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Developing a New Sustainable Architecture Design Studio Course: Connecting Students to Nature Case Study

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Abstract: Sustainable design in architecture is a dynamic and evolving field as it continuously adapts to address the challenges of contemporary environmental issues. In doing so, it would stand to reason that there are several themes architecture programs must undertake in order to educate future architects effectively. One of the themes that continues to gain momentum in the realm of sustainable design, which is particularly evident in the Architecture Design Studio Course Projects, is that of residential architecture, commercial architecture, and urban landscapes integrating Biophilic Design principles. This is a great tool for architecture students to understand the basics of sustainable design. Nevertheless, realizing the fundamental first step in teaching students. So, they might reconnect with nature and teach them about the intrinsic value of the natural world. In this context, it is important to introduce in the curriculum other design topics, such as Modern Sustainable Farms, which offer the right context to accomplish this by becoming a place where students integrate practices that not only minimize the environmental impact of a modern farm but also enhance the resource efficiency and ensure the long-term viability of the farm. To assess the success metric of the course and the topic, the Accreditation Board for Engineering and Technology (ABET) methodology is adopted. The results were promising. The end of semester assessment findings indicate that defined Course Learning Outcomes (CLOs) have been achieved over 70%, and it is satisfactory. Additionally, selected ABET student outcomes (SOs) clearly show that 82% of the students reached developing and 18% reached a proficient level.

Keywords: Course development, Sustainable architecture design studio, ABET, Course learning outcomes, Student outcomes

Introduction

The Department of Architectural Engineering in the College of Engineering at The American University of Kurdistan was founded in the fall of 2016 to offer a five-year Bachelor of Science degree in Architectural Engineering that provides students with a background in structural engineering and construction management skills necessary to be a successful architectural engineer. The curriculum is more extensive than traditional architectural engineering programs. The program aims to graduate productive members and leaders within the profession who can contribute to society by furthering the quest for a safe, healthy environment and a more sustainable surrounding economy (AUK, 2024a). To accomplish this, The Department of AE seeks ABET accreditation for the following reasons:

- *Quality Assurance* - Accreditation provides a solid assurance for students that the school where they are studying can give the faculty resources, a well-rounded curriculum, and facilities necessary for them to practice architectural engineering.
- *Recognition* - Accreditation can provide professional recognition [in countries other than the U.S.] to practice professional architectural engineering.
- *Global Standards* - Engineers working in the global environment will have the means to compare their backgrounds with their U.S. counterparts.
- *Employment Opportunities* - Because some governmental, corporate, and engineering educational institutions employ only ABET-accredited engineering graduates.

- *Licensure, Registration, and Certification* - To provide documentation by which U.S. registrars and others registering architecture engineers in their home countries can determine that an individual's requirement meets the legal talents and abilities specified by the Society of Architectural Engineers.
- *Student Loans, Grants, Scholarships* - Grants, scholarships, and government loans are available for students attending institutions with ABET-accredited degree programs.
- *Global Work Opportunities* - Accreditation awards that employers outside the U.S. more widely accept students with degrees from ABET-accredited programs than those of students not attending such programs (ABET, 2021b).

Additionally, the ABET accreditation process generates valuable information and insights to help deliver the best educational experiences possible. It also supports an "effective, evidence-based pedagogical approach" that "requires faculty to evaluate and improve quality of instruction continuously" (Bennedsen et al., 2015). Thus, it assesses learning objectives rather than what instructors deliver (ABET, 2021a). Therefore, developing a new sustainable architecture design studio course is one more example of the Department of Architectural Engineering living its mission of continuous quality improvement.

Current Sustainable Design Study Topics in Architecture Programs Around the Globe

Sustainable design is an essential part of architectural education around the world. Integrating sustainable design principles into the architecture curriculum provides future architects with the knowledge and skills to create environmentally responsible and resource-efficient built environments. A sampling of sustainable design project topics from architecture programs around the world include:

- The consistent top market driver for the past three years is biophilic design, which focuses on incorporating nature and natural elements to improve the well-being of occupants and promote environmental sustainability (University of Minnesota, 2024).
- The top near-term innovation in the report is net-zero energy buildings, where the project aims to create as much energy as it uses, ultimately reducing the need for traditional energy sources (University of Illinois, 2023).
- The second most used undergraduate term focuses on passive design strategies that maximize natural light, ventilation, and thermal comfort in buildings through strategic architectural design (Princeton University, 2023).
- The top long-term innovation explored by The University of Sydney with Mattis Architecture focuses on using sustainable materials and construction techniques. More specifically, projects are looking into using environmentally stable and locally sourced materials and unique construction methods to reduce waste and promote a smaller environmental footprint in the building process (The University of Sydney, 2024).
- Green infrastructure and urban agriculture: These areas focus on integrating green spaces, such as green roofs, vertical gardens, and urban farms, into the built environment to improve air quality, reduce the heat island, and promote food sustainability (Nitya Rao, 2024).
- Circular economy and waste management: These areas focus on designing buildings and systems that promote zero waste, energy efficiency, recycling and reuse of materials, and moving towards a resilient economy, where waste is considered a valuable resource (The University of Edinburgh, 2023).
- Socially inclusive design: These areas aim to design architecture that is equitable, accessible, and inclusive for individuals of all abilities, ages, and socioeconomic status (Royal College of Art, 2023).
- Resilient design: These projects "focus on bolstering the life and value of a building and by extension its users, through designs intended to respond to current environmental challenges, heeding environmental fluctuation, thermal tolerance, humidity, precipitation, wind movement, receding daylight, the scarcity of freshwater, the greening of the earth, and resilient performance post-natural disaster," Bruce Stubbs of the New Jersey Institute of Technology, one of the ASID panelists, wrote in his report (New Jersey Institute of Technology, 2024).
- Regenerative design: These projects go "beyond simply being 'green' and suggest that the human-built solution could partner with Earth-based ecosystems, reversing the impact we have had and be a healing force for restoration and the fast-forwarding of ecosystems, biodiversity and social system" through architectural interventions, according to Saif Haobsh of the University of Bath, another panelist, in his report (University of Bath, 2024).

Additional projects such as: The Makers Museum. This "explores the rethinking of the typology of the museum as a place not only for the exhibition and gallery space but as a place for the making" at the Singapore University of Technology and Design (SUTD). Rebuilding Paradise: A Critical Relook at Wildfire Resilience by Understanding the Wildfire Crisis in the Californian Context at MIT – Massachusetts Institute of Technology (Dezeen staff, 2021). Other specialties' studies may focus on an AI (Artificial Intelligence) integrated sustainable design, including parametricism (Archiroots, 2024). Due to this, universities now have Sustainable Farm Design Projects in higher education (Australian National University, 2024). However, no evidence has been found that the offering is taught as an interdisciplinary studio design topic by Architecture Departments.

Course Design

Description

This studio focuses on sustainability, builds on and integrates previous studios and current coursework (Green Buildings), and involves designing complex architectural projects situated in challenging contexts and developed concerning the program, climate, culture, site, building, and representation. In addition to the expected deliverables, the final project requires digital animation and public participation to focus on sustainability, environmental impact, and equity (AUK, 2023b).

Objectives

a. To understand architectural sustainability in a practical and comprehensible manner.
b. To apply the fundamentals and sustainability.
c. To evaluate sustainable technologies.
d. To demonstrate concepts, the final project, strategies, processes, and the analyses involved in sustainable design.

Course Learning Outcomes

Students who complete this course successfully will possess the capability to:
1. Understand the principles and fundamentals of sustainable technologies. (Objectives b & c).
2. Apply design principles for sustainable solutions (Objectives a, b, c & d).
3. Compare the past and present sustainable industry and market advancement (Objectives b & c).
4. Analyze human-centric sustainable design and its applications. (Objectives a, c & d).
5. Evaluate sustainable solutions (Objective d).
6. Recognize the considerations in selecting and specifying sustainable materials (Objectives a, c, & d).
7. Summarize the benefits of sustainable design (Objectives c & d).
8. Evaluate control strategies for Sustainability (Objective d).
9. Critique energy performance improvements (Objective d).

Curriculum Mapping for ABET

This course is mapped with the Student Outcomes defined by the Accreditation Board for Engineering and Technology (ABET) for the assessment and evaluation processes. The results of the assessment are used to evaluate the following ABET's Student Outcomes:
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics,
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors,
3. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives,
4. An ability to acquire and apply new knowledge using appropriate learning strategies,
5. An ability to function effectively on a team whose members provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives,
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to conclude,
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies (ABET, 2021c).

The following Rubrics have been designed for seven ABET Student Outcomes:

a. Rubric for Performance Indicators of Student Outcome (1). "An ability to identify, formulate, and solve complex engineering problems by applying engineering, science, and mathematics principles" (ABET, 2021a).

Table 1. Assessment rubric for ABET SO1 by author

PI #	Performance Indicator	Beginning	Developing	Proficient	Exemplary
PI-11	Formulate the problem and identify critical issues/variables.	• Missing conceptual design. • Missing most key issues /variables. • Missing most criteria. • Missing most constraints. • Missing most assumptions.	• Weak conceptual design. • Some issues/variables were identified, but many were missing. • Many criteria are missing. • Many constraints are missing. • Many assumptions are missing.	• Adequate conceptual design. • Most key issues/variables are identified. • Almost all criteria presented for ranking alternatives. • Almost all constraints identified. • Almost all assumptions identified.	• Complete and succinct conceptual design. • Key issues/variables identified. • All relevant criteria presented for ranking alternatives. • All relevant constraints identified. • All relevant assumptions identified.
PI-12	Recognize the need for multiple solutions.	• Alternative solutions are not presented.	• Alternative solutions are not significantly different, i.e., involve only a minor parameter change.	• Alternative solutions adequately cover design space. • A variety of tradeoffs are presented in alternative solutions.	• Alternative solutions cover design space in several significant dimensions. • All significant tradeoffs are presented in alternative solutions.
PI-13	Analyze alternative solutions to an engineering problem.	• Little analysis. • Severely flawed analysis Criteria not evaluated. • Constraints ignored.	• Limited analysis of alternatives. • Only some criteria were evaluated. • Only some constraints are considered.	• Appropriate analysis approach. • Mostly correct analysis results. • Criteria evaluated with minor errors. • Constraints considered with minor errors.	• Well-thought-out or clever analysis approach. • Complete and correct analysis results. • Complete evaluation of design criteria. • Complete consideration of constraints.
PI-14	Justify a solution to an engineering problem.	• Little discussion of analysis results. • Missing documentation of the decision-making process. • The arbitrary choice for the final solution.	• Weak discussion of analysis results. • Significant steps are missing in the decision-making process. • There is a weak justification for the final solution.	• Adequate discussion of analysis results. • Document decision-making process. • The final solution is justified based on design criteria.	• A detailed discussion of analysis results. • Detailed documentation of the decision-making process. • Clear justification is shown for the final solution based on design criteria

b. Rubric for Performance Indicators of Student Outcome (2).

"An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors" (ABET, 2021a).

Table 2. Assessment rubric for ABET SO2 by author

PI #	Performance Indicator	Beginning	Developing	Proficient	Exemplary
PI-21	Formulate the problem (identify the "need") and analyze the constraints.	• Unable to formulate the problem at all. • Does not understand the concept of constraint.	• Partial formulation but missing some key constraints. Understands the concept of constraints but cannot formulate the problem.	• Formulates the problem and uses constraints in the formulation. • Unable to use the most efficient formulation.	• Formulates the problem and analyzes all relevant constraints. • Find the best formulation.
PI-22	Establish "fitness" criteria for evaluating potential solutions and tradeoffs.	• Unable to establish fitness criteria. • Does not understand the concept of tradeoffs.	• Somewhat able to establish fitness criteria and tradeoffs with significant weaknesses. • Misses several critical tradeoffs.	• Establishes fitness criteria and tradeoffs with minor weaknesses.	• Establishes complete fitness criteria • Analyzes tradeoffs thoroughly.
PI-23	Generate alternative solutions.	• Unable to derive any meaningful solution.	• Derives a meaningful solution • Unable to derive alternative solutions.	• Derives multiple solutions • There are some weaknesses in the evaluation of alternative solutions.	• Derives alternative solutions • Performs proper evaluation of alternative solutions.
PI-24	Draw a BIM model and analyze the performance.	• Unable to build a proper BIM model.	• Builds a BIM model with some help. • Shows major weaknesses in analyzing performance.	• Builds an adequate BIM Model • Somewhat able to analyze performance.	• Builds a well-developed BIM Model • Comprehensively analyzes the performance.
PI-25	Improve the BIM model.	• Unable to identify weaknesses in the BIM model.	• Identifies some weaknesses in the BIM model, but still missing some essential items • Unable to make any improvement to the BIM model.	• Identifies fundamental weakness in the BIM Model • Makes some improvements with minor weaknesses.	• Identifies any weakness in the BIM model • Remedies any weakness in the BIM model • Determines the best BIM model.

c. Rubric for Performance Indicators of Student Outcome (3).

"An ability to communicate effectively with various audiences" (ABET, 2021a).

Table 3. Assessment rubric for ABET SO3 by author

PI #	Performance Indicator	Beginning	Developing	Proficient	Exemplary
PI-31	Organize the material.	• Little organization (paragraphs, sections). • Missing Problem Statement or Purpose. • Missing Conclusion or Summary. • Missing other major section • Missing references.	• Confusing organization. • Weak Problem Statement or Purpose. • Weak Conclusion or summary. • Other sections are weak. • Weak list of references.	• Mostly logical and complete organization. • Adequate Problem Statement or Purpose. • Adequate Conclusion or Summary • Adequate list of references.	• Excellent organization. • Well-stated problem statement or purpose. • Strong Conclusion or summary. • A thorough list of references.
PI-32	Present content in students' words to demonstrate comprehension.	• Lacking information or information is inaccurate or irrelevant. • Some text has been plagiarized. • Presents little understanding of the topic.	• Some basic information, but some are inaccurate or irrelevant. • A significant amount of text is copied verbatim from another source with a citation. • Presents a basic understanding of some parts of the topic.	• Adequate information with a few minor errors or omissions. • Adequate research. • Text is primarily the author's own words; only a slight amount of copied and cited text. • Presents a general understanding of the topic.	• Exceptional information (accurate and relevant). • Careful and thorough research. • All text is the author's own. • Presents in-depth understanding and insight.
PI-33	Provide data to support claims or inform the audience.	• Ideas not expressed clearly nor supported by details. • No interpretation of data. • No illustrations, or they do not support core message(s).	• Ideas not expressed clearly or details are weak. • Data analysis is weak. • Illustrations are unrelated, confusing, or mislabeled.	• Ideas are generally expressed clearly, and details are adequate. • Data analysis is adequate. • Illustrations support ideas but have some mislabeling or do not present data in the best way.	• Ideas are well-developed and expressed clearly with many appropriate details. • Data analysis is thorough and clever • Illustrations support core message(s), are properly labeled and captioned.
PI-34	Demonstrate proper use of English.	• Numerous errors in grammar, punctuation, and spelling. • Many sentences have an awkward construction. • It does not appear to have been proofread.	• Several errors in grammar, punctuation, and spelling. • Several sentences have an awkward construction. • Proofreading appears to have been done hastily.	• A few errors in grammar, punctuation, and spelling. • Sentences are mostly well-crafted. • It appears to have been proofread, but further revision could improve the text.	• Minor errors, if any, in grammar, punctuation, and spelling. • Varied and creative sentence structure. • Demonstrates thorough proofreading and revision.

PI-35	Deliver an oral presentation.	• Control of speaking tone, clarity, and volume is not evident. • The speaker is visibly nervous and does not convey interest in the topic. • The student does not make eye contact with the audience during the presentation. • Physical gestures and awareness of facial expressions are absent.	• Clarity of speech is uneven; delivery is halting. • The speaker is not entirely sure of the topic and appears nervous or disengaged. • Limited or sporadic eye contact with the audience. • Limited or inappropriate use of physical gestures and facial expressions.	• Good speaking voice; recovers quickly from speaking errors. • The speaker is in command of the topic but appears slightly nervous in the delivery. • Good eye contact with the audience throughout most of the presentation. • The use of physical facial expressions and gestures is good but sometimes appears forced or artificial.	• Strong, clear speaking voice easily understood by the audience. • The speaker conveys confidence in talking about the topic. • Excellent eye contact with the audience throughout the presentation. • Using facial expressions and physical gestures conveys energy and enthusiasm.

d. Rubric for Performance Indicators of Student Outcome (4). “The ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments must consider the impact of engineering solutions in global, economic, environmental, and societal contexts” (ABET, 2021a).

Table 4. Assessment rubric for ABET SO4 by author

PI #	Performance Indicator	Beginning	Developing	Proficient	Exemplary
PI-41	Identify the global, economic, environmental, and societal context of an engineering situation.	• Unable to identify relevant contexts of the problem. • Relevant contexts are described minimally.	• One relevant context of the four listed context types was identified. • The one relevant context described in only a rudimentary fashion.	• Relevant contexts among two or three of the four listed context types are recognized. • At least two contexts are described substantively.	• Relevant contexts among three or four listed context types identified. • At least three of the contexts are described thoroughly.
PI-42	Describe ethical and professional responsibilities related to an engineering project.	• Description of ethical and professional responsibilities absent or minimal.	• Description of ethical and professional responsibilities is rudimentary.	• Description of ethical and professional responsibilities is substantive.	• The description of ethical and professional responsibilities is complete and thorough.
PI-43	Explain the impact of engineering decisions in a global, economic, environmental, and societal context.	• Explanation of relevant impacts of engineering decisions absent or extremely limited.	• The explanation of the impact of engineering decisions touches on only one context. • Explanation of relevant impacts of engineering decisions is rudimentary.	• Explanation of relevant impacts of engineering decisions touches on two to three contexts. • The explanation is substantive in the majority of contexts.	• Explanation of relevant impacts of engineering decisions touches on three or four contexts. • The explanation is at least substantive in all contexts and is thorough in the majority.

e. Rubric for Performance Indicators of Student Outcome (5).

“An ability to function effectively on a team whose members provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives” (ABET, 2021a).

Table 5. Assessment rubric for ABET SO5 by author

PI#	Performance Indicator	Beginning	Developing	Proficient	Exemplary
PI-51	Establish a collaborative and inclusive environment (Teamwork).	• Does not provide encouragement or constructive criticism. • Does not listen to other teammates or share knowledge. • Does not help other teammates or demonstrate leadership.	• Sometimes provides encouragement and constructive criticism. • Sometimes listens to other teammates and shares knowledge. • Sometimes helps other teammates and demonstrates leadership.	• Frequently provides encouragement and constructive criticism. • Frequently listens to other teammates and shares knowledge. • Frequently helps other teammates and demonstrates leadership.	• Always provides encouragement and constructive criticism. • Always listens to other teammates and shares knowledge. • Always helps other teammates and demonstrates leadership.
PI-52	Fulfill individual responsibilities and contribute to the team’s success. (Individual accountability).	• Does not complete individual tasks timely. • Does not contribute to the team efforts. • Does not interact with other team members.	• Completes a small number of individual tasks timely. • Contributes little to the team's efforts. • Interacts little with other team members.	Completes most of the individual tasks timely. • Contributes frequently to the team efforts. • Interacts regularly with other team members.	• Completes all of the individual tasks timely. • Always contributes to the team's efforts. • Constantly interacts with other team members.
PI-53	Define team goals and deadlines, plan tasks, and organize and facilitate effective team meetings. (Project management)	• Does not define any goal or deadline. • Does not plan shared or individual tasks. • Does not organize nor facilitate any part of any team meeting.	• Defines at least one goal with a deadline. • Plans at least one shared and one individual task. • Organizes and facilitates at least one part of one team meeting.	• Defines a few necessary goals with deadlines. • Plans a few necessary shared and individual tasks. • Organizes and facilitates a few parts of a few team meetings.	• Defines several necessary goals with deadlines. • Plans several necessary shared and individual tasks. • Organizes and facilitates several parts of several team meetings.

f. Rubric for Performance Indicators of Student Outcome (6).

“An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to conclude” (ABET, 2021a).

Table 6. Assessment of rubric for ABET SO6 by author

PI #	Performance Indicator	Beginning	Developing	Proficient	Exemplary
PI-61	Design an Experiment Plan. (How do you answer the driving question?)	• Missing experiment plan. • Missing driving question. • Missing identification of critical variables. • Missing data collection procedure.	• Flawed experiment plan. • Weak driving question. • The majority of key variables are not identified. • The data collection procedure is formulated poorly.	• Adequate Experiment Plan. • A Driving Question is presented, though it might have minor flaws. • Almost all variables have been identified. • The data collection procedure is formulated adequately but does not account for all externalities.	• Well-thought-out experiment plan. • The driving Question is appropriately narrow and focused. • All relevant variables and externalities have been identified. • The data collection procedure is detailed without being unnecessarily complicated.
PI-62	Acquire data on appropriate variables.	• Data acquisition appears to have significant errors or unrealistic accuracy. (fake data?) • Data collected for variables that are not part of the experiment Plan or some variables that are not sampled. • Large portions of the data range are missing.	• Data acquisition does not include any detail on instrument precision or accuracy performance. (sensitivity & calibration) • A data acquisition illustration does not accompany acquired data or a diagram. (test setup not adequately described) • The input data range is significantly limited or meaningless for some variables.	• Data acquisition includes most instrument capabilities. (sensitivity & calibration) • Data acquisition setup is illustrated/explained, but a few minor details are missing. • Input data covers most of the “range of interest” for the key variables.	• Data acquisition includes all relevant sensitivity and calibration information • Data acquisition setup is carefully and thoroughly explained. • Input data covers the entire range of interest and some additional points/configurations that might be interesting without wasting time on unnecessary procedures.
PI-63	Interpret experimental data and results concerning appropriate theoretical models.	• No comparison was made, or comparison was made to nonsensical models.	• Weak comparison of data to the appropriate model • Comparison of data made to model that does not include some critical relationships among key variables.	• Adequate comparison made to appropriate model • Model includes important • relationships among key variables, though some minor details are missing.	• Thorough comparison conducted between the sufficiently varied data set and detailed model • The theoretical model is sufficiently detailed to provide insight into the Driving Question.
PI-64	Explain observed differences between model and experiment (wrong model, bad measurements,	• Differences are not identified or are incorrectly explained. • Neither the possibility of using the wrong model nor of collecting	• Most differences are correctly identified, but many are poorly explained. • Explanation of differences does not consider the use of the wrong model	• All significant differences are identified; only a few minor differences have been ignored. • Both model and data have been	• All relevant differences have been identified. • Potential weaknesses in both model and data collection procedures have been identified, but both are well done.

	noise, and so on.) and conclude.	erroneous data has been identified. • Conclusions are not justified.	or the possibility of having erroneous data. • Conclusions are weakly justified.	explored as possible sources of error. • Conclusions are partially justified by analysis.	• Conclusions are fully justified by rigorous analysis.

g. Rubric for Performance Indicators of Student Outcome (7).

"An ability to acquire and apply new knowledge using appropriate learning strategies" (ABET, 2021a).

Table 7. Assessment rubric for ABET SO7 by author

PI#	Performance Indicator	Beginning	Developing	Proficient	Exemplary
PI-71	Identify necessary techniques, skills, and tools for a new situation (research)	• Identifies a small subset of necessary techniques, skills, and tools • Identifies unrelated techniques, skills, and tools.	• Identifies some techniques, skills, and tools but missing some essential items • Includes some unrelated techniques, skills, and tools.	• Identifies almost all of the relevant techniques, skills, and tools • Missing some minor techniques, skills, and tools.	• Identifies all relevant techniques, skills, and tools • Does not include unrelated techniques, skills, and tools.
PI-72	Explain the use of the new techniques, skills, and tools (acquisition)	• Provides little explanation of how the techniques, skills, and tools should be used • Provides an incorrect explanation of how to use techniques, skills, and tools.	• Explains how some techniques, skills, and tools should be used but missing some critical items • Provides some incorrect explanations of how to use techniques, skills, and tools.	• Explains how almost all of the techniques, skills, and tools should be used • Shows adequate understanding of techniques, skills, and tools • Missing the explanation of some minor techniques, skills, and tools.	• Explains how all relevant techniques, skills, and tools should be used • Shows in-depth understanding of techniques, skills, and tools • Does not explain unrelated aspects of techniques, skills, and tools.
PI-73	Apply the new techniques, skills, and tools to the given situation	• Applies a small subset of the necessary techniques, skills, and tools • Incorrectly applies the techniques, skills, and tools.	• Correctly applies some of the techniques, skills, and tools but missing some critical items • Incorrectly applies some techniques, skills, and tools.	• Correctly applies almost all of the techniques, skills, and tools • Demonstrates good use of techniques, skills, and tools • Incorrectly applies minor techniques, skills, and tools.	• Correctly applies all relevant techniques, skills, and tools • Demonstrates mastery of techniques, skills, and tools • Does not apply unnecessary techniques, skills, and tools.

Assessment Rubrics for ABET cover the whole AE department courses. Regarding the studied course, for the Spring 2024 Semester, the data collected from Architecture Design VI – Architecture Sustainability is used to evaluate the attainment of Student Outcomes 2 (SO2), Student Outcomes 3 (SO3), Student Outcomes 4 (SO4), and Student Outcomes 7 (SO7). Therefore, each course in AE has different corresponding SOs, and the ABET accreditation committee considers the overall department course coverage regarding SOs.

The assessment plan was drawn up to collect the necessary data to evaluate the attainment of outcomes. The course covered giving Participation 20%, Final Assignment Progress Critics 30%, Midterm 20%, and Final Project (30%). The following Table shows the sum of the points.

Table 8. The course overall percentage breakdown and given assignments by author

Participation	20%
Final Assignment Progress& Critics	30%
Midterm	20%
Final Project	30%
TOTAL	100%
Assignment 1.	Literature Review of Concept Report.
Assignment 2.	Study of a Modern Farm (The Scope of Work) report.

Table 9 below shows the mapping of each CLO, the assessment and evaluation methods used, and the results regarding ABET Student Outcome Results 2,3,4 and 7.

Table 9. CLO mapping by author

Outcomes	Assessment Method	Evaluation Method
CLO 1	Assignments 1,2	Average Participation
CLO 2	Assignment 2 & Final Project	Average Grade
CLO 3	Assignments 1 & 2	Average Grade
CLO 4	Midterm & Final Project	Average Grade
CLO 5	Final Project	Average Grade
CLO 6	Final Project	Average Grade
CLO7	Final Project	Average Grade
CLO8	Final Project	Average Grade
CLO9	Final Project	Average Grade
ABET Student Outcome 2	Final Project	SO Rubrics
ABET Student Outcome 3	Final Project	SO Rubrics
ABET Student Outcome 4	Final Project	SO Rubrics
ABET Student Outcome 7	Final Project	SO Rubrics

Course Schedule

The following course schedule per AUK`s 2023-2024 academic calendar has been introduced (AUK, 2023a). Table 10 also addresses Student Outcomes and program Education Objectives in corresponding weekly boxes.

Table 10. Architecture design VI: Architecture sustainability course schedule by author

Week	Lesson Title	SO/PEO	Learning Activity (if applicable)	Assignment Due
1	Introduction to the Course Overview of the course General Guidelines & Learning Approach Assessments Briefing Introduction to the subject area Part I: History of Sustainability	Learning disciplinary terminology	Lecture	-
2	Part II: Basics of architectural sustainability Concept and Conceptual Mass Study Assignment I: Literature Review of Concept Report	Learning disciplinary terminology	Lecture and application of terminology	Week 3
3	Part III Final Project: You will design a designated 50,000 m² Sustainable Modern Farm site. Each student shall choose a different site and provide the GPS coordinates (latitude and longitude). You must design the buildings using a sustainable assessment study that includes building materials, solar, and artificial light. You need to provide sustainable design	Continued – introduction to terminology	Application of terminology to examples; group participation	Week4

	analysis simulations for your structures. Moreover, you will draw foundation plans and floor plans, including all equipment, furniture, elevations, sections, 3D views, electrical, lighting, and reflected ceiling plans. Your sustainable analyses of technical information/data will be presented in a booklet format during your final presentation. Therefore, the set of your plotted technical drawings and the project booklet will be presented during your final presentation. The scale of your plots will be 1/100, besides the site plan, which can vary between 1/200 and 1/500. Assignment II: The Scope of Work Report		
4	Studio Work • Site Selection • Crop Rotation and Diversification • Water Management	Demonstration of knowledge of terminology	Lecture, Presentation, and Group Participation
5	Studio Work • Revit Add Inns, how to assess sustainability • Organic Farming Practices • Agroforestry	Continued – introduction to terminology	VR Integration
5	The Progress Evaluation I (10 percent of the total grade) Studio Work • Energy Efficiency • Livestock Management	Demonstration of knowledge of terminology	Group Participation and Critics, VR experience of the projects
6	The Progress Evaluation II (10 percent of the total grade) Studio Work • Waste Management • Technology Integration	Demonstration of knowledge of terminology	Presentations and Critics, VR experience of the projects
7	Studio Work • Community Engagement • Education and Outreach	Demonstration of knowledge of terminology	Group Participation and Critics, VR experience of the projects
8	Studio Work • Certifications and Standards • Green Building Assessment	Demonstration of knowledge of terminology	Group Participation and Critics, VR experience of the projects
9	Studio Work The progress evaluation III (10) percent of the total grade)	Continued – introduction to terminology	Lectures and Group Participation, VR experience of the projects
10	Midterm Exam	Demonstration of knowledge of terminology	Group Participation and Critics, VR experience of the projects
11	Studio Work	Continued – introduction to terminology	Group Participation and Critics, VR experience of the projects

12	Studio Work	Demonstration of knowledge of terminology	Group Participation and Critics, VR experience of the projects	
13	Studio Work	Demonstration of knowledge of terminology	Individual Critics, Reviews, and Presentations, VR experience of the projects	
14	Studio Work	Demonstration of knowledge of terminology	Group Participation and Critics, VR experience of the projects	
15	FINAL PRESENTATIONS		Individual Critics, Reviews, and Presentations, VR experience of the projects	Final Project Presentations
16	EXAMINATION WEEK			

Research Hypothesis

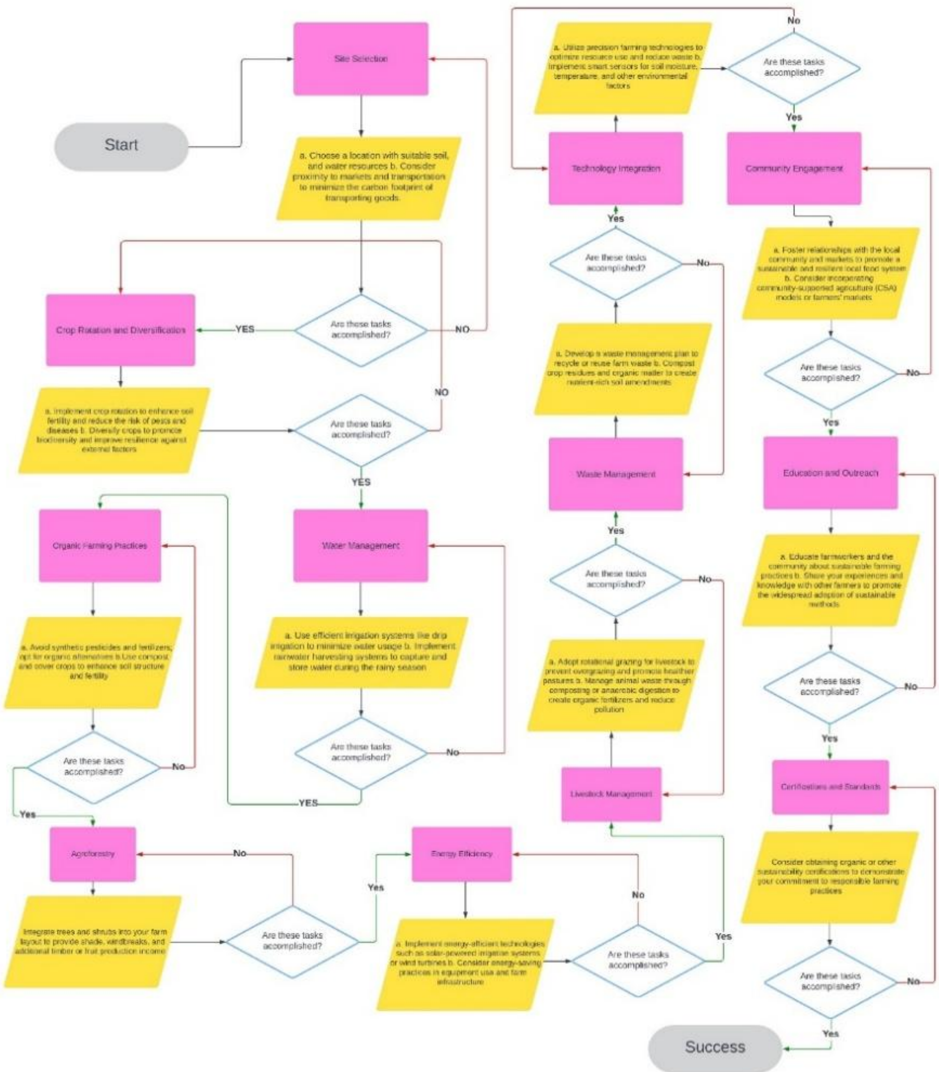

Figure 1. Modern sustainable farm design processes: Roadmap to success by author

Sustainable design in architecture is continually progressing and transforming in response to ever-increasing and pervasive environmental challenges. Accordingly, architecture programs addressing these vital and emergent issues must survey and undertake multiple themes. An especially significant recent theme that has emerged in Architecture Design Studio Course Projects is the creation of innovative contemporary residential architecture, compelling and groundbreaking urban landscapes, and revolutionary new commercial architecture that incorporates or is at least in ethos and spirit increasingly insistent, Biophilic Design. Using these increasingly sophisticated projects, architecture students can autonomously discover the critical principles of sustainable design.

However, it is important to recognize that truly teaching and connecting students to nature must, at its heart, involve sharing a deep love of the natural world. With that in mind, it would be ideal to start introducing new design and creative subjects in the curriculum, allowing teachers to inspire future generations of farmers and other world savers. That is where some new design topics, like Modern Sustainable Farm," come in. Designing a sustainable modern farm involves making decisions that not only help the farm minimize its environmental impact but also ensure that it becomes a highly efficient resource user and can continue to be viable over the long term. The developed flow chart, which provides a comprehensive pictogram of the intricate steps that a modern farm designer must take to realize a farm design of this type, is sure to come in handy for educators as well.

The project success flow chart ensures that the project is completed perfectly. Each stage of the design process has several tasks that must be completed to progress to the next step. If one stage is incomplete, a loop takes the designer back to the previous stage until all tasks are completed. According to the flow chart, the success criteria are made to be followed linearly. So, the following flow chart is a great resource that details the major considerations and steps needed to design a modern sustainable farm. Combining the above practices and routinely reassessing and adjusting methodologies where necessary allows it to establish a contemporary and ecologically sound agricultural operation that mitigates its environmental footprint and guarantees its longevity.

Methodology

ABET course assessment methodology is adopted for this study. ABET requires that accredited programs provide evidence that they utilize effective processes in assessing student learning outcomes. The program identifies these outcomes and aligns them with AE's Program Educational Objectives (PEOs): to produce ethical professional graduates (AUK, 2024b) that:

PEO1. Be ready to advance state of the art in research and further education to enhance the sustainability of the built environment.
PEO2. Be prepared to solve project-related challenging problems, demonstrate innovation and critical thinking in engineering design, and successfully practice the profession of Architectural Engineering,
PEO3. Assume leadership responsibilities and conduct multidisciplinary interactions.

Therefore, the Bachelor of Architectural Engineering program was specifically designed with three main focuses in mind: Advancement of state-of-the-art research, Development of critical thinking, and Exposure to societal multidisciplinary interactions. These essential elements are believed to be significant in cultivating well-rounded excel in their careers and communities. Moreover, these Program Educational Objectives (PEOs) align closely with the mission and vision of the university and the College of Engineering.

Assessment Tools

Direct assessments directly examine or observe student performance against measurable learning outcomes. They may include projects, presentations, and oral and written reports. In our case, the previous examples, such as the final project, literature review assignments, and oral presentations, are executed to examine the student performance by Student Outcome Rubrics that have been developed on performance indicators for the seven Student Outcomes. These rubrics provided clear criteria by which student success in each outcome can be evaluated. Thus, data on student performance is collected using rubrics. This provided grades, scores, and other information of interest. They also helped to ensure consistency and objectivity in the assessment process. As mentioned in Section 3.3. Student Outcomes 2 (SO2), Student Outcomes 3 (SO3), Student Outcomes 4 (SO4), and Student Outcomes 7 (SO7) are selected to provide direct assessments. The other method is indirect assessment, which also measures the perceived extent or value of learning experiences. It assesses opinions or thoughts about student knowledge and skills. Indirect measures also provide information about the respondent's perception of student learning. Regarding the course's initial stage, indirect measurements are planned for the following semesters to assess a bigger sample student size. Therefore, the use of multiple methods provides converging evidence of student learning.

Assessment and Continuous Improvement

Based on the assessment data, appropriate actions are taken to enhance student learning. This can include changes to teaching methods, course content, or student support mechanisms. The assessment process is an ongoing data collection, analysis, and improvement cycle so the program may maintain and enhance its educational quality over time. It is important to note that ABET does not prescribe a specific assessment methodology. Programs are expected to have a systematic and continuous improvement process for assessing student learning outcomes. The details of the assessment methodology vary by Engineering Accreditation Commission (EAC) (ABET, 2021a) and by educational objectives. Therefore, AE adopted an ABET-based assessment methodology to achieve a better quality of education and Continuous Improvement.

Assessment Outcomes

As previously addressed, the assessment plan was drawn to collect the necessary data to evaluate the attainment of outcomes. The course covered giving Participation 20%, Final Assignment Progress Critics 30%, Midterm 20%, and Final Project (30%). Each outcome was linked to a particular assignment and design task within the presentations related to the SO2, SO3, SO4, and SO7 of the ABET's Student Outcome criterion for this assessment. The following table shows the mapping of each CLO, the assessment and evaluation methods used, and the outcome results. Regarding ABET Student Outcome Results 2,3,4 and 7, rubrics are used, and the results showed histograms correlated with the number of students.

Table 11. CLO, the assessment, evaluation methods, and results mapping by the author

Outcomes	Assessment Method	Evaluation Method	Results
CLO 1	Assignments 1&2	Average Participation	90%
CLO 2	Assignments 2 & Final Project	Average Grade	79%
CLO 3	Assignments 1& 2	Average Grade	80%
CLO 4	Midterm & Final Project	Average Grade	71%
CLO 5	Final Project	Average Grade	73%
CLO 6	Final Project	Average Grade	73%
CLO 7	Final Project	Average Grade	73%
CLO8	Final Project	Average Grade	73%
CLO9	Final Project	Average Grade	73%
ABET Student Outcome 2	Final Project	SO Rubrics	77%
ABET Student Outcome 3	Final Project	SO Rubrics	77%
ABET Student Outcome 4	Final Project	SO Rubrics	77%
ABET Student Outcome 7	Final Project	SO Rubrics	77%

Results and Discussion

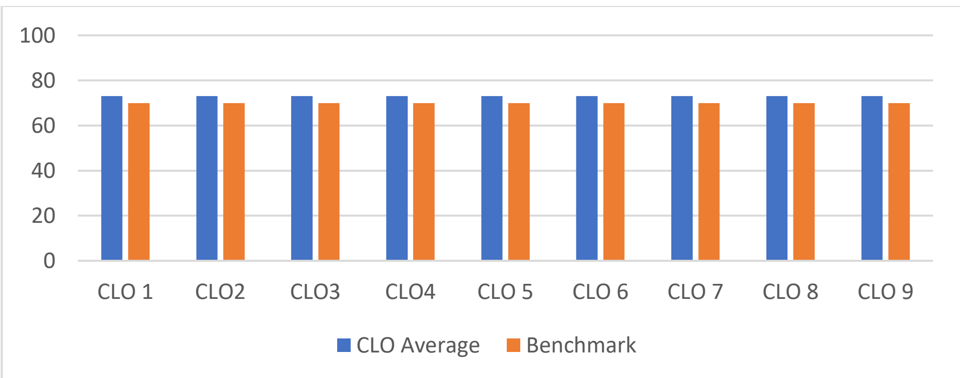

Figure 2. Course learning outcome (CLO) achievements for the architecture design studio

The following criteria are shown in the measurement of CLOs. 0 – 69% Weak / non-achievement, 70% – 79% Satisfactory achievement, 80% – 89% Good, 90% - 100% Excellent achievement. The results indicate that CLOs 1-9 have been achieved, as all results are above 70%. Following the above benchmark and criteria, the attainment of CLO1, CLO2, CLO3, CLO4, CLO5, CLO6, CLO7, CLO8, and CLO9 is satisfactory. Thus, the histogram in Figure2 demonstrates the attainment percentage of each Course Learning Outcome, and the orange bar is the threshold of 70%. Additionally, the histograms in Figure 3 show the Performance Indicators, assessment range, and the number of students for SO2, SO3, SO4, and SO7.

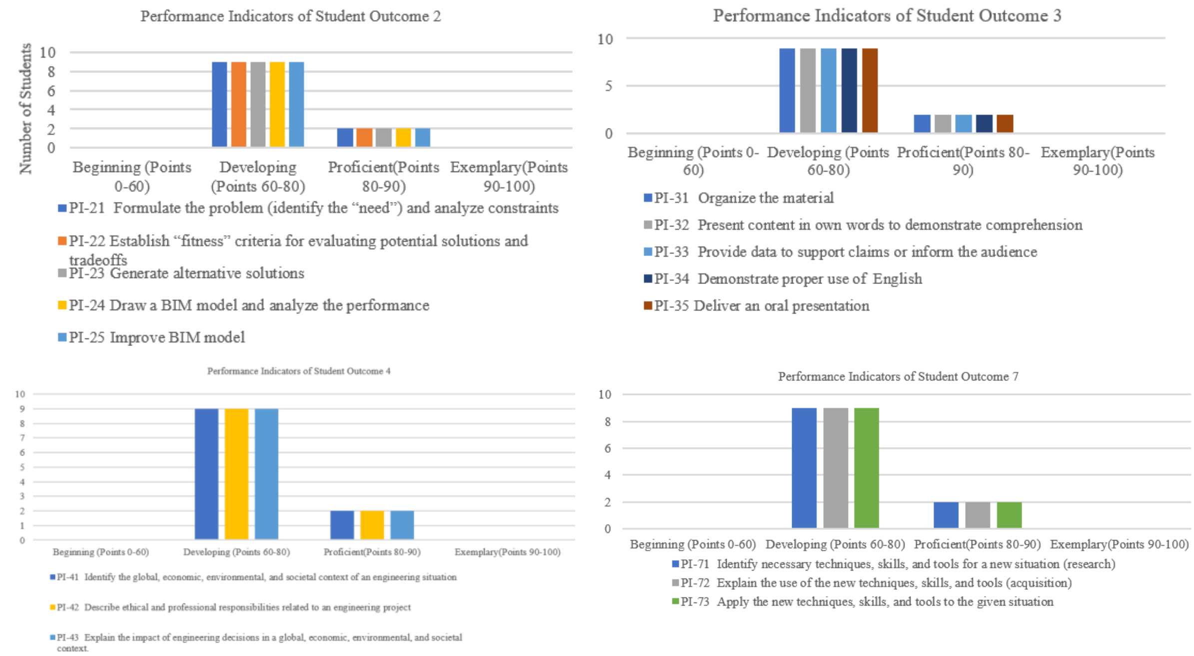

Figure 3. Performance indicators of student outcomes (SOs)

Therefore, the following discussion can be introduced as a new context of sustainable design practices: Modern Sustainable Farm was the right context to accomplish this by becoming a place where students integrate practices that minimize the environmental impact of a modern farm, enhance resource efficiency, and ensure the farm's long-term viability. It is planned that ongoing data collection can serve as a case study and possible publication during the following terms. Therefore, Architecture Design VI – Architecture Sustainability is designed to give students a full comprehension of sustainable design in architecture. The achievement and average of SOs and CLOs were satisfactory.

Limitations

This study is based on a few students (11) who took the Architecture Design VI: Architecture Sustainability Course in the Spring 2024 semester. This must be considered when interpreting this study's findings and in any further research or interventions to increase the number of actively registered students in the college. The college is growing; it has 230 active students at the time of this study, with 300 forecasted to be active at the closing of Fall 2025. The sample size is planned to be increased in the next assessments, and the developed framework can be applied to any sample size. It is important also to note that these limitations should be considered when considering the conclusions of this study. They should not be viewed as invalidating the findings but as providing areas for further exploration and research.

Conclusion

A revolutionary approach to methods is creating a studio course in architectural design that will focus on sustainability and a deep connection to nature. As the challenges of the 21st century become more prevalent, the goal of the course is to prepare the future generation of architects with the knowledge, skills, and mindset to develop built environments that are environmentally aware and socially responsible.

Developed over a year, the curriculum has been carefully crafted to weave design principles, ecological mindfulness, and a deep connection with nature throughout the studio experience. Drawing from nature-inspired design and regenerative architecture, the studio combines the art of building with an understanding of our built environment as something more than functional. Doing so increases awareness of the interdependent relationship between architecture and the natural world.

The studio focuses on hands-on, project-based learning to encourage a learning experience for students rooted in real-world design and architecture challenges. Moreover, students can explore solutions to pressing issues while considering their unique, cultural, and situational contexts. The course curriculum also integrates eco-friendly building materials so students can experience ground-up construction. Working with a focus on biomimicry and low-impact approaches to design inspired by nature sustainability approaches; students are encouraged to incorporate those principles into their creations.

In advancing education and developing a strong sense of obligation and care among future architects, the course on sustainable architecture design studio strives to breed a new class of design authorities who hold environmental resilience, social welfare, and holistic sustainability as their primary endeavors in their architectural pursuits. The promising results from the initial assessments indicate that the course effectively meets its objectives, with students demonstrating satisfactory achievement in both CLOs and SOs. Therefore, Architecture Design VI – Architecture Sustainability is designed to give students a full comprehension of sustainable design in architecture.

Data Availability Statement

* The data set analyzed for this study is available and can be provided by the author upon request.

Scientific Ethics Declaration

* The author declares that the scientific, ethical, and legal responsibility of this article published in EPESS Journal belongs to the author.

Conflict of Interest

* The author declares that he has no conflict of interest.

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