correlation links between tools and research strategies, spatial scales, and course types for creating a methodological framework addressing the role of tools in sustainability and heritage in architectural higher education. The conclusion summarizes the findings and highlights essential aspects to be addressed in the further development of the remaining intellectual outputs within the HERSUS project.

Research context:
HERSUS Strategic Partnership

1. HERSUS project

The HERSUS project (Enhancing of Heritage Awareness and Sustainability of Built Environment in Architectural and Urban Design Higher Education) is developed and implemented as an Erasmus+ project within the Strategic Partnerships for higher education action scope. The project started in 2020 and is developed by five higher education institutions (HEIs) from five different European countries: 1) the University of Belgrade, Faculty of Architecture as the Lead Organization (Serbia), 2) Iuav University of Venice (Italy), 3) The University of Cyprus, Department of Architecture (Cyprus), 4) The Aristotle University of Thessaloniki, School of Architecture (Greece), and 5) the University of Seville, the UNESCO Chair on Built Urban Heritage CREhAR in the digital era (Spain).[1] To create a multi-contextual research platform, HERSUS consortium members give distinct reflections and contextual knowledge deriving from their unique socio-economic and cultural backgrounds, following the geographic line of Southern European schools of architecture. The project is structured around five types of activities: (1) Design and development of Intellectual Outputs (IO) – six results with tangible and meaningful outcomes, specifically publications, book of courses, an interactive platform, and a handbook (2) Learning, Training, and Teaching (LTT) activities – one seminar for teachers, three student workshops, and one training for teachers, (3) Multiplier Events (ME) – nine events for the dissemination of intellectual outputs and the overall results in the form of public presentations, and Open Houses at participating higher education institutions; (4) Transnational Project Meetings (TPM) – six design and development meetings of consortium members; and (5) Project Management and Implementation activities (PMI) – communication, dissemination, and creating a sustainable framework for implementing results. Learning, training, and teaching activities with intellectual outputs are at the core of the HERSUS project's implementation, with all other activities supporting and supplementing their design and development. LTT is a platform for testing principles and methodologies developed from intellectual outputs, ME is a platform for the dissemination and public presentation of intellectual outputs, and TPM promotes the discussion, creative development, and critical reflection of intellectual outputs. As part of the project, four intellectual outputs, along with three student workshops and one seminar, were finished by November 2022 (Fig. 1).

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1   For more information, see: https://hersus.org.

Figure 1. HERSUS Completed Results until November 2022 (IO1 - Review of the Best Practices on Educating Sustainability and Heritage (developed from November 2020 – May 2021), IO2 - Questionnaire for the State of the Art (developed from January 2021 – June 2021), IO3 - Statements for Teaching through Design for Sustainability of the Built Environment and Heritage Awareness (developed from February 2021 – December 2021), IO4 - HERSUS Sharing Platform (development started in December 2020, published in November 2021, updating and maintenance until the end of the project), LTT1 - Workshop 1: Sustainable Reconstruction in Urban Areas (Venice, Italy - 22nd–26th November 2021 (onsite), LTT2 - Workshop 2: Adaptive Reuse (Nicosia, Cyprus - 2nd–6th May 2022 (onsite), LTT3 - Workshop 3: Resilience and Future Heritage (Thessaloniki, Greece - 17th–21st October 2022 (onsite). (Figure by authors)

Over the previous two years, the project was gradually implemented, offering a wide scope of activities for cooperation between the research, private, and public sectors, securing both local and regional support for cooperation within higher education and the practical arena. With its research activities and the establishment of high-level expert groups, the project strives to analyze critical issues for the modernization and development of higher education in architecture and urban design across Europe, with an emphasis on the social and educational value of European cultural heritage. The HERSUS project is specific in that there is a visible conditionality between the six intellectual outputs (IO), which are conceptualized both as inputs for each other and as an integral result of the project that is gradually evolving and establishing a conceptual framework for improving higher education in architecture and urban design with a focus on heritage and sustainability.

2. Statements on teaching through design for sustainability of the built environment and heritage awareness

"Statements on Teaching through Design for Sustainability of the Built Environment and Heritage Awareness" are part of HERSUS' third intellectual output (IO3), coordinated by the University of Belgrade – Faculty of Architecture, and aimed at reaching an agreement among the HERSUS consortium on the concepts and fields of action relevant to sustainability and heritage (Djokić et al. 2022, 7). The results from IO3 have been prepared in the form of Teaching Vademecum: Statements on Notions, Ideas, Design Strategies, Design Tactics, Tools and Techniques, and Heritage Types relevant to the HERSUS scope. The IO3 findings led to the development of a strategy containing: (1) the requirements for an architect to be qualified in architectural and urban design, and (2) up-to-date qualifications an architectural educator must obtain to advance their teaching about the sustainability of the built environment and heritage awareness (Djokić et al. 2021). Vademecum provides insight into the above-mentioned analyzed terms along with their definition (explanation) and information regarding the content, methods, goals, course type, scale, learning outcomes, and teachers' competencies most suitable for the education of future professionals in the field. The general structure and instructions for reading Vademecum, as a system of terms relevant to the study of heritage and sustainability in architectural and urban design, is presented in Figure 2.

An important part of this publication is the HERSUS Glossary, which the project's target groups (students/teachers/trainers/tutors) can use to get

a clearer picture of specific training and teaching activities that help to align the needs of the practice and teaching of urban and architectural heritage sustainability. The Glossary was developed to help the project consortium establish consensus on concepts and fields of action relevant to the project, and it has specificities and limitations as a result of the expertise and views of individual researchers and experts involved in its development.[2]

The overall focus of IO3 was on a set of recommendations that aim to define and elaborate on professional competencies that need to be developed by both architects/urban designers and architectural educators in a dual perspective by (a) developing statements on the relevant notions, ideas, design strategies, design tactics, tools, techniques, and heritage types, and (b) developing statements on their importance for education (Djokić et al. 2022, 9).

Research framework: Review of analytical tools and design approaches

Based on previous HERSUS IO3 findings, a specific research framework was developed to test the applicability of tools as a driving and operational element of a design process that should be applied systematically to achieve a design goal and solve a design problem. By analyzing the group of terms used to cover all analytical and problem-based approaches in the design process and to treat and preserve a particular category of heritage, specific design approaches were identified.[3] Accordingly, a set of distinctive tools that are currently used or are in the domain of the expertise of researchers participating in the HERSUS project were analyzed following the predefined structure (Fig. 2).[4] Nevertheless, the established list of tools is by

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2   The overall methodology of the HERSUS glossary design and development has been previously elaborated (Đorđević et al. 2022).

3   While focusing on individual aspects in the fields of heritage and sustainability, the HERSUS project identifies several different approaches aimed at (1) preserving and emphasising inherited socio-cultural, spatial, and ecological values (Community Building and Representation, Historic Urban Landscape (HUL), Design For All In Cultural Heritage, Multi-scale Design Approach), (2) increasing ecological performance of buildings/places (Environmentally Responsive / Energy – Conscious/Climate-Sensitive/Whole-Lifecycle/Carbon-Neutral/Passive/Active Sustainable Design, Thermal/Visual/Acoustic Comfort Design, and Green Blue Infrastructure), and (3) investigating architectural programs capable of generating a sustainable use of heritage (Heritage Reprograming)

4   The HERSUS project identifies various tools in the field of heritage and sustainability: Image Rectification, 3D Printing, As Built / as Found Recording, Space Syntax, Morphogenesis Study, Mapping, Documenting, Cataloguing, Use of GIS Technology, Heritage Building Information Modelling HBIM, Collaborative cartography, Collab-
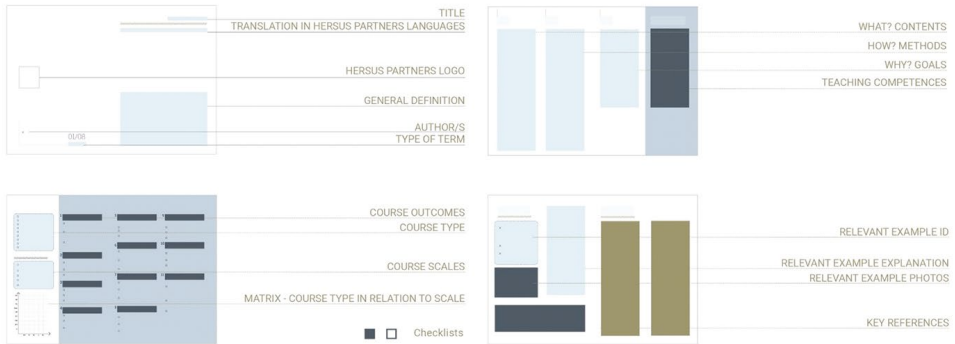
Figure 2. How to read HERSUS Vademecum Statements. (Figure by authors)

no means complete and it needs to be constantly upgraded in line with the ever-changing nature of tools used in architectural and urban design.

1. Role of tools in architectural and urban design

The constant evolution of design tools from perceptual (concrete) to conceptual (abstract), from static (the practice of representation) to dynamic (the practice of simulation), is adding new layers to already complex operations (Đorđević et al. 2022).

Tools in relation to research strategies and design processes

When referring to the design process, three phases are commonly highlighted: (1) the analytical phase characterized by systematic observation, inductive reasoning, experience, and measurement, (2) the creative phase characterized by assessment, deduction, reasoning, and decision making, and (3) the executive phase consisting of describing, translating, and transmission. The design process, perceived in this manner, enables one to understand when a specific tool is applied within the design process. Simultaneously, linking tools to research strategies enables one to understand the rationale behind applying specific tools. In this research, seven types of research strategies were adopted: historical research, qualitative research, correlational research, experimental and quasi-experimental research, simulation research, logical argumentation and case studies,

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orative Workshop CHARRETTE, Creative and Artistic Approaches, Heritage Value Matrix HVM, Thermal Energy Simulation, Lighting Simulation, Post-Occupancy Evaluation POE, Petrography, Conservation Status Evaluation, Archaeometry, Digitization of Heritage
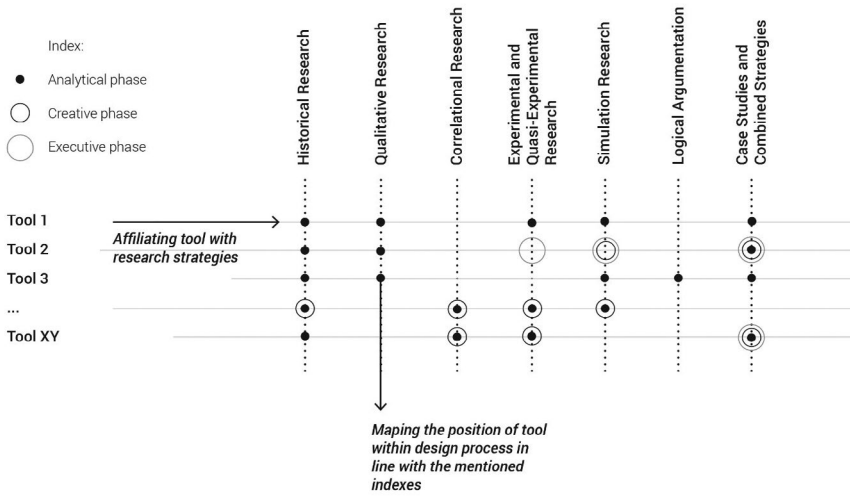
Figure 3. Methodological matrix: Examining the relation in-between research strategies, design phases and design tools. (Figure by authors)

and combined strategies, all of which are elaborated in detail by Linda Groat and David Wang (Groat and Wang 2013).

In this sense, the research framework is based on the methodological matrix (Figure 3) of tools and their affiliation with research strategies. The methodological matrix enables mapping the position of the tool within the design process in line with the mentioned indexes (analytical, creative, and executive phases).

Tools in relation to spatial scales

Considering the multi-scale nature of urban phenomena, spatial scale is of great importance for understanding urban processes and applying design approaches, necessitating architectural education to prepare future professionals to think broadly and act on multiple scales. Accordingly, the spatial scales included within the curricula can be classified as Construction Detailing and Interior Design Scale (XS), Architecture: Buildings Scale (S), Urban Design Scale (M), Urban and Regional Planning Scale (L), and Landscape Scale (XL). Concerning the relationship between spatial scales and design tools, a methodological matrix allows one to map the scope of tools in relation to the spatial scales (Figure 4). Visual representation within the matrix enables additional reading of the applicability span of specific tools (horizontal axes) and the level of tool representation within each scale (vertical axes).
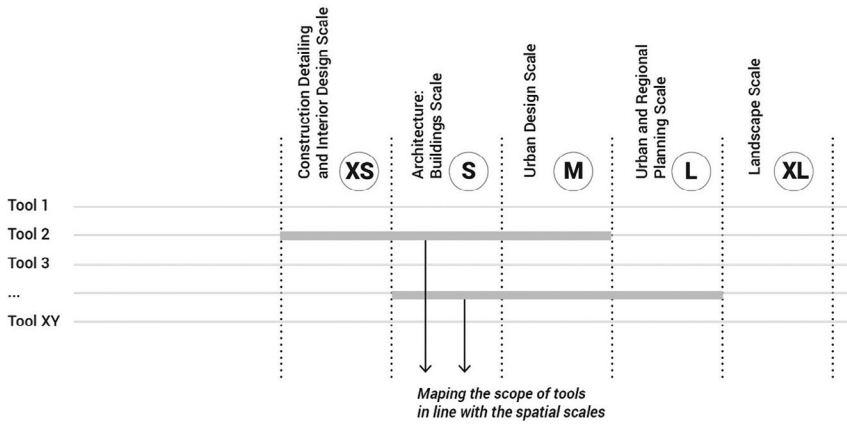
Figure 4. Methodological matrix: Examining the relation in-between spatial scales and design tools. (Figure by authors)

Tools in relation to educational framework and course types

The list of specific course types based on the HERSUS intellectual output 3 (IO3) included the following: Design Studio (DS), Intensive Workshop (IW), Theory Course (TC), Seminar (short comprehensive) (SSC), Laboratory Work (LW), Research Thesis (RT), Field Work (FW), and Internship Practical Training (IPT). The methodological matrix allows one to map the course types within which specific tools can be taught (horizontal axes), while vertical axes helps one to identify the various tools that can be taught within specific course types (Fig. 5).

Conclusions

The conclusions in this paper are conceived as a Concept Note for further research – as a methodological framework for the further critical development of tools and design approaches to heritage. Regarding the importance of tools when dealing with the specific subject of heritage and value-based design, one can recommend their equal use in all phases of the design process – analytical, creative, and executive. Contrary to the most widely held opinion that tools are predominantly used in the analytical phase, the HERSUS project advocates for the equal importance of tools in all phases of the design process. The project's methodological matrix provides a framework for future research and knowledge acquisition: (1) Research strategies and tools – collecting the best examples of good practice of tool application in research and practice which are and will be
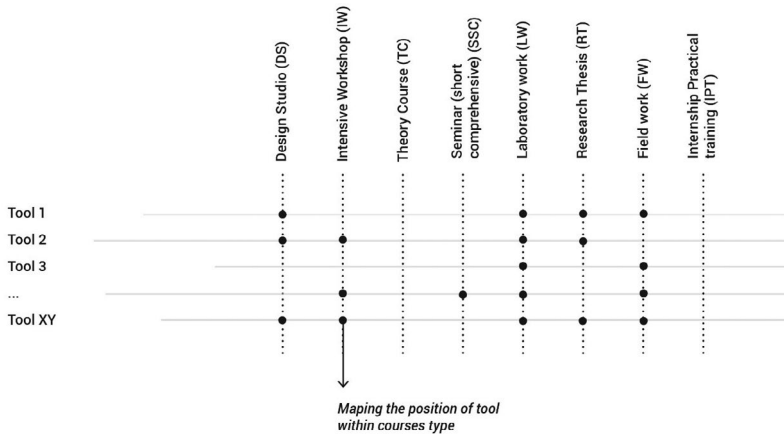
Figure 5. Methodological matrix: Examining the relation in-between course types and design tools. (Figure by authors)

further disseminated through Intellectual Output 4 – Hersus Sharing Platform[5] and used for its upgrade; (2) Spatial scales and tools – developed within IO3 by mapping a wide specter of possibilities and identifying gaps within these relations; this enables the framework for creating new tools and expanding the level of application of existing ones; (3) Course types and tools – tested and promoted through the development of new study courses from the HERSUS book of courses, as part of IO5 findings.

Acknowledgement

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5   For more information, see: https://hersus-sharingplatform.org.

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