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Emotional and Cognitive Maps for Urban Design Education: A Human-Centered Design Learning Approach

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Abstract. The paper presents the exp-EIA© method applied to a Master of Science university architectural course at Politecnico di Milano for fostering a human-centered and evidence-based urban design approach. The method, coupling architectural and psychological perspectives, enables to investigate the people-environment relationship using Virtual/Augmented Reality technology and psychological assessment scales. The method adopts a tool designed ad hoc to collect data regarding the urban experience and represent the outcomes in various forms, including the cartographic one. The procedure includes a virtual exploration of an area through spherical panoramas and a survey investigating the area's emotional and cognitive effects from specific points of view. An open discussion on the results with the 38 international students participating in the survey concluded the workshop. In particular, the collected individual reactions to the scenes were clustered, and the average emotional and cognitive results associated with the specific viewpoints were analyzed and discussed. Results show that some particular visual perspective constitutes robust social attractors characterized by intense emotional and cognitive reactions, whereas other points of view in the surroundings are socially negligible and emotionally neutral. This experiential approach favors practical considerations to inform the project phases from a sensory design perspective.

Keywords: Virtual reality · Emotional appraisal · Urban design · Design education

1 Introduction

The relevance of learning 'how to look at architecture' [1] is well known in architectural education. Furthermore, this knowledge-acquisition process should lead to the crucial professional ability [2] to correctly envision future developments, including the physical environment and the related subjective experience [3]. This paper presents a teaching approach combining architecture and environmental psychology based on the

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exp-EIA© [1] method and an *ad hoc* web tool developed by the authors. The tool allows collecting subjective reactions to specific urban perspectives and representing the results in various forms, including the cartographic one [4]. The main goal of this method is to foster a human-centered approach to urban design. Measuring the effects of urban transformations on people's experience before construction is relevant to demonstrate the effectiveness of the design outcomes for informing urban decision-making based on an evidence-based design approach [5]. The proposed procedure and the overall process applied to university architectural education aims at delivering a reliable teaching method to: i) learn about the psychological effects of urban space; ii) spatialize the components of the subjective experience; iii) raise students' awareness about the human-centered design perspective. The contribution briefly frames the state of the art on the topic; then, it introduces the methodology applied in an architectural university course (Master of Science) at Politecnico di Milano; consequently, data analysis and results are presented before the conclusions.

2 Theoretical Background

Understanding the psychological dimension of architecture should be a pivotal element in architectural education [6–8]. In the psychological field, many theoretical constructs describe different aspects of the people-environment relationship, which plays a crucial role in affecting the well-being of people [9, 10]. The main advantage of relying on proper constructs is that they allow describing the psychological factors underlying the observed phenomena, enabling to quantify the subjective perception of present\future environments [11]. In such a perspective, it is crucial selecting the adequate constructs [12] and related tools depending on the goal, be it an investigation of the existing condition [13] or the assessment of a design proposal [14, 15]. Emotions are one of the most investigated constructs describing the subjective reaction to a given environment [16], applied, for example, to commercial settings [17, 18] or mobility experience [19–21]. The place experience can be described also referring to the cognitive dimension, for example, considering the balance between a good understanding of a place and the attraction to further explore it as an indicator of preferred environments [22]. This 'preference matrix' can be applied for environmental assessments, such as appraising a landscape's aesthetic value [23] or the facades of buildings [24].

In the field of architecture and civil engineering (AEC), Virtual Reality (VR) and Augmented Reality (AR) technologies can enable the study of space both as a place in which to move and act [25] and as a complex emotional response to it [26, 27]. Usually, VR/AR representations are used as a means of subjective (pre)visualization [3, 28] and constructive aspects of education [29, 30]. The use of three-dimensional models and experiential simulations is increasing [3, 8, 31–33], in some cases associated with immersive viewing modalities [34]. Importantly, experiential simulation systems

[1] Experiential Environmental Impact Assessment - exp-EIA© - B. Piga, M. Boffi, N. Rainisio (Copyright BOIP N. 123453 - 06.05.2020 & Copyright BOIP N. 130516 - 25.02.2021). The data collected via the exp-EIA method are analysed with the patented "Method for calculating one or more isovists of a physical or extended reality environment" (Patent for Invention application N. 102021000017168 - 30/06/2021).

can ease the understanding to non-experts, which is crucial to involve citizens in a constructive dialogue around urban transformations [12, 35, 36].

These technological means allow teaching approaches based on a human-centered design perspective, contributing to developing spatial awareness while virtually experiencing the relationships between the design project and its context [37]. In addition, in the educational field, AR/VR technologies foster the learning approach via a 'learning by experiencing' process [38] due to the direct subjective navigation of the design solution [39]. So far, the main difficulty in disseminating these practices lies in the availability and costs of the tools [30], even though the rapid technological development and its wide-spreading will probably reduce this issue relatively soon.

3 Method: Participants, Procedure, and Instruments

The pilot event "Experiencing Città Studi"[2] was held on 2 October 2020 at the Politecnico di Milano (POLIMI) in the 'Città Studi' neighborhood, where the historic buildings of POLIMI and Università degli Studi di Milano (UNIMI) are located. The form was a full-day workshop with 38 international master's students (12 different nationalities) aged between 19 and 25: 56% women, 40% men, 4% non-binary. The case study application allowed us to evaluate the students' experience of Città Studi in its current condition. Beyond the residents, the area is frequented daily by researchers, workers, and students of these institutions. Due to the Covid-19 and the consequent restrictions introduced in Italy in that period, the activity took place in the form of blended workshops, i.e., with some participants attending in the classroom and others remotely connected.

The event was structured in three main phases: 1) explanation of the psychological tools and constructs included in the exp-EIA© method [40]; 2) evaluation of the Città Studi neighborhood through a questionnaire associated with Streetview™; 3) presentation of results by the instructors and following students' discussion about the outcomes. The questionnaire included individual socio-demographic questions and a list of items investigating emotional and cognitive reactions to the pre-set spherical views of the neighborhood (Fig. 1). The research group selected four Points of View (PoVs) considered representative of the area's narrative. From the pre-set standpoints, each participant looked around by panning the VR spherical panoramas, ending the exploration selecting the most representative perspective before filling the questionnaire.

[2] The instructors' team of the international workshop was interdisciplinary, in particular: prof. B. Piga (POLIMI) was responsible for experiential simulation and sensory urban (co-)design, prof. Marco Boffi (UNIMI) and prof. Nicola Rainisio (UNIMI) for social and environmental psychology. www.labsimurb.polimi.it/experiencing-citta-studi.

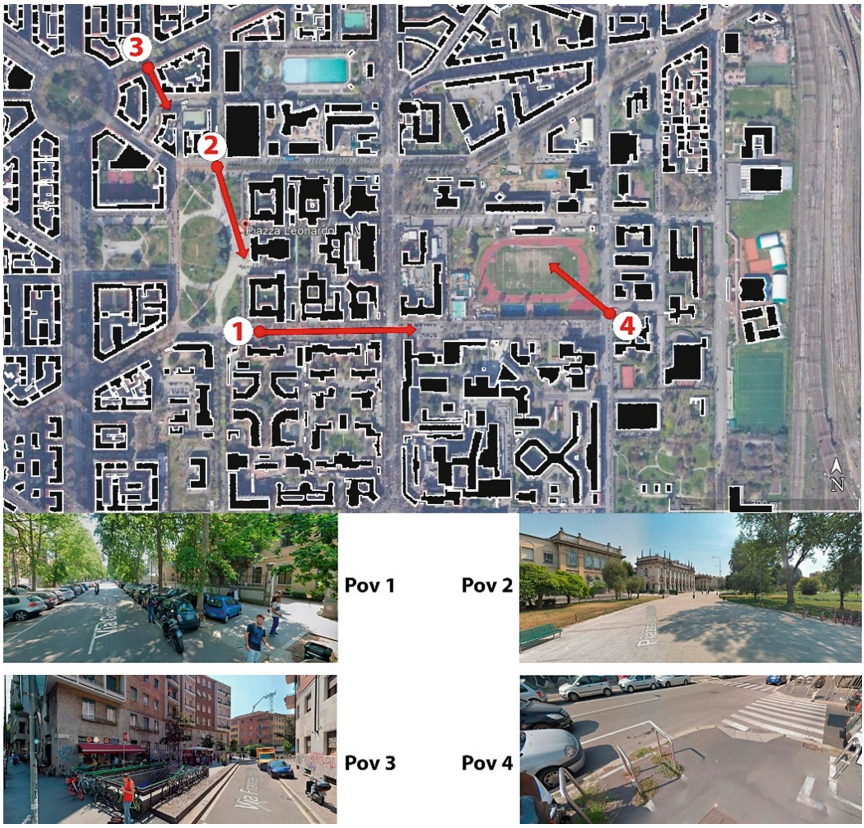

Fig. 1. Keymap: the four pre-selected PoVs to explore; PoV 4 points downward to induce participants to change the camera direction. Primary source: Google StreetView™

The questionnaire items on emotions are based on the well-known Russell model, which assesses the two dimensions of Pleasure and Arousal separately [16]. Participants rate each of these dimensions filling in a numerical filed using a reference scale ranging from 1.0 to 9.0, where the extremes represent unpleasant/pleasant and deactivating/activating experiences, respectively. The answers to these two bipolar dimensions allow placing the lived experience in the emotional space, a Cartesian plane where Pleasure is on the horizontal axis and Arousal on the vertical one, representing the Russell's circumplex model. The items on the cognitive dimension explore both the Ease of Understanding (EU), i.e. "comprehending or making sense of a scene" [41], and the Nudging Exploration (NE), i.e. "being held by the setting, being attracted by or pulled toward sources of additional information" [41]. Participants rated their agreement on a 5-points Likert scale with four items investigating the cognitive appraisal.

4 Analyses and Results

The visual target, selected by students for each scene, informed a clustering process based on the DBSCAN method [42, 43], Scikit-learn 0.22, and Python 3.8 libraries, which clustered students looking in the same direction. We repeated the procedure for each point of view. The average emotional and cognitive reactions emerging from the data analysis of participants belonging to each cluster were calculated applying the exp-EIA© method and the related Patent for Invention (N. 102021000017168 - 30/06/2021). This process allows spatializing the observers' emotional and cognitive reactions, thus relating the physical layout to people's experiences.

The outcomes highlight that each pre-set point of view of the Città Studi neighborhood generates, on average, a different emotional (Fig. 2) and cognitive experience (Fig. 2. In detail, piazza Leonardo da Vinci (PoV 3) has been perceived as positive and arousing, resulting in an elated emotion. In contrast, three other areas (PoV 1 and PoV 4a/b, which includes two main different gaze orientations from the same location) activated subtly negative and deactivating emotions corresponding to sadness and depression. Finally, PoV 2 is perceived as weakly negative and arousing, that is, stressing. This latter is the access area to the subway and is characterized by car traffic, visual disorder, and a large flow of people. The same difference is evident if we consider the graph in Fig. 2 – right side**,** in which PoV 3 shows a higher emotional intensity (connoted in a positive sense). In contrast to piazza Leonardo da Vinci, the other PoVs show a weak emotional activation. Furthermore, PoV 4 led to two different visual clusters (PoVs 4a–4b, Fig. 3) connotated by different emotional qualities.

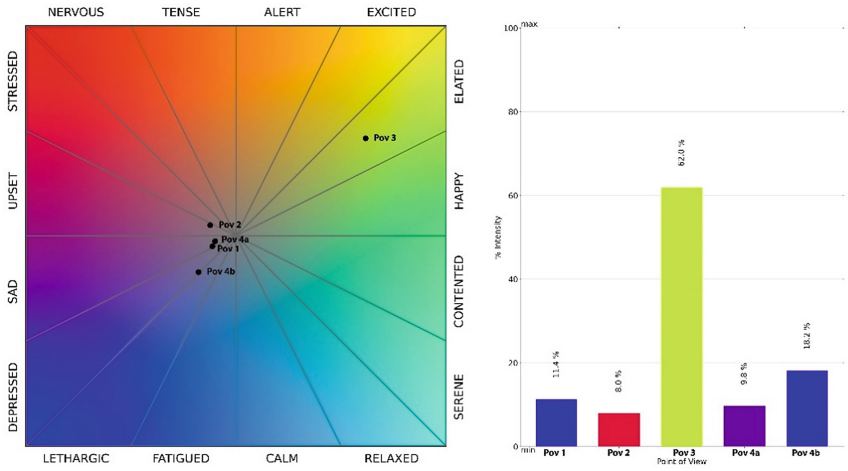

Fig. 2. Emotional appraisal of the clustered PoVs. On the left side: location of results on Russell's circumplex model; on the right side: average emotional intensity emerged for each PoV. Source: the authors.

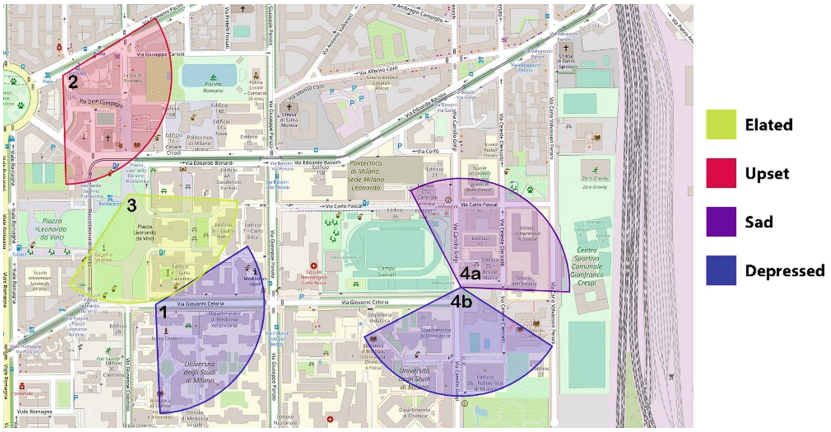

Fig. 3. Map of the clustered PoVs and related emotions. Two opposite clusters of the same PoV (PoV 4) emerged (PoV 4a and 4b). The colors of the visual cones highlight the prevailing emotion associated with the cluster. Source: the authors.

The cognitive appraisal (Fig. 4) highlights similar differences to the emotional appraisal. PoV 3 shows a higher value, with an imbalance in favor of Ease of Understanding. PoVs 1 and 4b scored significantly lower, even if they have a good balance between understanding and exploration. PoV 4a is the only one characterized by a minimal imbalance towards nudging exploration.

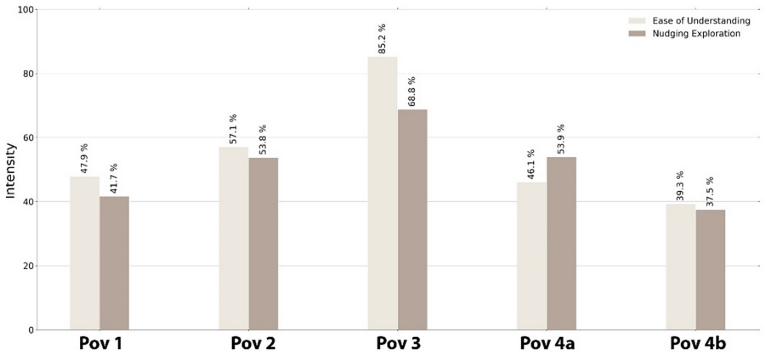

Fig. 4. The graph is the result of the cognitive appraisal of the case study. The 'ease of understanding' is the prevailing reaction associated with the clustered PoVs, except for PoV4a (i.e. looking toward the north side of via Camillo Golgi) where the 'nudging exploration' is slightly higher. Source: the authors.

5 Conclusions

The spatialization of the psychological assessment outcomes, i.e. participants' emotional and cognitive average clustered reactions, allowed students to observe a shared

map of urban experiences. On this basis, feedback on the pros and cons of the places was discussed to inform the area's design thinking. The overall emotional and cognitive reactions vary consistently between different PoVs in the same neighborhood. They highlight how the subway station constitutes a stressful area, whereas piazza Leonardo da Vinci, in front of the main POLIMI building, presents positive emotional and high cognitive values; indeed, results about this place denote a robust social attractor of the neighborhood for the sample. Other nuances of emotions were experienced by participants in other PoVs of the neighborhood. Results also show the discriminatory capacity of our tool, as the area with the highest historical-symbolic value (the central pedestrian square in front of the POLIMI university, namely piazza Leonardo Da Vinci, PoV 3) obtained significant positive scores compared to the other PoVs, which were anonymous and car-oriented sections of streets.

The proposed teaching approach provides a concrete example of a human-centered and evidence-based design method for architecture students. Moreover, the interdisciplinary process enables students to understand other disciplines' contributions to urban design and vice versa. We consider this process fruitful in increasing students' awareness of the importance of considering actual urban experiences of local communities in a holistic perspective when designing urban places.

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Patent. Through an architectural/psychological integrated framework, the interaction with the simulated environment triggers an experience that can be reliably assessed using established psychological constructs. The method is protected by: exp-EIA© -Experiential Environmental Impact Assessment - Copyright BOIPN. 123453 – 6 May 2020 and N. 130516 - 25 February 2021; Patent for Invention application N. 102021000017168 - 30 June 2021.

Institutional Review Board Statement. The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Ethics Committee of POLITECNICO DI MILANO (protocol code 7/2019 on 18/03/2019, and 15/2020 on 15/07/2020).

Author Contributions. The authors' contribution according to CRediT (Contributor Roles Taxonomy) is described as follows. Conceptualization, B.E.A.P.; methodology, B.E.A.P., G.S.; software, G.S.; formal analysis, G.S.; investigation, B.E.A.P., G.S.; data curation, G.S.; writing - original draft preparation, G.S. and G.F.; writing - review and editing, B.E.A.P.; visualization, B.E.A.P. and G.S.; supervision, B.E.A.P.; project administration, B.E.A.P.; funding acquisition, B.E.A.P. All authors have read and agreed to the published version of the manuscript.

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