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Development of the interdisciplinary graduate certificate program and its contribution to architects and engineers

Dr. bodhisatta hajra, Oklahoma State University

Assistant professor of architectural engineering at the school of architecture, Oklahoma State University

Development of the interdisciplinary graduate certificate program and its contribution to architects and engineers

Bodhisatta Hajra, PhD; Khaled Mansy, PhD
School of Architecture, Oklahoma State University, USA

Abstract: Historically, the School of Architecture (SOA) at Oklahoma State University (OSU) has been offering undergraduate programs in architecture, architectural design studies and architectural engineering. Due to an increased interest in the subject of energy efficient buildings, in 2019, the second author of this article along with other faculty members at the SOA decided to develop a Graduate Certificate (GC) program for integrative design of the building envelope. In particular, the second author's expertise in energy, daylighting and high-performance building enclosures, was instrumental towards developing the GC program. This unique program is open to undergraduate students from any discipline including those pursuing a degree in architecture or architectural engineering at the SOA. Students wishing to pursue a GC are required to complete 12 credit hours, which includes at least three courses and a thesis or a creative component. The students can choose the three courses from a wide range of available graduate level courses in architecture, architectural engineering, civil, mechanical and fire engineering. A specific topic of research that culminates into a thesis is typically undertaken under the supervision of at least two advisors representing two areas of expertise at the SOA. The eclectic thesis topics range from energy efficiency to structural design of building components. Since the students complete the GC program while pursuing an undergraduate degree, it provides them additional knowledge which they can apply in practice or while pursuing a graduate degree. To date, the SOA has produced twenty-one graduates who successfully completed the GC program, and there is one additional student on the verge of completing the GC program this year. Out of the twenty-one students, most of them are currently pursuing a career in the industry with one of them recently completing a graduate degree elsewhere. Some of the students also presented their work at various conferences, based on the research conducted during the GC program. This article presents a detailed overview of the development of the GC program, besides providing information on the duration of study, coursework and thesis requirements. The paper also highlights how the GC program can contribute towards producing accomplished architects and engineers from the SOA, despite being different from traditional graduate degrees (MS and PhD) in architecture offered at most US universities.

Keywords: Graduate Certificate; Architecture; Engineering; Building Envelope; Energy

Introduction

Modern buildings of the twenty-first century must provide adequate comfort for occupants, besides being structurally safe and energy efficient [1, 2, 3]. Formal education for architects and architectural engineers is therefore very important to ensure that buildings are structurally adequate, energy efficient, besides being aesthetically pleasing [4]. Currently there are several institutions across the US and Canada offering undergraduate/graduate degrees and certificates in architecture, as shown in Figure 1 from Association of Collegiate Schools of Architecture (ACSA).

The SOA at OSU currently offers undergraduate programs in architecture, architectural engineering, architectural design studies and a graduate certificate (GC) program. The undergraduate degree programs at the SOA have been offered for many years, and include various courses that are studio based, besides courses in art, science, math and engineering.

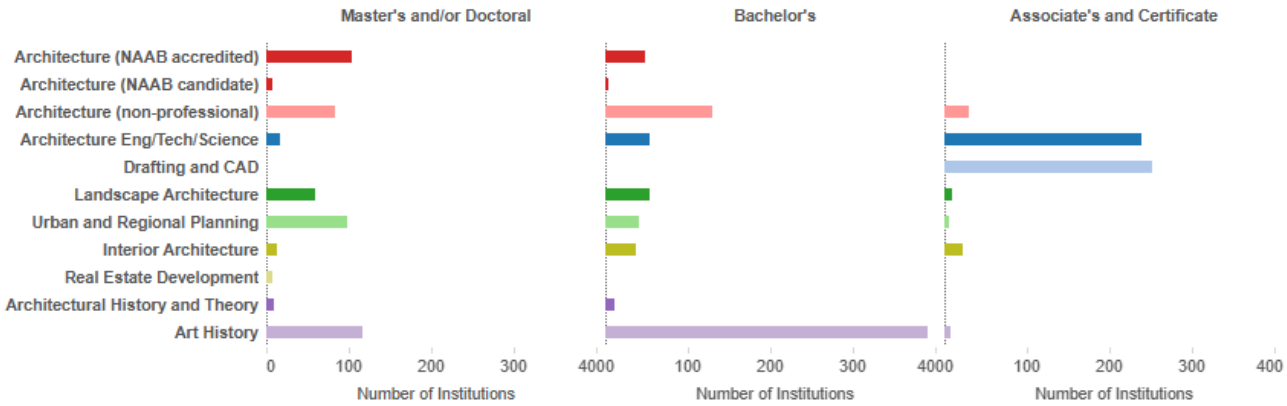


Figure 1. List of programs in architecture in US and Canada (source: ACSA website)

Due to the recent rising energy costs, coupled with the need for energy efficient buildings, there has been a demand for architects and engineers in the industry that can work on energy efficient and sustainable building design [5]. This would naturally require a program that could train and educate architects and engineers graduating from SOA that would have a diverse skillset and knowledge, in addition to the courses learnt during the undergraduate program at the SOA. To fulfill this idea, the GC program was first created in 2019 by the second author of this paper, in collaboration with several other faculty members at the SOA and within the University.

The GC program at the SOA is of 12 credit hours which can all be double-counted towards their undergraduate degree in architecture/architectural engineering. Within 12 credit hours, the GC requires the student to complete a capstone independent study and at least 3 courses from a selection of courses in civil, mechanical, architectural and fire engineering. Typically, the GC program requires at least two advisors from the SOA, from diverse areas of study so that the student can enhance their knowledge. As of now, there are 21 students that have successfully completed the GC program and another student on the verge of completing the GC by the end of this year.

This paper presents a detailed overview of the development of the GC program at the SOA besides requirements for completion of the GC program. Two separate surveys were conducted by the authors – one survey for faculty members at the SOA and the other survey for the students who completed or are currently pursuing a graduate certificate. Results from both surveys show that the students greatly benefitted from the GC by gaining more knowledge about sustainable building design. The faculty members at the SOA also experienced a positive feeling about the GC program and provided several suggestions for improvements. The GC program has tremendously contributed to producing architects and engineers from the SOA since its inception in 2019. Current research carried out by students through the GC program and future developments that can contribute to architectural education are discussed in this article.

Graduate Certificate Program at the School of Architecture, OSU

Construction of buildings requires close collaboration between architects and engineers to ensure that buildings are structurally adequate to sustain various loads, besides being energy efficient and sustainable [6]. Due to the recent increased use of non-renewable sources such as coal contributing to the greenhouse effect [7], coupled with a push for energy efficient buildings [8], some of the faculty members at the SOA spearheaded by the second author decided to develop the graduate certificate (GC) program in Integrative Design of the Building Envelope in 2019.

The GC program consists of 12 credit hours of which courses worth 9 credits must be taken by the student from a diverse list of courses in architecture (ARCH), civil engineering (CIVE), fire protection and safety tech (FPST), fire safety and explosion protection (FSEP), forensic sciences (FRNS) and Materials Science and Engineering (MSE). The current list of courses is shown below, which shows the diversity of relevant courses that can be taken by the architecture and engineering students from various departments. These course were selected due to their potential to provide better understanding of the building envelope, its structure, materials, performance, environmental impact and cost.

- ARCH - Timbers & Masonry Design & Analysis
- ARCH - Real Estate Development
- ARCH - Special Topics in Architecture
- ARCH - Advanced Energy Issues in Architecture
- ARCH - Advanced Architecture Technology Seminar
- ARCH - Entrepreneurship in Architecture
- ARCH - Analysis III
- ARCH - Steel III
- ARCH - Concrete III
- CIVE - Contracts and Specifications
- CIVE - Construction Estimating
- CIVE - BIM for Constructions
- CIVE - Concrete Durability
- CIVE - Advanced Construction Materials
- CIVE - Air Pollution Control Engineering
- FPST - Industrial Ventilation and Smoke Control
- FSEP - Risk Analysis
- FSEP - Fire & Explosion Hazard Recognition
- FSEP - Principles of Process Safety
- FSEP - Structural Design for Fire & Life Safety
- FSEP - Principles of Industrial, Physical & Building Security
- FRNS - The Chemistry of Pyrotechnics
- FRNS - The Chemistry of Explosives
- FRNS - Fire Dynamics in Forensic Investigations
- MSE - Advanced Thermodynamics of Materials

• MSE - Diffusion & Kinetics
• MSE - Composite Materials
• MSE - Smart Materials
• MSE - Fundamentals of Materials Science
• MSE - Fundamentals of Photovoltaics
• MSE - Additive Manufacturing: Materials, Methods & Applications

In addition, the GC program requires a student to complete a capstone study that is supervised by at least two advisors representing two different fields of study. The capstone study can be a 'creative component' or a 'research report'. The GC is of relatively low cost and can greatly help students wishing to pursue a graduate (MS or PhD) degree in future, besides being helpful in practice. A student is required to devise a plan of study (POS) in consultation with the two advisors and requires a contract between the student, graduate college and the school. The graduate certificate consists of 12 credit hours which can all be double-counted towards the undergraduate degree.

At the time of writing this article, 21 students successfully completed the GC and one student is on the verge of completing the GC this year. Some of the students also published their findings in conferences and symposiums based on their research carried out during the GC.

Some of the topics researched by students who have completed the GC at the SOA are shown below:

- Carbon footprint of envelope improvement for energy efficiency
- External vs internal shading devices
- Impact of material lifespan on carbon analysis
- Carbon footprint of three construction types
- Energy savings due to natural ventilation and double roofs in South Africa
- Low carbon thermal insulation options
- Artistic PV external shading devices
- Carbon sequestering and structural abilities of Eucalyptus Cloeziana
- Sustainability and theory of the curtain wall and its perception
- The cost of carbon, carbon tax of negative-carbon concrete
- Green roofs
- PV performance and wind uplift
- Testing glass structural properties

To better understand the impact of the GC program on architects and engineers, two separate surveys were conducted by the authors, as described further.

Surveys conducted at the School of Architecture

The authors conducted two separate surveys consisting of multiple-choice questions and one open-ended question for each survey. The first survey was sent to the 19 full-time faculty members at

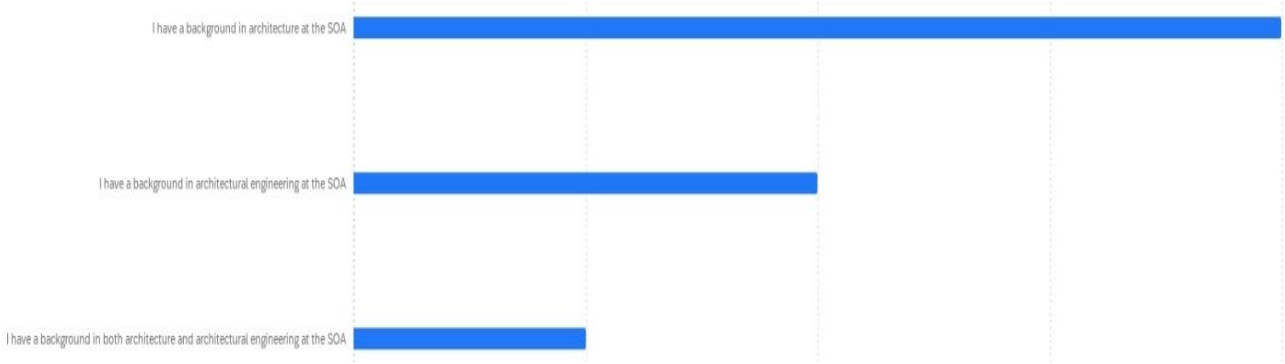
the SOA of which 14 responses were received. Out of those 14 faculty members, most of them had supervised a student for the GC before, with a few of them who had not supervised any student but were very interested in doing so in future. The second survey was sent to the 22 students that were enrolled in the GC program, of which 15 responses were received. Both surveys were conducted using "qualtrics" and were anonymous, without requesting any personal information from any of the survey respondents. At the time of the survey, 19 out of the 22 students had completed the GC and there were 3 other students enrolled in the GC program. A few weeks earlier during fall 2024 graduation, 2 out of those 3 students also completed the GC. Currently, 2 students are enrolled for the GC program and are expected to complete it this year. A few more students are expected to enroll in this program later this year. The questions and various options for each question for the faculty, and corresponding figures showing the survey results are presented in Table 1.

Table 1. Survey questions for faculty

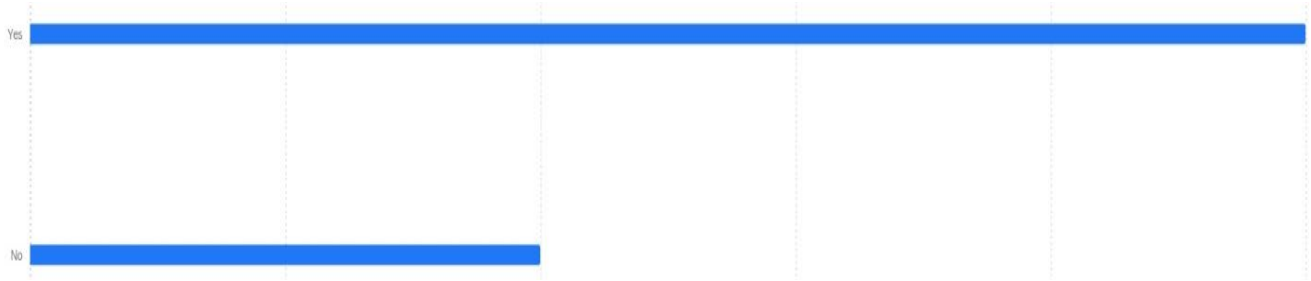
Survey questions and options	Figure number
1. Which of the two options best describe you? • I have a background in architecture at the SOA • I have a background in architectural engineering at the SOA • I have a background in both architecture and architectural engineering at the SOA	Figure 2 (a)
2. Have you supervised a student for the GC program at the SOA? • Yes • No	Figure 2 (b)
3. While the student was being supervised by you, which option did the student choose for the independent study? • Research report • Creative component • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (c)
4. Do you think the list of available courses from other disciplines, such as civil and environmental engineering, a good selection of courses to choose from? • Yes • No • Not sure	Figure 2 (d)
5. The graduate program typically requires at least two professors from the SOA, so that the student is exposed to more than one expertise of study. Do you think this is a good idea? • Yes • No • Not sure	Figure 2 (e)
6. Did the student supervised by you publish any articles in conferences, symposiums or journals based on their work during the graduate certificate program? • Yes • No • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (f)
7. Would you recommend other students at the SOA to pursue a graduate certificate program? • Yes • No • Not sure	Figure 2 (g)
8. How many GC students have you supervised at the SOA, so far? • 1 • 2	Figure 2 (h)

• More than 2 • Not applicable, since I have not supervised any GC student at the SOA	
9. As a faculty member, how did you communicate with the GC student? • Emails • In-person meetings • Emails and in-person meetings • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (i)
10. How often did you meet with the students? • Weekly • Biweekly • Once a month • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (j)
11. How prepared were the students you supervised for graduate level work? • Well prepared • The student struggled • Could not do the work on his/her own • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (k)
12. Did the student complete the work on time? • Yes • No • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (l)
13. Did the GC program help you expand your research? • Yes • No • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (m)
14. How rewarding was the time spent with the student pursuing their graduate certificate? • Very rewarding • Less rewarding • Not applicable, since I have not supervised any GC student at the SOA	Figure 2 (n)
15. Will you be interested in supervising students for the GC program again? • Yes • No • I have not supervised any students so far but would be interested in future.	Figure 2 (o)

Figures 2 (a) to 2 (o) present results from the faculty survey.



a)


Yes
No

b)


Research report
Creative component
Both research report and creative component
Not applicable, since I have not supervised any GC student at the SOA

c)


Yes
Not sure

d)


Yes
Not sure

e)


Yes
No
Not applicable, since I have not supervised any GC student at the SOA

f)


Yes
No
Not sure

g)


1
2
More than 2
Not applicable, since I have not supervised any GC student at the SOA

h)


Emails and in-person meetings
Not applicable, since I have not supervised any GC student at the SOA

i)


Weekly
Biweekly
Once a month
Not applicable, since I have not supervised any GC student at the SOA

j)

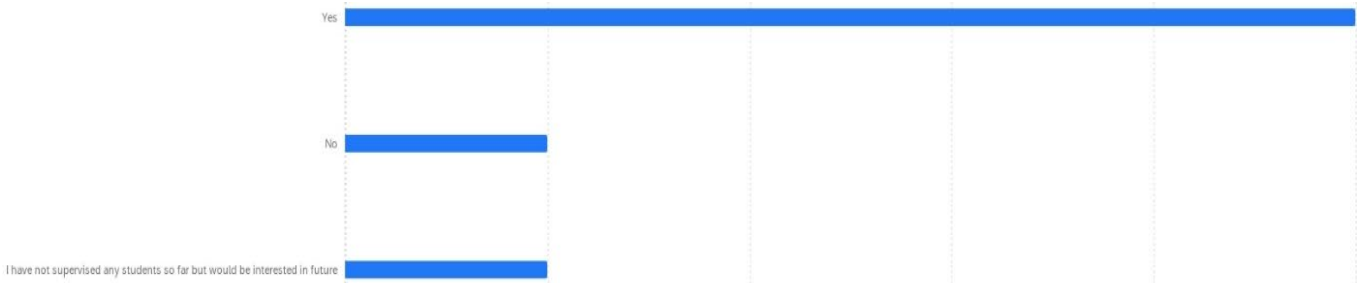

Well prepared
The student struggled
Not applicable, since I have not supervised any GC student at the SOA

k)

l)

m)

n)



o)

Figure 2. Survey results based on responses from faculty at the SOA

14 out of the 19 faculty members participated in the survey. Results show that a majority of faculty members had a background in architecture who have supervised a student in the GC program (Figure 2 (a,b)). Data show that the faculty were involved in research and creative component and approved the wide selection of courses available to students, and the current format of having at least 2 advisors (Figure 2 (c,d,e)). The students and faculty members were able to contribute to research through publications in conferences (Figure 2 f). Most of the faculty members communicated through emails and in-person meetings on a weekly or biweekly basis (Figure

2(i,j)). In general, faculty were interested in the GC program and expressed their interest in supervising students in future (Figure 2 (n,o)). Some of the suggestions provided by the faculty included, the use of a standard format to prepare a report, expanding the research topics to other areas, besides allowing collaborations with other departments at OSU. Following this, a separate survey was sent out to the 22 students enrolled in the GC program. At the time of writing this article, 15 of the 22 responded to the survey. Table 2 presents the questions and options available for each question and the corresponding figure showing the responses received. The survey was conducted using 'qualtrics', was anonymous, and did not seek any personal information.

Table 2. Survey questions for students who were enrolled in the GC program at the SOA

Survey questions and options	Figure number
1. Which of the two options best describe you? • I have graduated with a graduate certificate from the SOA • I am currently enrolled in a graduate certificate at the SOA	Figure 3 (a)
2. Your area of study at the SOA at OSU? • Architecture • Architectural design studies • Architectural Engineering	Figure 3 (b)
3. Which option did you choose for your independent study? • Research report • Creative component	Figure 3 (c)
4. Do you feel that you have gained sufficient theoretical and practical knowledge through the graduate certificate program offered at the SOA, including the independent study course? • Yes • No • Not sure	Figure 3 (d)
5. Following the completion of the GC program, have you pursued a graduate degree (e.g. Masters/PhD) or are you planning to pursue a graduate degree in future? • Yes • No • Not sure	Figure 3 (e)
6. Did the graduate certificate help you in your job search? • Yes • No • Not sure	Figure 3 (f)
7. Are you currently working or planning to work in the industry? • Yes • No • Not sure	Figure 3 (g)
8. Do you think the knowledge gained from the GC program is helpful in your current profession? • Yes • No • Not sure	Figure 3 (h)

9. Do you think the list of available courses from other disciplines, such as civil and environmental engineering, a good selection of courses to choose from? • Yes • No • Not sure	Figure 3 (i)
10. The graduate program typically requires at least two professors from the SOA, so that the student is exposed to more than once expertise of study. Do you think this is a good idea? • Yes • No • Not sure	Figure 3 (j)
11. Did you publish any articles in conferences or journals based on your work during the graduate program, or would like to publish an article in future? • Yes • No • Not sure	Figure 3 (k)
12. Were you able to double-count all 12 hours of the GC towards your undergraduate degree, or did you have to pay for extra courses? • Yes • No • Not sure	Figure 3 (l)
13. Would you recommend other students at the SOA to pursue a graduate certificate program? • Yes • No • Not sure	Figure 3 (m)

Figure 3 presents the student responses for each question shown in Table 2.

a)

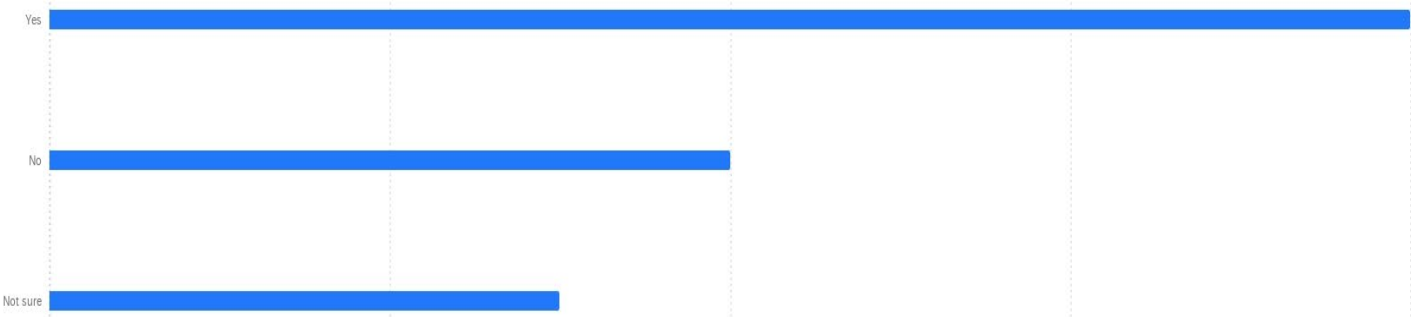
b)


Research report
Creative component

c)


Yes
Not sure

d)


Yes
No
Not sure

e)


Yes
No
Not sure

f)


Yes
Not sure

g)

h)

i)

j)

k)

l)

m)

Figure 3. Survey results based on responses from students enrolled in the GC program

Results show that most students enrolled in the GC program had a background in architecture with some students from architectural engineering (Figure 3(b)). Students also felt that they gained additional knowledge through the GC program, enabling them to pursue a graduate degree in future (Figure 3(d,e)). The knowledge gained from the GC has helped several students serve the industry successfully (Figure 3 (g,h)). The students were also in favor of multiple faculty members being supervisors since this helped students to pursue research, besides being able to utilize the 12 credit hours of the GC towards their undergraduate degree (Figure 3 (j,k,l)).

Both surveys conducted within the faculty at the SOA and students enrolled in the GC, showed high interest among faculty and students. There were some faculty who also indicated strong interest in supervising a GC student although they had not done so before. Students also expressed the interest in recommending fellow students to pursue a GC program due to their positive experience (Figure 3m).

The statistical relationship between GC assisting the student with their job search (Question 6 of the student survey – see Table 2) and whether the knowledge gained from the GC is helpful in their profession (Question 8 from student survey – see Table 2), was determined (see Table 3) by the χ^2 value of 7.12 (>5.991 critical) and p-value of 0.0284 (<0.05), which suggests the rejection of null hypothesis (i.e. the presumption that no relationship exists between the two questions). These results show that the GC program has greatly contributed to the SOA and the society at large since students have served the industry, besides contributing to research.

Table 3. Statistical relationships from student survey responses

Survey question (options: YES, NO, NOT SURE)	Chi-square (χ^2)	p-value
Q6. Did the graduate certificate help you in your job search? Q8. Do you think the knowledge gained from the GC program is helpful in your current profession?	7.12 > 5.991 (critical) Null hypothesis is rejected	0.00284 < 0.05 Null hypothesis is rejected

As the push for constructing sustainable and energy efficient building continues, the demand for architects and engineers that have advanced knowledge in this area becomes essential. In future, the GC program will try to include faculty members from other departments at OSU, besides expanding the number of courses that the students can choose from.

Conclusions

This paper presented an overview of the GC program developed in 2019 by the second author and several of his colleagues at SOA, due to an increased interest on the subject of energy efficient buildings. This unique program is open to undergraduate students from any discipline including those pursuing a degree in architecture or architectural engineering at the SOA. Students wishing to pursue a GC are required to complete 12 credit hours, which includes at least three courses and a thesis. The students can choose the three courses from a wide range of available courses in architecture, architectural engineering, civil, mechanical and fire engineering. A specific topic of research that culminates into a thesis is typically undertaken under the supervision of at least two advisors representing two areas of expertise at the SOA. The eclectic thesis topics range from energy efficiency to structural design of building components. Since the students complete the GC program while pursuing an undergraduate degree, it provides them additional knowledge which they can apply in practice or while pursuing a graduate degree. To date, the SOA has produced twenty-one graduates who successfully completed the GC program. Out of the twenty-one students, most of them are currently pursuing a career in the industry with one of them recently completing a graduate degree elsewhere. Some of the students also presented their work at various conferences, based on the research conducted during the GC program. A survey was conducted among the faculty members at the SOA and the students who enrolled for the GC program. Results show that both the faculty and students expressed a strong interest in the continuation and expansion of the program. The paper also highlights how the GC program can contribute towards producing accomplished architects and engineers from the SOA, despite being different from traditional graduate degrees (MS and PhD) in architecture offered at most US universities. The GC program will continue to be offered at the SOA and based on the survey, future work is underway to add other areas of research and additional courses to choose from, that will enhance student knowledge.

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