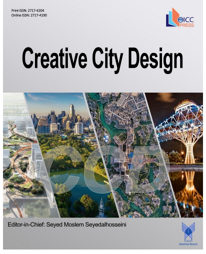

Volume 8, Issue 1, 082502 (1-14)

Creative City Design (CCD)

https://doi.org/10.57647/j.ccd.2025.0801.02

Assessment of the impact of the new training model on optimal housing architecture design towards energy consumption reduction (case study: architects in Bushehr province)

Elmira Omidvar[1], Ahmad Torkaman[2,*], Mohammad Ali Rahimi[1]

[1]*Department of Architecture, Bushehr Branch, Islamic Azad University, Bushehr, Iran.*
[2]*Department of Architecture, Marvdasht Branch, Islamic Azad University, Marvdasht, Iran.*

[*]**Corresponding author:** ahmadtorkamon@miau.ac.ir, ahmadtorkamon@yahoo.com

Original Research

Received:
29 June 2024
Revised:
10 August 2024
Accepted:
23 September 2024
Published online:
1 March 2025

Abstract:

Aims: In recent years, due to irresponsible human behaviors, we have witnessed a significant increase in the consumption of non-renewable energy resources. The construction industry plays a crucial role in the efficient consumption of energy, and since the impact of architectural practices is influenced by the education of architects and fundamental education in this field can be a source of solving environmental challenges, this research is aimed at developing and evaluating a training model for architects to optimize energy consumption in mid-range housing in warm and humid regions. using the architects of Bushehr province as a case study.
Methodology: To identify effective components in energy consumption optimization and educational models, a documentary method was employed. The perspectives of experts were examined, and after content analysis, the components were presented to the expert community. Following a consensus on the components by the Delphi method, a questionnaire was distributed among licensed architects with a Level 2 design permit in Bushehr.
Findings: The findings indicate that the use of natural light, windows, insulation, suitable materials, double-skin facades, porous volume, active ventilation, solar chimneys, terraces, proper orientation, green roofs, bright colors, and shading are effective components in optimizing energy consumption. Additionally, elements such as epistemology, ethics, research affairs, practical workshops, fundamental models, foresight, environmental factors, indigenous knowledge, being up-to-date, cognition, and material recycling were identified as key components of the architects' training model for optimizing energy consumption. Using the Friedman method, these components were ranked, and an educational model was formulated and then made available to the sample population.
Conclusion: Considering the significant difference in energy consumption levels obtained from pre-test and post-test methods, the educational model was validated.

Keywords: Environmental challenges; Energy consumption optimization; Architectural training model; Warm and humid climate; Bushehr

1. Introduction

Energy is as the crisis of the twentieth century. Fossil fuels, as the richest of the world's gas and oil resources, will run out in the next thirty years [1]. Climate change and the rising need for energy demand comprehensive efforts from all sectors [2]. The heat obtained from the fossil fuels consumption is becoming more intense and unbearable day by day. Based on the statistics published by the International Energy Agency, more than 30% of countries' different energy sources are consumed in residential, office, commercial and other buildings [3] and it is forecasted that by 2050, energy consumption in residential buildings will increase more than eight times [4]. Global statistics show a doubling of energy consumption worldwide in each decade, with developing countries, including Iran, experiencing a 10% annual growth in energy consumption [5]. Meanwhile, the discussion related to the environment is always of spe-

cial importance. It is obvious that increasing the efficiency of energy consumption is in a direct relationship with reducing the rate of pollution. On the other hand, the use of new and renewable energies is an effective factor in reducing carbon dioxide [6]. The task of architects in this field is very serious and sensitive, and early design decisions have a significant impact on energy consumption and comfort of residents in buildings [7]. Architects, as designers of buildings, play a great role in preserving the environment. With the knowledge that the field of construction, whether in the design stage or construction and operation, plays a prominent role in the field of environmental protection and optimal use of energy resources, and given the fact that what is emerging in the field of architecture is influenced by the way architects are educated, providing basic education to architects may be considered as a way to solve and improve many environmental issues.
Notable efforts have been so far made in the field of architectural education regarding the topic of energy consumption reduction, and various solutions have been proposed. However, it is less observed that architects effectively incorporate these solutions into their logical design. The reason could be the lack of a model aligned with global standards in the academic architectural education domain. Thus, this research is aimed at "developing and evaluating a proposed training model for architects to optimize energy consumption in mid-range housing in warm and humid regions (case study: Bushehr city)". The present study has been conducted with the goal of finding an answer to the question "How can an educational model for architects, with a focus on optimizing energy consumption in mid-range housing in warm and humid regions (case study: Bushehr); be developed and evaluated?" The research hypothesis is "Focusing on key components influencing energy consumption in mid-range housing (case study: Bushehr city) is effective in formulating an educational model aimed at modifying energy consumption by architects. This can be evaluated by comparing the energy consumption of buildings before and after providing training to architects."

2. Research background

Given the importance and necessity of addressing environmental issues and the role of architects in this domain, numerous researchers have investigated solutions to reduce energy consumption in buildings and the role of architectural education in improving environmental issues and optimizing energy consumption. They have explored this issue from various perspectives. Factors affecting the reduction of energy consumption and improving architectural education on environmental issues for architects, from the experts' perspective, are briefly presented in content analysis tables (Tables 1 & 2).
From the experts' perspective in the energy and education domains, key components effective in optimizing energy consumption include the use of natural light, windows, insulation, suitable materials, double-skin facades, porous volume, active ventilation, solar chimneys, terrace, proper orientation, green roof, pond roof, central courtyard, bright colors, and shading devices; while epistemology, research affairs, practical workshops, basic models, foresight, environmental factors, indigenous knowledge, scientific visit, being up-to-date, knowledge and recycle of materials, and examining examples are the key components of the architects' training model with the approach of energy consumption optimization.

3. Research methodology

This is an applied research in terms of its objective. The study is aimed at explore and assess educational components for modifying the educational model of graduate architects through a fundamental upgrading course for architects, focusing on optimizing energy consumption in design. A survey method is employed to develop an educational model with this approach.
Based on the literature review and content analysis of existing perspectives derived from literature review and background research, the recurring components in this field are extracted and categorized. Then, the components derived from previous research are provided for expert validation. To utilize the Delphi method, 16 individuals available were purposefully and conveniently sampled as the sample population, and the components were made available to them online. Subsequently, questionnaires based on the obtained components from content analysis and Delphi methods were prepared in Likert scale and distributed among the sample population. For examining and evaluating the energy consumption optimization components, all architects with practicing licenses, totaling 253 individuals (153 according to the Cochran formula) are selected as the sample population. To assess and evaluate the components of the educational model, 104 architects with a degree in architecture and practicing licenses (82 according to the Cochran formula) are systematically chosen as the sample population. For analyzing the questionnaire data, the Friedman method is used to rank the components. Based on the results, the components are incorporated into the educational model and presented to the sample population. The syllabus and content are formulated considering the components derived from the Delphi method and the questionnaire results, with the importance of addressing each component.
Subsequently, to assess and evaluate the mentioned training program, the energy consumption levels in designs by 21 architects (post-test group selected through convenience sampling) are examined before and after the training using Design Builder software. These architects, selected from level 2 basic architects with a minimum of five mid-range design projects (Building Group B) in 2021, form the statistical population. In this study, descriptive statistical methods were initially employed to characterize the data, including frequency statistics, mean, and standard deviation. Subsequently, in the inferential statistics section, parametric tests such as independent samples t-test and paired samples t-test were utilized. The analysis was conducted using SPSS26 software. The mean and standard deviation of total energy consumption scores for cooling and heating in the experimental and control groups were compared before and after the intervention. Furthermore, the results of independent samples t-tests were used to compare the total energy

Table 1. Factors affecting energy consumption optimization from the experts' perspectives.

Introduction of concepts	Content containing concepts
the use of natural light and daylight	Bust'an-Gaona et al. (2023) [8]; Pilechiha et al. (2020) [9]; molaei et al. (2019) [10]; Gago (2015) [11]; Mahdavinejad et al. (2014) [12]; Lampret et al. (2007) [13]
The use the appropriate window	Monteiro et al. (2021) [14]; Al- Yasiri & Szabo (2021) [15]; Kasmaei & Varmaghani (2021) [16]; Kaasalainen et al. (2020) [17]; Kosir et al. (2018) [18]
suitable skin design and double-skin view	Farhadi Nasab et al. (2024) [19]; Du et al. (2021) [20]; Butt et al. (2021) [21]; Houd et al. (2020) [22]; Bideli et al. (2020) [23]; Barbosa (2016) [24]; Afshinmehr et al. (2015) [25]
the use of porous volume for shading	Saligheh & Saadatjou (2020) [26]; Mahdavinejad et al (2019) [27]; Saadatjou et al. (2019) [28]; Attarian & Safarali Najar (2018) [29]; Khanmohammadi et al. (2016) [30]; Lavafpour & Sharples (2015) [31]
proper insulation (walls, floor and ceiling)	Azemati et al. (2023) [32]; Kumar et al. (2020) [33]; Rostampour et al. (2020) [34]; Kalogirou & Tassou (2019) [35]; Cabeza et al. (2010) [36]
the use of suitable materials	K. Figueiredo (2021) [37]; Pourkarid Shokoohi et al (2021) [38]; Long & Ye (2016) [39]; Mirrahimi et al. (2016) [40]; Yüksek (2015) [41]
the use of active ventilation	Zhong et al. (2023) [42]; Houd et al. (2020) [22]; Afshinmehr et al (2015) [25]; Mohammadi & Heydari (2015) [43]; Van Hooff & Blocken (2012) [44]; Mahmoudi & Pourmousa (2010) [45]
the use of solar chimney	Serageldin et al. (2020) [46]; Abdallah (2019) [47]; Fakhari & Heydari (2013) [48]; Chungloo & Limmeechokchai (2009) [49]; Miyazaki et al. (2006) [50]
the use of balcony	Yang et al. (2021) [51]; Saadatjou et al. (2018) [52]; Bahrani et al. (2016) [53]; Khanmohammadi et al. (2016) [30]; Mohamed et al. (2009) [54]
proper form and orientation of the building	Sabah Haseeb et al., (2023) [55]; Monteiro et al., (2021) [14]; Akbari and Hosseininejad (2019) [56]; Ghodsi et al., (2018) [57]; Kosir et al., (2018) [18]; Morrissey et al. (2011) [58]
the use of green roof	Moulaee et al. (2018) [59]; Boafo et al. (2017) [60]; Khan Ahmadlou et al. (2017) [61]; Zarghami & Adibi (2016) [62]; Yaghoubian & Srebric (2015) [63]; Taghavi (2014) [64]; Mazzali et al. (2013) [65]
use of the central courtyard	Zamani et al., (2017) [66]; Taleghani et al. (2015) [67]; Taleghani et al. (2013) [68]; Rojas et al. (2012) [69]; Al-Masri & Abu-Hijleh (2012) [70]
the use of light color in the facade of the building	Khadroui & Sriti (2019) [71]; Memarian et al. (2018) [72]; Alpoch et al. (2014) [73]; Zolfaghari et al. (2014) [74]; Yao & Chengoon (2011) [75]
the use of shade (natural, horizontal, vertical and louver)	Tavazo et al. (2023) [76]; Kasmaei & Vermaghani, (2021) [16]; Saligheh & Saadatjou (2020) [26]; Fathalian & Kargar Sharifabad (2020) [77]; Houd et al. (2020) [21]; Mahdovinejad et al. (2019) [78]; Baek & Park (2016) [79]; Haghighi et al. (2015) [80]
the use of a pond roof	Goleh Kheili et al. (2022) [81]; Zabidi et al. (2020) [82]; Kasaeian & Sameti (2014) [83]; Spanaki et al. (2011) [84]; Yannas (2005) [85]

Table 2. Factors affecting compilation of the model of architect training from the experts' perspectives.

Introduction of concepts	Content containing concepts
epistemology	Eqapy & Al asadi (2020) [86]; McLaughlan & Lodge (2019) [87]; Iranmanesh & Khajepour (2014) [88]; Nazi Dizaji et al. (2010) [89]; Sterling (2008) [90]
being ethical	Iranfar & Nia (2022) [91]; Salman et al. (2019) [92]; Iranmanesh & Khajepour (2014) [88]; Adhami & Akbarzadeh (2011) [93]; Nazi Dizaji et al. (2010) [89]; Hosseini et al. (2008) [94]; Munier (2005) [95]
research affairs	Godemann et al. (2014) [96]; Zimmerman (2012) [97]; Hosseini et al. (2008) [94]; Sharif Shahidi et al. (2008) [98]; Lang (2002) [99]
practical workshop	Hejazi & Shafaei (2021) [100]; K. Tarabieh (2018) [101] ; Alalhesabi & Norouzian Maleki (2009) [102]; Hosseini et al. (2008) [94]; Zarghami (2008) [103]
basic models (archetypes)	Nayak et al. (2023) [104]; Razavizadeh (2020) [105]; Barati & Kakavand (2016) [106]; Kirbas & Hizli (2015) [107]; Iranmanesh & Khajepour (2014) [88]
foresight	Nyka & Marczak (2023) [108]; Koskinen et al. (2023) [109]; Santamouris & Vasilakopoulou (2021) [110]; Mahdovinejad et al. (2013) [111]; Gorji Mahlabani (2010) [112]
environmental and climatic factors	HamedSardar et al. (2021) [113]; Sun & Yu (2021) [114]; Mortazavi Alavi et al. (2021) [115]; Behrouzi & Fanaei (2019) [116]; Rieckmann (2012) [117]; Gorji Mahlabani & Armaghan (2010) [118]; Knights (2009) [119]
indigenous knowledge	Bust´an-Gaona et al. (2023) [8]; Sokar et al., (2023) [120]; Kirbas & Hizli (2015) [107]; Bodach et al. (2014) [121]; Bjornard (2010) [122]; Gorji, Mahlabani & Armaghan (2010) [118]; Guy & Moore (2005) [123]
being up-to-date	Hejrati Lahiji et al. (2022) [124]; Mortazavi Alavi et al. (2021) [115]; Zheng et al. (2014) [125]; Gerber et al. (2011) [126]
knowledge of green materials	Hejrati Lahiji et al. (2022) [124]; Campisi et al. (2020) [127]; Bielek (2016) [128]; Hosseini et al. (2008) [94]
scientific visit	Truong & Nguyen (2024) [129]; Kesim & Yöney (2021) [130]; Yusoff et al. (2019) [131]; George (2018) [132]; Batic, 2011 [133]
examining examples	Alipour (2019) [134]; Mirjani & Nadimi (2018) [135]; Alipour et al. (2017) [136]; Feyzi et al. (2015) [137]; Iranmanesh & Khajepour (2014) [88]; Cheng, Mugge & Schoorma (2014) [138]

consumption scores for cooling and heating between the experimental and control groups before the intervention. To examine the intervention's impact, analysis of covariance (ANCOVA) was employed. This test is utilized to control for pre-test scores and compare the intervention's effect in the two groups, as well as determining the effectiveness of the educational model.

Given that Iran's warm and humid regions are among the most critical climatic zones in the world in terms of energy consumption [139], and considering the high energy consumption for cooling and heating buildings, especially in warm and humid areas [140], Bushehr province, with a per capita household electricity consumption of 11,527 kilowatt-hours in 2020, has the highest per capita household electricity consumption in the country (According to Detailed Statistics of Iran's Electricity Industry, Power Distribution in 2020). Household consumers in this province, with a consumption of 69% of the total electricity consumption, hold the first rank in household electricity consumption in the country. This province has been selected as the research context for the present study.

4. Discussion

Commencing with components derived from the research background, validated by expert consensus through the Delphi method, Tables 3 & 4 outline the optimization components from the experts' perspective.

(The pond roof was eliminated due to operational challenges and the impracticality as well as using green roofs with this method and the use of central courtyards was excluded considering the impossibility of using them due to urban planning regulations and the small dimensions of urban plots).

(Using the Delphi Method, the Scientific Visit Component was excluded. The reason for its exclusion is the impracticality of individuals' presence in projects with an energy optimization approach since many of these projects are located outside the country. Moreover, the examination of examples can be encompassed within this component. Virtual visits can be planned and the lack of scientific visits

Table 3. Energy consumption optimization components from the experts' perspective.

Energy consumption optimization components after the second round of the Delphi method												
the use of natural light and daylight	the use the appropriate window	suitable skin design and double-skin view	the use of protrusions and depressions (porous volume for shading)	proper insulation (walls, floor and ceiling)	the use of suitable materials (suitable for the climate and recyclable)	the use of active ventilation	the use of solar chimney	the use of balcony	proper orientation of the building	the use of green roof	the use of light color in the facade of the building	the use of shade (natural, horizontal, vertical and louver)

Table 4. Components affecting the architectures' training model for energy optimization from the experts' perspectives (after using the Delphi method).

The components of the architect education model from the experts' perspective										
foresight	being ethical	research affairs	epistemology	being up-to-date	environmental factors	indigenous knowledge	examining examples	knowledge of green materials	practical workshop	basic models

can be compensated by observing images, maps, etc.)
Subsequently, by utilizing the finalized components in the field of energy consumption optimization and the training model for architects with the same approach, Likert-scale questionnaires were prepared. After examining the validity and reliability of the questionnaires, they were distributed among the target population. Then, the obtained questionnaire data were analyzed. The Delphi method was employed for validity, and the reliability was assessed using Cronbach's alpha coefficient (All Cronbach's alpha values exceeded 0.7, confirming the reliability of the questionnaire dimensions). The results of the questionnaire, ranked using the Friedman test, can be seen in figures 1 and 2.
After the validation of the aforementioned components by experts and their ranking through statistical methods, a handbook derived from these components was developed, considering their importance. This handbook was then provided to the sample community for their review with the aim of holding the architects' training course.
Finally, to assess and evaluate the aforementioned course, a residential plan was designed before and after the training. The energy consumption levels in these plans were examined through simulation using DesignBuilder software. The average energy consumption in all plans during the two mentioned phases was analyzed, and the relationship and impact of the training on energy consumption were evaluated. The results can be seen in figure 3.
Based on the normality test results for the research variables, skewness values fall within the range of (3 and -3); and kurtosis values within the range of (10 and -10). The data normality assumption for these variables is confirmed. For comparing pre-test scores in the two experimental and control groups, the mean and standard deviation of the total energy consumption scores for heating and cooling in the two experimental and control groups in Table 5 and the results of the independent t-test for comparing the total energy consumption scores for heating and cooling in the two experimental and control groups in Table 6 were examined before the intervention.
Considering the results, since the significant value of the independent t-test is less than 0.05 (0.003), there is a significant difference in the average energy consumption for heating and cooling (initial design) between the two experimental and control groups. The average energy consumption in the control group (48095.333) is significantly higher than the experimental group (46030.381). The mean and standard deviation of the total energy consumption scores for heating and cooling in the experimental group before and after the intervention, and the results of the paired t-test for comparing the scores before and after the intervention

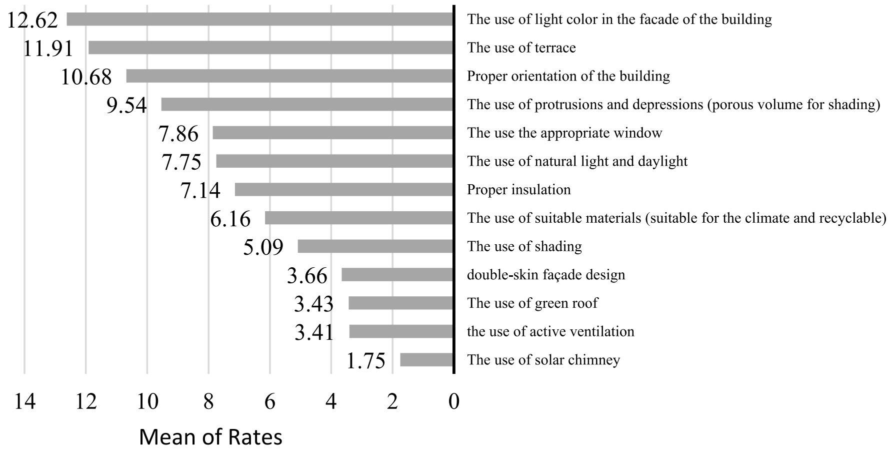

Figure 1. Ranking of energy consumption optimization components.

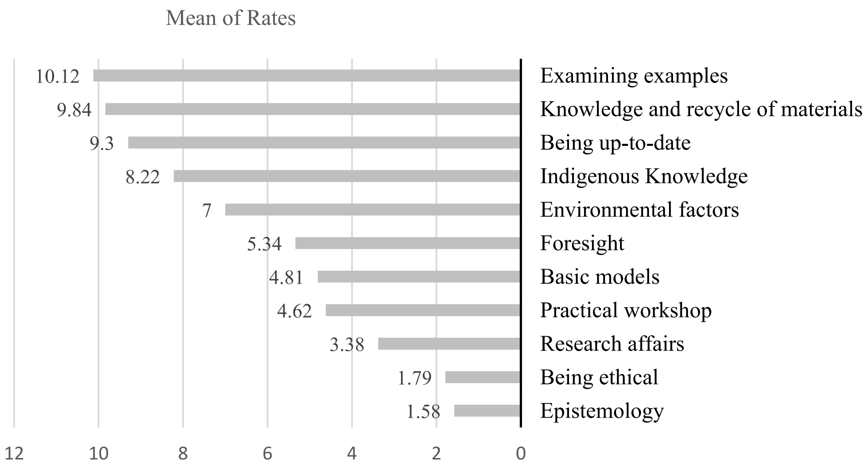

Figure 2. Ranking of effective components in the training model with an energy optimization approach.

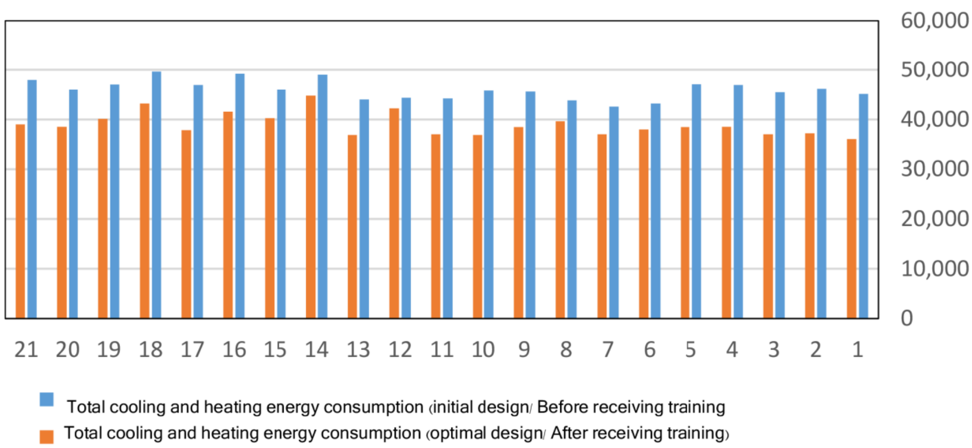

Figure 3. Comparison of energy consumption levels in initial and redesigned states (before and after training).

Table 5. Mean and standard deviation of total energy consumption scores for heating and cooling in the two experimental and control groups before the intervention.

Variable name	Group	n	Mean	SD	Standard error
total cooling and heating energy consumption (in the initial design mode)	test	21	46030.381	1938.213	422.953
	control	21	48095.333	2302.858	502.525

Table 6. Results of the independent t-test for comparing total energy consumption scores for heating and cooling in the two experimental and control groups before the intervention (initial design).

Variable name		Variances		t test (equality of means)						
		F statistic	Sig.	T statistic	Degree of freedom	Sig.	The mean difference between the two groups	Standard error	95% confidence level: Lower limit	95% confidence level: Upper limit
total cooling and heating energy consumption	assuming equality of variances	0.275	0.603	-3.144	40	0.003	-2064.952	656.826	-3392.447	-737.458
	without assuming equality of variances			-3.144	38.868	0.003	-2064.952	656.826	-3393.653	-736.252

in the experimental group are presented in Tables 7 & 8. Before and after the intervention Given the results, since the significance level of the paired t-test is less than 0.05 (p-value: 0.000), there is a significant difference in the average cooling and heating energy consumption between the two states of initial and optimized designs. In the optimized design, the average energy consumption (39012.048) is significantly lower than the initial design (46030.381). Finally, to examine the intervention's impact, the analysis of covariance (ANCOVA) is used to control the pre-test scores' effect and compare the intervention's effect in the two groups. As shown in Table 9, by controlling the pre-test scores' effect, for the group factor, a statistically significant value of the ANCOVA was obtained (0.000), with a significance level smaller than 0.05. Therefore, there is a significant difference in the mean scores of cooling and heating energy consumption between the experimental and control groups.

Based on the pre-test and post-test results, it is concluded that there is a significant difference in the energy consumption levels in the drawings created by the sample community before and after the received training and the proposed educational model has been effective.

5. Conclusions

In this research, education was investigated as the most influential factor in energy efficiency and optimization. According to the findings, the effective components in energy consumption optimization include epistemology, being ethical, research affairs, practical workshops, basic models, foresight, environmental factors, indigenous knowledge, scientific visit, being up-to-date, knowledge and recycle of materials, and examining examples are the key components of the architects' training model with the approach of energy consumption optimization. Moreover, the following results were obtained by presenting and evaluating this model:

- Epistemology: In most training courses, little attention is given to cultivating the architectural character and delving into the realm of knowledge. Instead, the focus is primarily on teaching optimization strategies in architecture. However, fostering the spiritual character of architects before initiating their education can significantly affect and transform their perspectives, instilling a sacred view of nature. Neglecting the spiritual aspect of education results in overlooking the significance of sustainable values and failing to achieve practical outcomes in environmental conservation. The current educational model addresses this issue by emphasizing the importance of altering architects' perspectives towards nature and the environmental challenges stemming from high energy consumption in the construction sector. Efforts have been made to increase their motivation to tackle this crisis through changing their outlook on nature and environmental issues.

- Being ethical: By delving into the statistics of energy consumption worldwide and in Iran, and the resulting consequences for the Earth, nature, humans, and animals, with a focus on the role of the construction industry and specifically architects and engineers, ar-

Table 7. The mean and standard deviation of the total energy consumption scores for cooling and heating in the experimental group before and after the intervention.

Variable name		**Mean**	**n**	**SD**	**Standard error**
total cooling and heating energy consumption	initial design mode	46030.381	21	1938.213	422.953
	optimal design mode	39012.048	21	23232.661	507.064

Table 8. Paired t-test results for comparing the total energy consumption scores for cooling and heating in the experimental group.

Variable name	**The difference between pre-test and post-test**					**T statistic**	**Degree of freedom**	**Sig.**
	Mean	**SD**	**Standard error**	**95% confidence level**				
				Lower limit	**Upper limit**			
total energy consumption	7018.333	1923.24	419.685	6142.885	7893.782	16.723	20	0.000

Table 9. ANCOVA results.

The source of the effect	**The sum of squares**	**Degree of freedom**	**Mean of squares**	**F statistic**	**Significance value**
corrected model	988.1008721058	2	494.504360529	274.553	0.000
constant value	568.273814	1	568.273814	0.149	0.702
pre-test scores	631.142407225	1	631.142407225	77.521	0.000
group	045.442878348	1	045.442878348	241.085	0.000
error	988.71643845	39	1837021.692		
total	80751170977	42			
corrected model	976.1080364904	41			

chitects become aware of the warning signs of the energy crisis and its ensuing problems. They recognize their responsibility and will feel the burden of this responsibility on their shoulders.

- Research affairs: Focusing on research regarding to education leads to gaining knowledge about the latest technologies. Furthermore, encouraging architects to engage in research contributes to their awareness of global statistics and the results of studies of experts in this field.

- Practical workshops: Introducing and providing initial familiarity with energy-related software and the application of each software create motivation among architects to learn them. Practical engagement with architectural for energy consumption optimization, rather than just theoretical training, results in architects acquiring knowledge about the design outcomes and energy consumption of their projects.

- Basic models: Exploring ancient models, free from specific location and time constraints, allows architects to establish a connection between the past and the future. Delving into this area enhances a deeper understanding of nature and architecture among architects and reminds them of the necessity of preserving nature.

- Foresight: Examining the historical evolution of architecture is an essential part of architectural training, as it guides architects toward planning for a better future. However, after learning from history, architects must focus on learning modern sciences and technologies to evolve from the past and present for a better future. Architects should also be aware of the future results of today's design to approach their professional work with greater awareness and responsibility.

- Environmental factors: A thorough understanding of the climatic and indigenous features of each region significantly affects building design; past Iranian architecture highlights architects' attention to the environmental, natural, and climatic characteristics of each region, designing buildings based on those features. However, current training courses generally neglect the natural and cultural characteristics of specific regions.

- Indigenous knowledge: In this educational model, familiarity with elements of architecture indigenous to warm and humid regions, emphasizing elements with the potential for updating and use in contemporary architecture, is prioritized. At present, there is a lack of in-depth exploration of these elements, and architects only superficially recognize them. Indigenous architectural elements, designed with full consideration of climatic conditions, can contribute significantly to contemporary architecture in the direction of sustainable architecture. While some of these elements may not be applicable in modern architecture, others have the potential for modernization and adaptation, addressed in the training model.

- Being up-to-date: Considering that addressing environmental issues, climate change, and the energy crisis are among the most crucial topics in the contemporary world, and numerous researches are conducted daily in this field, it is essential that each training program strives to incorporate the latest scientific achievements. The training model should be regularly updated accordingly. Since every architect undergoes periodic retraining, architects should be encouraged to engage in ongoing study and updating of information to stay abreast of the latest developments in this regard.
- Knowledge and recycling of materials (green materials): Despite the necessity of specifying materials in approved drawings, materials are often repetitively presented based on market availability. Precise education in this area and introducing new environmentally friendly materials can change the preferences of designers, architects, and consequently, the employers.
- Examining examples: Many buildings worldwide are designed and constructed with a sustainable and energy-efficient architectural approach and introduced to the architects. However, most of these buildings are located in European countries or regions with different climates. Recognizing these examples will not be very helpful for architects in warm and humid climates. This training model attempts to introduce important buildings in this field while emphasizing structures existing in warm and humid climates and detailing their characteristics.

Authors contributions
Authors have contributed equally in preparing and writing the manuscript.

Availability of data and materials
The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] G. Tumminia, F. Guarino, S. Longo, D. Aloisio, S. Cellura, F. Sergi, and M. Ferraro. "**Grid interaction and environmental impact of a net zero energy building**.". *Energy Conversion and Management*, 203:112228, 2020.
DOI: https://doi.org/10.1016/j.enconman.2019.112228.

[2] J. Sauerbrey, T. Bender, S. Flemming, A. Martin, S. Naumann, and O. Warweg. "**Towards intelligent energy management in energy communities: Introducing the district energy manager and an IT reference architecture for district energy management systems**.". *Energy Reports*, 11(2024):2255–2265, 2024.
DOI: https://doi.org/10.1016/j.egyr.2024.01.068.

[3] M. Hu. "**Does zero energy building cost more?–An empirical comparison of the construction costs for zero energy education building in United States**.". *Sustainable cities and society*, 45: 324–334, 2019.
DOI: https://doi.org/10.1016/j.scs.2018.11.026.

[4] S.M. Renuk, C.M. Maharani, S. Nagasudha, and R. Raveena Priya. "**Optimization of energy consumption based on orientation and location of the building**.". *Materials today: Proceedings*, 65(2): 527–536, 2022.
DOI: https://doi.org/10.1016/j.matpr.2022.03.081.

[5] M. Farrokhi, M.S. Izadi, and M. Karimi moshaver. "**Analysis of energy efficiency of urban fabrics in the hot and dry climates, case study: Isfahan**.". *Iranian Architectural Studies Quarterly*, 7 (13):127–148, 2018.
DOI: https://doi.org/10.22052/1.13.127.

[6] R. Bruno, P. Bevilacqua, T. Cuconati, and N. Arcuri. "**Energy evaluations of an innovative multi-storey wooden near Zero Energy Building designed for Mediterranean areas**.". *Applied energy*, 238:929–941, 2019.
DOI: https://doi.org/10.1016/j.apenergy.2018.12.035.

[7] B. Alkhatabeh, Y. Kurdi, and S. Asadi. "**Multi-objective optimization of classrooms' daylight performance and energy use in U.S. Climate Zones**.". *Energy and Buildings*, 297:113468, 2023.
DOI: https://doi.org/10.1016/j.enbuild.2023.113468.

[8] D. Bust´an-Gaona, M. Ayala-Chauvin, J. Buele, P. Jara-Garz´on, and G. Riba-Sanmartí. "**Natural lighting performance of vernacular architecture, case study oldtown Pasa**.". *Ecuador, Energy Conversion and Management: X*, 20:100494, 2023.
DOI: https://doi.org/10.1016/j.ecmx.2023.100494.

[9] P. Pilechiha, M. Mahdavinejad, FP. Rahimian, P. Carnemolla, and S. Seyedzadeh. "**Multi-objective optimisation framework for designing office windows: Quality of view, daylight and energy efficiency.**.". *Appl Energy*, 261:114356, 2020.
DOI: https://doi.org/10.1016/j.apenergy.2019.114356.

[10] M.M. Moulaii, P. Pilechiha, and A. Shadanfar. "**Optimization of window proportions with an approach to reducing energy consumption in office buildings**.". *NAQSHEJAHAN*, 9(2):117–23, 2019.

[11] EJ. Gago, T. Muneer, M. Knez, and H. Köster. "**Natural light controls and guides in buildings. Energy saving for electrical lighting, reduction of cooling load**.". *Renewable and Sustainable Energy Reviews*, 41:1–13, 2015.
DOI: https://doi.org/10.1016/j.rser.2014.08.002.

[12] J. Mahdinejad, M. Mahdavinejad, and S. Rezaei ahtiani. "**Thermal behavior of double skin buildings**.". *Journal of Energy Technologies and Policy*, 4(9), 2014.

[13] M. Lampret, V. Bukovec, A. Paternost, S. Krizman, V. Lojk, and I. Golobic. "**Industrial energy-flow management**.". *Applied Energy*, 84(7), 2007.
DOI: https://doi.org/10.1016/j.apenergy.2007.01.009.

[14] H. Monteiro, F. Freire, and N. Soares. "**Life cycle assessment of a south European house addressing building design options for orientation, window sizing and building shape**.". *Journal of Building Engineering*, 39:102276, 2021.
DOI: https://doi.org/10.1016/j.jobe.2021.102276.

[15] Q. Al-Yasiri and M. Szabo. "**Incorporation of phase change materials into building envelope for thermal comfort and energy saving: A comprehensive analysis**.". *Journal of Building Engineering*, 36(N 102122):1–23, 2021.
DOI: https://doi.org/10.1016/j.jobe.2020.102122.

[16] A. Kasmaei and H. Varmaghani. "**Factors affecting the reduction of energy consumption in buildings: A case study of high-rise buildings in district 22 of Tehran**.". *Iran's energy*, 24(1):67–100, 2021.

[17] T. Kaasalainen, A. Makinen, T. Lehtinen, M. Moisio, and J. Vinha. "**Architectural window design and energy efficiency: Impacts on heating, cooling and lighting needs in Finnish climates**.". *Journal of Building Engineering*, 27:100996, 2020.
DOI: https://doi.org/10.1016/j.jobe.2019.100996.

[18] M. Kosir, T. Gostisa, and Z. Kristl. "**Influence of architectural building envelope characteristics on energy performance in Central European climatic conditions**.". *Journal of Building Engineering*, 15:278–288, 2019.
DOI: https://doi.org/10.1016/j.jobe.2017.11.023.

[19] F. Farhadi Nasab, F. Mozaffari Ghadikolaei, and L. Mirsaeedi. "**An investigation on the suitable features of double-skin Façade in lines with reducing energy consumption in cold and arid climate, case study of Mashhad city**.". *Creative city design*, 7(1): 61–76, 2024.
DOI: https://doi.org/10.71619/crcd-2024-7725.

[20] T. Du, S. Jansen, M. Turrin, and A. Van den Dobbelsteen. "**Effect of space layouts on the energy performance of office buildings in three climates**.". *Journal of Building Engineering*, 39(N 102198): 1–14, 2021.
DOI: https://doi.org/10.1016/j.jobe.2021.102198.

[21] A. A. Butt, S.B. De Vries, R. C.G.M. Loonen, J. L.M. Hensen, A. Stuiver, J.E.J. van den Ham, and B.S.J.F. Erich. "**Investigating the energy saving potential of thermochromic coatings on building envelopes**.". *Applied Energy*, 291(N116788):1–1, 2021.
DOI: https://doi.org/10.1016/j.apenergy.2021.116788.

[22] D. Houd, M. Mahmoudi Zarandi, and S. Kamyabi. "**Achievement of design principles of double-skin facades with emphasis on creating chimney ventilation in hot and humid climates**.". *Naghshe Jahan*, 10(2):109–119, 2020.

[23] M. Bideli, H. Medi, J. Soheili, and K. RahbariManesh. "**Assessment of the intermediate cavity impact on the cooling energy performance of the multi-story double- skin facade in hot and humid climate (Kish Island)**.". *Architecture & Urban Development*, 30:11–29, 2020.
DOI: https://doi.org/10.22034/AAUD.2019.159288.1748.

[24] S. Barbosa and K. Ip. "**Predicted thermal acceptance in naturally ventilated office buildings with double skin façades under Brazilian climates**.". *Journal of Building Engineering*, 7:92– 102, 2020.
DOI: https://doi.org/10.1016/j.jobe.2016.05.006.

[25] V. Afshinmehr, F. Aref, and M. Shanehsaz. "**A numerical analysis of double skin facades in summer**.". *NAQSHEJAHAN*, 5(2):77–85, 2015.

[26] E. Saligheh and P. Saadatjou. "**Impact of building porosity on self-shading and absorbed solar heat reduction in hot and humid regions**.". *Naqshejahan- Basic studies and New Technologies of Architecture and Planning*, 9(4):257–271, 2020.

[27] M.J. Mahdavinejad and S. Masoodi Tonekaboni. "**Selfshading and high performance architecture, case studies: Configuration of contemporary buildings of Tehran**.". *Armanshahr Architecture & Urban Development*, 11(25):201-8, 2019.

[28] P. Saadatjou, M. Mahdavinejad, and A. Zarkesh. "**Porosity rendering in high-performance architecture: Wind-driven natural ventilation and porosity distribution patterns**.". *73Armanshahr Architecture & Urban Development*, 12(26):73–87, 2019.
DOI: https://doi.org/10.22034/AAUD.2019.89057.

[29] K. Attarian and B. Safarali Najjar. "**Defining sustainability characteristics for residential buildings in hot and humid climate (case study: traditional houses of Ahwaz)**.". *NaqsheJahan*, 23:3, 2018.

[30] M.A. Khanmohammadi, S. Azimi, Y. Rahmanei, and M. Hossaini. "**Studying the qualitative and quantitative roles of Ivan in traditional houses and revitalization of them in the shape of the terrace**.". *HOVIATE SHAHR*, 10(26):21- 32, 2016.

[31] Y. Lavafpour and S. Sharples. "**Summer thermal comfort and self-shading geometries in Passivhaus dwellings: A pilot study using future UK climates**.". *Buildings*, 5(3):964- 84, 2015.
DOI: https://doi.org/10.3390/buildings5030964.

[32] A.A. Azemati, S.S.R.Rahimian Koloor, H. Khorasanizadeh, G.A. Sheikhzadeh, B.S. hirkavand Hadavand, and M. Eldessouki. "**Thermal evaluation of a room coated by thin urethane nanocomposite layer coating for energy-saving efficiency in building applications**.". *Case Studies in Thermal Engineering*, 43: 102688, 2023.
DOI: https://doi.org/10.1016/j.csite.2022.102688.

[33] D. Kumar, M. Alam, P. X.W. Zou, J.G. Sanjayan, and R.A. Memon. "**Comparative analysis of building insulation material properties and performance**.". *Renewable and Sustainable Energy Reviews*, 131(7):110038, 2020.
DOI: https://doi.org/10.1016/j.rser.2020.110038.

[34] K. Rostampour, H. Hekmat, and M. Zabihi. "**The role of phase change materials in improvement and revitalization of wind tower function; Case study: Warm & humid climate**.". *Naghshe-Jahan*, 10(2), 2020.

[35] S. Kalogirou, G. Florides, and S. Tassou. "**Energy analysis of buildings employing thermal mass in Cyprus**.". *Renewable Energy*, 27:353–368, 2019.
DOI: https://doi.org/10.1016/S0960-1481(02)00007-1.

[36] L.F. Cabeza, A. Castell, M. Medrano, I. Martorell, G. Pérez, and I. Fernández. "**Experimental study on the performance of insulation materials in Mediterranean construction**.". *Energy Build*, 42(5):630–636, 2010.
DOI: https://doi.org/10.1016/j.enbuild.2009.10.033.

[37] K. Figueiredo, R. Pierott, A.W.A. Hammad, and A. Haddad. "**Sustainable material choice for construction projects: A Life Cycle Sustainability Assessment framework based on BIM and Fuzzy-AHP**.". *Building and Environment*, 196:107805, 2020.
DOI: https://doi.org/10.1016/j.buildenv.2021.107805.

[38] M. Pourkarid Shokoohi, M. Faizi, A. Tarkashvand, and M. Khakzand. "**Comparison of the environmental effects of a building with steel and concrete structure in Tehran with a life cycle assessment approach in the design phase**.". *Journal of Sustainable Architecture and Urban*, 8(2), 2021.
DOI: https://doi.org/10.22061/jsaud.2021.5608.1538.

[39] L. Long and H. Ye. "**The roles of thermal insulation and heat storage in the energy performance of the wall materials: A simulation study**.". *Scientific Reportd*, 7, 2016.
DOI: https://doi.org/10.1038/srep24181.

[40] S.Z. Mirrahimi, M.F. Mohamed, L.C. Haw, N.L.N. Ibrahim, W.F. Yusoff, and A. Aflaki. "**The effect of building envelope on the thermal comfort and energy saving for high-rise buildings in hot–humid climate**.". *Renewable and Sustainable Energy Reviews*, 53:1508–1519, 2016.
DOI: https://doi.org/10.1016/j.rser.2015.09.055.

[41] I. Yüksek. "**The evaluation of building materials in terms of energy efficiency**.". *Period. Polytech. Civ. Eng.*, 59(1):45–58, 2021.
DOI: https://doi.org/10.3311/PPci.7050.

[42] W. Zhong, Y. Pan, W. Xiao, and T. Zhang. "**Identifying bioclimatic techniques for sustainable low-rise high-density residential units: Comparative analysis on the ventilation performance**

of vernacular dwellings in China.". *Journal of Building Engineering*, 80(1):108008, 2023.
DOI: https://doi.org/10.1016/j.jobe.2023.108008.

[43] M. Mohammadi and Sh. Heidari. "**Air flow window: An effective element in reduction of buildings' energy consumption in Tehran**.". *HONAR-HA-YE-ZIBA*, 20(2):13–22, 2015.
DOI: https://doi.org/10.22059/jfaup.2015.56714.

[44] T. Van Hooff and B. Blocken. "**Full-scale measurements of indoor environmental conditions and natural ventilation in a large semi-enclosed stadium: Possibilities and limitations for CFD validation**.". *Journal of Wind Engineering and Industrial Aerodynamics*, 104–106:330–341, 2012.
DOI: https://doi.org/10.1016/j.jweia.2012.02.009.

[45] M. Mahmoudi and M. Pourmoosa. "**Potential measurement of wind energy and its fundamental role in air conditioning and moisture removal (case example of Rasht city)**.". *Arman Shahr*, 4:147–156, 2010.

[46] A.A. Serageldin, A. Abdeen, M.M.S. Ahmed, A. Radwan, A.N. Shmroukh, and S. Ookawara. "**Solar chimney combined with earth to-air heat exchanger for passive cooling of residential buildings in hot areas**.". *Solar Energy*, 206:145–162, 2020.
DOI: https://doi.org/10.1016/j.solener.2020.05.102.

[47] A.S.H. Abdallah. "**A new design of passive air condition integrated with solar chimney for hot arid region of Egypt**.". *International Journal of Environmental Science and Technology*, 16: 2611–2618, 2019.

[48] M. Fakhari and Sh. Heydari. "**Optimizing the solar chimney and investigating its effect on building ventilation**.". *Honarhaye Ziba*, 18(2), 2013.
DOI: https://doi.org/10.22059/jfaup.2013.50536.

[49] S. Chungloo and B. Limmeechokchai. "**Utilization of cool ceiling with roof solar chimney in Thailand: The experimental and numerical analysis)**.". *Renowable Energy*, 34(4):623– 633, 2009.
DOI: https://doi.org/10.1016/j.renene.2008.05.026.

[50] T. Miyazaki, A. Akisawa, and T. Kashiwagi. "**The effects of solar chimneys on thermal load mitigation of office buildings under the Japanese climate**.". *Renewable Energy*, 31:987–1010, 2006.
DOI: https://doi.org/10.1016/j.renene.2005.05.003.

[51] Q. Yang, N. Li, and Y. Chen. "**Energy saving potential and environmental benefit analysis of application of balcony for residence in the hot summer and cold winter area of China**.". *Sustainable Energy Technologies and Assessments*, 43:100972, 2021.
DOI: https://doi.org/10.1016/j.seta.2020.100972.

[52] P. Saadatjoo, M. Mahdavinejad, and G. Zhang. "**A study on terraced apartments and their natural ventilation performance in hot and humid regions**.". *Building Simulation*, 11:359–372, 2023.

[53] H.R. Bahrani, E. Ranjbar, and S. Ahmadi. "**An analysis of the function of external senasir types and their effects on the wind flow in the historical part of Bushehr**.". *NAQSHEJAHAN*, 8(3): 179-86, 2018.

[54] M.F. Mohamed, D. Prasad, S. King, and K. Hirota. "**The impact of balconies on wind induced ventilation of single-sided naturally ventilated multi-story apartment**.". *Low Energy Architecture*, 2009.

[55] Q. Sabah Haseeb, S. Muhammed Yunus, A. Attellah Ali Shoshan, and A. Ibrahim Aziz. "**A study of the optimal form and orientation for more energy efficiency to mass model multi-storey buildings of Kirkuk city, Iraq**.". *Alexandria Engineering Journal*, 71:731–741, 2023.
DOI: https://doi.org/10.1016/j.aej.2023.03.020.

[56] H. Akbari and F. Hoseini Nejad. "**Determining the optimal angle of the building's vertical surfaces based on receiving solar energy in a hot and humid climate (case study: Bandar Abbas, Bushehr and Ahvaz cities)**.". *Scientific Journal of Architecture and Urban Planning of Iran*, pages 99– 112, 2010.
DOI: https://doi.org/10.30475/isau.2020.103679.

[57] M. Qodsi, Kh. Daneshjoo, and M. Mofidi Shamirani. "**Impact of geometric indicators on residential thermal**.". *Naqshejahan*, 8 (3):143–148, 2018.

[58] J. Morrissey, T. Moore, and R.E. Horne. "**Affordable passive solar design in a temperate climate: An experiment in residential building orientation**.". *Renew. Energy*, 36(2):568–577, 2021.
DOI: https://doi.org/10.1016/j.renene.2010.08.013.

[59] M. Molaei, P. Pilechiha, and A. Afshar. "**Energy efficiency evaluation of green roof in Iran. Case study: Tehran, Tabriz, Ramsar, Bandar Abbas**.". *Urban Management*, 52, 2018.

[60] F.E. Boafo, J.T. Kim, and J.H. Kim. "**Evaluating the impact of green roof evapotranspiration on annual building energy performance**.". *International Journal of Green Energy*, 14(5):479–489, 2017.
DOI: https://doi.org/10.1080/15435075.2016.1278375.

[61] S. Khan Ahmadlo, M. Feizi, and M. Mofidi Shemirani. "**The effect of the thermal behavior of the building shell in the modified construction of residential buildings to reduce energy waste**.". *Urban Management*, 47:433–446, 2021.

[62] E. Adibi E. Zarghami. "**Thermal performance evaluation of green roof on sustainability and energy efficiency in residential buildings in hot and dry climates of Iran**.". *Journal of Sustainable Architecture and Urban*, 1:75–90, 2016.

[63] N. Yaghoobian and J. Srebric. "**Influence of plant coverage on the total green roof energy balance andbuilding energy consumption**.". *Energy and Buildings*, (103):1–13, 2015.
DOI: https://doi.org/10.1016/j.enbuild.2015.05.052.

[64] L. Taghavi. "**The role of roof and green wall in sustainable urban development, a case study: Tehran**.". *Development and environment*, pages 20–36, 2014.

[65] U. Mazzali, F. Peron, P. Romagnoni, RM. Pulselli, and S. Bastianoni. "**Experimental investigation on the energy performance of Living Walls in a temperate climate**.". *Building and Environment*, 64:57–66, 2016.
DOI: https://doi.org/10.1016/j.buildenv.2013.03.005.

[66] Z. Zamani, Sh. Heydari, and P. Hanachi. "**Arranging courtyards in urban blocks to reduce energy consumption (case study: Tehran dwellings)**.". *Honar-Ha-Ye-Ziba-Memari-Va-Shahrsazi*, 22 (3), 2017.
DOI: https://doi.org/10.22059/jfaup.2017.228540.671674.

[67] M. Taleghani, L. Kleerekoper, M. Tenpierik, and A.Van Den Dobbel-steen. "**Outdoor thermal comfort within five different urban forms in the Netherlands**.". *Building and Environment*, 83: 65–78, 2015.
DOI: https://doi.org/10.1016/j.buildenv.2014.03.014.

[68] M. Taleghani, M. Tenpierik, A. Van Den Dobbelsteen, and R. De Dear. "**Energy use impact of and thermal comfort in different ur-ban block types in the Netherlands**.". *Energy and Buildings*, 67:175–166, 2013.
DOI: https://doi.org/10.1016/j.enbuild.2013.08.024.

[69] J. M. Rojas, C. Galán-Marín, and E.D. Fernández-Nieto. "**Parametric study of thermodynamics in the mediterranean courtyard as a tool for the design of eco-efficient buildings**.". *Energies*, 5(7):2381–2403, 2012.
DOI: https://doi.org/10.3390/en5072381.

[70] N. Al-Masri and B. Abu-Hijleh. "**Courtyard housing in mid-rise buildings: An environmental assessment in hot-arid climate**.". *Renewable and Sustainable Energy Reviews, Elsevier Ltd*, 16(4): 1892–1898, 2012.
DOI: https://doi.org/10.1016/j.rser.2012.01.008.

[71] M.A. Khadroui and L Sriti. "**The effect of cool paints and surface properties of the facade on the thermal and energy efficiency of buildings in a hot and arid climate**.". *Journal of Materials and Engineering Structures*, 9(1), 2019.

[72] G.H. Memarian, S.M. Madahi, S. Aeini, and A. Abdolahi. "**Investigating the effects of walls on reducing energy consumption in traditional-residential areas of Kashan, case study: Boroujerdi House**.". *Armanshahr Architecture & Urban Development*, 21:113–124, 2018.

[73] M.G. Alpuche, I. Gonzalez, J. M. Ochoa, I. Marincic, A. Duarte, and E. Valdenebro. "**Influence of absorptance in the building envelope of affordable housing in warm dry climates**.". *Energy Procedia*, 57:1842–1850, 2014.
DOI: https://doi.org/10.1016/j.egypro.2014.10.048.

[74] A. Zolfaghari, M. Saadati-Nasab, and E. Norouzi. "**Evaluation of the influence of exterior façade on the annual energy consumption of residential building in different climate zones of Iran**.". *Iranian Journal of energy*, 17(4), 2014.

[75] J. Yao and Ch. Yan. "**Effects of solar absorption coefficient of external wall on building energy consumption**.". *Proceedings of World Academy of Science, Engineering and Technology*, 76:758–760, 2011.

[76] N. Tavazo, M. Nik pour, M. Ghasemi, and H. Farzan. "**The effect of canopy protrusion amount on energy consumption and thermal comfort in the dome structure (case study: Sheikh Lotfollah Mosque)**.". *Creative city design*, 6(3):16–36, 2010.
DOI: https://doi.org/10.30495/ccd.2023.1983578.1204.

[77] A. Fathalian and H. Kargar Sharif Abadi. "**Investigating the effect of different energy saving strategies on energy rating of building by design builder software (case study: Office building)**.". *Journal of Environmental Science and Technology*, 22(7), 2020.

[78] M. J. Mahdavi Nejad, M. Arbab, and M. Arbab. "**Genetic algorithm for multi-objective optimization external louvers in high-performance office buildings**.". *Journal of Architectural thought*, 5:214–235, 2019.
DOI: https://doi.org/10.30479/at.2019.10243.1131.

[79] S. Baek and J. C. Park. "**Fundamental study on the optimal design of a folding shading device: Solar radiation model & potential cooling load saving**.". *Journal of Asian Architecture and Building Engineering*, 15(2):335–41, 2018.
DOI: https://doi.org/10.3130/jaabe.15.335.

[80] N. Haghighi, S. Asadi, and H. Babaizadeh. "**The effect of shading design and materials on building energy demand**.". *5th International/11th Construction Specialty Conference, Vancouver, British Columbia*, 2015.
DOI: https://doi.org/10.14288/1.0076496.

[81] M. Goleh Kheili, N. Nikghadam, and S.M. Mofidi Shemirani. "**Simulation analysis of thermal performance of the pond roof in sustainability and optimization of energy consumption and compare it with green roof by design builder software (case study: Yazd City)**.". *Modeling Earth Systems and Environment*, 9: 1759–1774, 2022.
DOI: https://doi.org/10.1007/s40808-022-01529-w.

[82] H.A. Zabidi, H.W. Goh, C.K. Chang, N.W. Chan, and N.A. Zakaria. "**A review of roof and pond rainwater harvesting systems for water security: The design, performance and way forward**.". *sustainability, MDPI*, 12(11):3163, 2020.
DOI: https://doi.org/10.3390/w12113163.

[83] A. Kasaeian, M. Sameti, and A.T. Eshghi. "**Silmplified method for night sky radiation analysis in a Cool-pool system**.". *Science and Education Publishing, Sustainable energy*, 2(1), 2014.
DOI: https://doi.org/10.12691/rse-2-1-6.

[84] A. Spanaki, T. Tsoutsos, and D. Kolokotsa. "**On the selection and design of the proper roof pond variant for passive cooling purposes**.". *Renewable and Sustainable Energy Reviews*, 15(8): 3523–3533, 2014.

[85] S. Yannas. "**Education for Sustainable Architecture**.". *the 22nd Conference*, 2005.

[86] A.H.El. Eqapy and D.S.R. Al. asadi. "**Epistemology and creativity in architecture**.". *IOP Conference Series: Materials Science and Engineering*, 928(022034), 2020.
DOI: https://doi.org/10.1088/1757-899X/928/2/022034.

[87] R. McLaughlan and J.M. Lodge. "**Facilitating epistemic fluency through design thinking: a strategy for the broader application of studio pedagogy within higher education**.". *Teaching in Higher Education*, 24(1):81–97, 2019.
DOI: https://doi.org/10.1080/13562517.2018.1461621.

[88] M. Iranmanesh and E. Khajehpour. "**Education of sustainable architecture or sustainable education of architecture**.". *Honar-Ha-Ye-Ziba-Memari-Va-Shahrsazi*, 19(1):83–92, 2014.
DOI: https://doi.org/10.22059/jfaup.2014.55380.

[89] S. Nazi Dizji, M. Vafamehr, and A. Keshtkar Ghalati. "**Ethics in architecture**.". *Ethics in science and technology*, 3 & 4, 2010.

[90] S. Sterling. "**Sustainable Education towards A deep learning Response to unsustainability**.". *Education for sustainable development, Policy And Practice*, 6:63–68, 2008.

[91] M. Iranfar and H.A. Nia. "**The aesthetic evaluation in sustainable architecture through ethics to reach**.". *Journal of Salutogenic Architecture*, 1(1):32–51, 2022.
DOI: https://doi.org/10.38027/jsalutogenic_vol1no1_3.

[92] A.S. Salman, A.J. Jasem, and N.M. Hadi. "**Effect of ethic discourse in the sustainability of architecture**.". *IOP Conference Series: Materials Science and Engineering*, 518(2), 2019.
DOI: https://doi.org/10.1088/1757-899X/518/2/022081.

[93] A. Adhami and E. Akbarzade. "**Investigating the cultural factors affecting the preservation of the environment in Tehran. (Case study of areas 5 and 18 of Tehran)**.". *Specialized Journal of Sociology*, 1:37–62, 2011.

[94] S.B. Hosseini, S.S.M. Mofidi, and H. Madi. "**Sustainable architecture education in Iran, obstacles and trends**.". *Journal of Technology and Education*, 2, 2008.
DOI: https://doi.org/10.22061/tej.2008.1294.

[95] N. Munier. "**Introduction to sustainability: Road to a better future**.". *The Netherlands: Springer*, 2005.

[96] J. Godemann, j. Bebbington, Ch. Herzig, and J. Moon. "**Higher education and sustainable development: Exploring possibilities for organisational change**.". *Accounting, Auditing & Accountability Journal*, 27(2):218–233, 2014.
DOI: https://doi.org/10.1108/AAAJ-12-2013-1553.

[97] M.E. Zimmerman. "**Globalization, multiculturalism, and architectural ethics**.". *Ethics and Globalization*, 2009.

[98] M. Shahidi, M. Bemanain, and M. Yalpanian. "**The role of research in the architectural design education process**.". *Hoviatshahr*, 2: 81–92, 2008.

[99] J. Lang. "**Creating architectural theory: The role of behavioral sciences in environmental design**.". 2002.

[100] S. Hejazi and M. Shafaei. "**Assessing the relationship between education and professional work in architecture**.". *Technology of Education Journal*, 15(2), 2021.
DOI: https://doi.org/10.22061/tej.2020.6535.2412.

[101] K. Tarabieh, M. Aly, and M. Kazamel. "**Teaching energy simulation in the architectural design studio: An experimental approach**.". *Journal of Engineering of Science and Military Technologies*, 2(2):59–64, 2018.
DOI: https://doi.org/10.21608/ejmtc.2017.1036.1043.

[102] M. Al al hesabi and S. Nouroozian Maleki. "**Experience of design education in schools of architecture**.". *education technology*, 4: 323–336, 2009.
DOI: https://doi.org/10.22061/tej.2009.1329.

[103] E. Zarghami and E. Adibi. "**Thermal performance evaluation of green roof on sustainability and energy efficiency in residential buildings in hot and dry climates of Iran**.". *Journal of Sustainable Architecture and Urban Design*, 4(1):75–90, 2014.

[104] B.K. Nayak, S.K. Sansaniwal, J. Mathur, T. Chandra, V. Garg, and R. Gupta. "**A review of residential building archetypes and their applications to study building energy consumption**.". *Architectural Science Review*, 66(3):187–200, 2023. DOI: https://doi.org/10.1080/00038628.2023.2193167.

[105] A.S. Razavizade. "**Representation of sustainable archy type in the architecture of the past and present of the Iranian House (Kashan and Yazd Houses, Qajar and contemporary period)**.". *JRIA, Iran University of Science & Technology*, 8(2):96–100, 2020.

[106] N. Barati and A. Kakavand. "**Phenomenological investigation in the event of archetype recognition in Islamic-Iranian architecture (Cases study: Toopkhane square, Laleh park, shahzade garden, naqhsh-e jahan square)**.". *Baghe Nazar*, 13(42):5–18, 2016.

[107] B. Kirbas and N. Hizli. "**Learning from vernacular architecture: Ecological solutions in traditional Erzurum Houses**.". *Procedia - Social and Behavioral Sciences*, 216:788–799, 2016. DOI: https://doi.org/10.1016/j.sbspro.2015.12.076.

[108] L. Nyka and E. Marczak. "**Frontier education for a sustainable future - speculative design in architecture as a transdisciplinary experiment**.". *Global Journal of Engineering Education*, 25(1), 2023.

[109] I. Koskinen, N. Gilmore, and E.M. Gui. "**Designing energy futures: a participatory foresight study in Australia**.". *Foresight*, 25(4), 2023. DOI: https://doi.org/10.1108/FS-09-2021-0186.

[110] M. Santamouris and K. Vasilakopoulou. "**Present and future energy consumption of buildings: Challenges and opportunities towards decarbonisation, e-Prime**.". *Advances in Electrical Engineering, Electronics and Energy*, 1(100002), 2021. DOI: https://doi.org/10.1016/j.prime.2021.100002.

[111] M. MahdaviNejad, F. Yari, Gh. Parvizi, and S. Dehghani. "**Development in architecture teaching: Interaction between history & technology**.". *Journal of Sustainable Architecture and Urban Design*, 2:55–63, 2013.

[112] M.Y. Gorji Mahlabani. "**Architectural education and future hallenges**.". *Journal of Technology of Education*, 3:223–234, 2010.

[113] H. HamedSardar, S. Tizghalam Zonouzib, and Sh. Khoshbakht Bahramani. "**Investigation and evaluation of the ecological architecture components from the perspective of designers and special users in multi-functional buildings, case study: Padideh complex of Mashhad City**.". *Creative city design*, 4(3):43–54, 2021. DOI: https://doi.org/10.30495/ccd.2023.1983578.1204.

[114] F. Sun and J. Yu. "**Improved energy performance evaluating and ranking approach for office buildings using Simple-normalization, Entropy-based TOPSIS and K-means method**.". *Energy Reports*, 7:1560–1570, 2021. DOI: https://doi.org/10.1016/j.egyr.2021.03.007.

[115] H. Mortazavi Alavi, Sh. Heydari, and N. Nikghadam. "**Evaluation of thermal comfort of users in hot and humid climate (Case study: Native housing of Kish Island)**.". *housing and village environment*, 174:29–44, 2021. DOI: https://doi.org/10.22034/40.174.29.

[116] S. Behruzi and A. Fanaei. "**Assessment of Respect for nature theory in environmental ethics**.". *Existence and Knowledge*, 6(1): 121– 142, 2019. DOI: https://doi.org/10.22096/ek.2020.114703.1175.

[117] M. Rieckmann. "**Future-oriented higher education: Which key competencies should be fostered through university teaching and learning?**.". *Futures*, 44(2):127–135, 2012. DOI: https://doi.org/10.1016/j.futures.2011.09.005.

[118] M. Armaghan and Y. Gorji. "**The values of vernacular architecture of Iran in relation with sustainable architecture approach**.". *Housing and Rural Environment*, 28(126):20–35, 2009.

[119] P. Knights. "**Virtue ethics, biodiversity and environmental educations**.". *Inter -Disciplinary Press, Oxfordshire, Freeland*, 2009.

[120] L. Sokar, A. Brakez, and I. Sobhy. "**A scientific process for a sustainable architectural design: A case study of a rural pavilion in a hot semi-arid climate**.". *Journal of Building Engineering*, 79 (107816), 2023. DOI: https://doi.org/10.1016/j.jobe.2023.107816.

[121] S. Bodach, W. Lang, and J. Hamhaber. "**Climate responsive building design strategies of vernacular architecture in Nepal**.". *Energy and Buildings*, 81:227–242, 2014. DOI: https://doi.org/10.1016/j.enbuild.2014.06.022.

[122] K. Bjornard. "**The principles of vernacular design & their applications today**.". *AIGA. Response_Ability Conference*, 2010.

[123] S. Guy and S. A. Moore. "**Sustainable architecture: Cultures and natures in Europe and North America**.". *Taylor & Francis*, ISBN 0415700442, 2005.

[124] A. Hejrati Lahijani, M. Vafamehr, A. Farajollahi, V. Ahmadi, and M. Mofidi Shemirani. "**Identification and ranking of effective indicators on waste prevention in residential buildings for sustainable regional development**.". *the scientific-research, quarterly of geography and regional planning*, 12(3):523–508, 2022.

[125] Zh.F. Zheng, M.J. Lu, and G.X. Wang. "**Strategy on updating talents training mode in architectural specialty from energy-saving and emission reduction perspective**.". *Applied Mechanics and Materials*, 584-586:2740– 2744, 2014. DOI: https://doi.org/10.4028/www.scientific.net/AMM.584-586.2740.

[126] B.B. Gerber, D.J. Gerber, and K. Ku. "**The pace of technological innovation in architecture, engineering, and construction education: Integrating recent trends into the curricula**.". *Journal of Information Technology in Construction*, 16:411– 432, 2011.

[127] T. Campisi, S. Colajanni, and M. Saeli. "**Architectural technologies for life environment: biomaterials for an eco-efficient and sustainable architecture**.". *ArchDesign'20 Conference Proceedings, Archivio istituzionale della ricerca dell'Università degli Studi di Palermo*, pages 25–41, 2020.

[128] B. Bielek. "**Green building–towards sustainable architecture**.". *Applied Mechanics and Materials*, 824:751–760, 2016. DOI: https://doi.org/10.4028/www.scientific.net/AMM.824.751.

[129] H.T.P. Nguyen T.N.N. Truong. "**Navigating experiential learning: Insights from vietnamese architecture students on an educational field trip**.". *Journal of Experiential Education*, 1(4), 2023. DOI: https://doi.org/10.1177/10538259241248634.

[130] B. Kesim and N.B. Yöney. "**Architectural travelers: The role of field trips in spatial design education**.". *Periodica Polytechnica Architecture*, 52(2), 2021. DOI: https://doi.org/10.3311/PPar.18861.

[131] W.F.M. Yusoff, N.H. Ja'afar, and N. Mohammad. "**Perception of architecture students on factors influencing the selection of locations for academic trip and site visit**.". *Journal of Technical Education and Training*, 11(3), 2019.

[132] B.H. George. "**Using virtual tours to facilitate sustainable site visits of historic sites**.". *European Journal of Sustainable Development*, 7(4):411–411, 2018. DOI: https://doi.org/10.14207/ejsd.2018.v7n4p411.

[133] J. Batic. "**The field trip as part of spatial (architectural) design art classes**.". *CEPS journal*, 2:73–86, 2011.
DOI: https://doi.org/10.25656/01:6528.

[134] L. Alipour. "**Improving precedent-based architectural design ideation with action research methodology**.". *Journal of Fine Arts: Architecture & Urban Planning*, 24(3):47–60, 2019.
DOI: https://doi.org/10.22059/jfaup.2019.275696.672219.

[135] H. Mirjany and H. Nadimi. "**Active experience model in architectural education a method to gain practical knowledge through design-oriented experience of architectural examples**.". *Journal of Iranian architecture studies*, (14):5–20, 2018.
DOI: https://doi.org/10.22052/1.14.5.

[136] L. Alipour, M. Feizi, A.M. Moradi, and Gh. Akrami. "**The true mapping from precedents in architectural ideation**.". *Journal of Fine Arts: Architecture & Urban Planning*, 21(3):81–90, 2016.
DOI: https://doi.org/10.22059/jfaup.2016.61104.

[137] M. Feizi, L. Alipour, and A.M. Moradi. "**Training for consious adaptation from architectural precedents: Approaches and strategies**.". *Journal of Architecture and Urban Planing, Art University*, 19:5–22, 2015.
DOI: https://doi.org/10.30480/aup.2019.691.

[138] P. Cheng, R. Mugge, and J.P. Schoormans. "**A new strategy to reduce designfixation: Presenting partial photographs to designers**.". *Design Studies*, 35(4):374–391, 2014.
DOI: https://doi.org/10.1016/j.destud.2014.02.004.

[139] N. Nikghadam. "**Patterns of semi-open spaces in vernacular houses of Dezful, Bushehr and Bandar-e-Lenge considering climate atributes**.". *Journal of Fine Arts: Architecture & Urban Planning*, (18):69–80, 2013.
DOI: https://doi.org/10.22059/jfaup.2013.51319.

[140] J. Wrobel, P.S. Walter, and G. Schmitz. "**Performance of a solar assisted air conditioning system at different locations**.". *Solar Energy*, 92:69–83, 2013.
DOI: https://doi.org/10.1016/j.solener.2013.02.030.