DESIGN EXERCISE STRATEGY FOR LOCUS OF CONTROL AND SELF-EFFICACY

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ABSTRACT

In the past years, there has been an interest to map and characterize the architectural engineering and the lighting design programs at the School of Engineering, Jönköping, Sweden. The investigations revealed issues related to student's self-efficacy and locus of control. This study aimed to create a routine for solving design problems by planning a small individual design exercise as a mental reward mechanism for students to boost their self-efficacy and internal locus of control. It was hypothesized that internal locus of control correlates to an increased self-efficacy level. The study objectives were (1) to propose an interior design exercise on problem-oriented learning that fits in the overall curriculum of Architectural engineering and Lighting design programs at the undergraduate level. Also, (2) to assess students' locus of control and status of individual preference for problem-solving approaches and self-efficacy. The interior design exercise lasted for a month in February 2020. With the outbreak of the COVID-19, the interior design exercise was the only design exercise held. Altogether, sixteen students completed the workshop. The pre- and post-evaluations show that a single design exercise had slightly shifted the students' locus of control to more internal, which indicates a more self-controlling behaviour. Also, an increase in the enjoyment of a design exercise was recorded, and students demonstrated a slight preference shift towards a less defined and more open design exercise. Students' internal locus of control correlated to self-efficacy measures in the pre-intervention phase but only showed a tendency in post-intervention. The design workshop teacher's reflection on the participants' design process revealed that many worked in groups, which might decrease the self-oriented decision-making rating for self-efficacy. The future investigation would extend these design workshops' complexity by involving a set of lighting design, architectural and urban space design exercises for a more comprehensive review of the effects.

KEYWORDS

locus of control, self-efficacy, design workshop, active learning, engineering education research, Standards: 5

INTRODUCTION

In the past three years, the investigation and mapping of the group design exercises at the School of Engineering at Jönköping University (Fischl, Granath, & Bremner, 2018; Fischl & Wänström-Lindh, 2020) had established a sense of urgency for examining the students' affinity

to deal with design problems. Studies generated a powerful guiding coalition and vision for developing strategy and empowerment for faculty members to implement a design process.
In the beginning, it was assumed that an architectural design problem could be more successfully approached and completed when the students' locus of control is more internally driven and the design problem is less prescribed. These investigations' original hypothesis was to prove an architecture-engineering design method capable of transforming undergraduate design learners' mental resources to deal with *wicked problems* (Rittel and Webber, 1973). In line with this, the current investigation follows Kottler's (1995) recommendation about establishing organizational and people's attitude change toward an architecture-engineering problem-solving process. The entire process is conceived by the CDIO approach (Crawley, Malmqvist, Ostlund, Brodeur, & Edström, 2014, p.35) to promote deep learning and conceptual understanding for student motivation and their interpersonal skills in the culture of experimentation and critical and creative thinking. Therefore, a generic design process was formulated over recent years to accommodate the new requirements. This paper focuses on the next stage of change management, namely, introducing small mental rewards for teachers and students in multidisciplinary design projects. Consequently, this study aimed to create a method for solving design problems by planning a small individual design exercise as a mental reward mechanism for students to boost their internal locus of control and self-efficacy.
The locus of control (LOC) is a personality trait that refers to a perception of events happening to an individual. The outcome of events can be either internally instructed by behavior or externally by fate, luck, or other conditions. Its origin is in the Social Learning Theory (e.g., Kormanik & Rocco, 2009), which posits "*that an individual's actions are predicted on the basis of the individual's expectations for reinforcement, the perceived value of the reinforcement, and the situation in which the individual finds himself or herself*" (p. 466). Consequently, when university students receive reinforcement, and their situation matches their expectancy, their self-efficacy is boosted. The positive reinforcement would build up a mental reward system that avoids adverse outcomes, and therefore the experience of the event can be appreciated.
On the contrary, when events are negatively appraised, a stress reaction is generated, heightening arousal and giving rise to the flight response to avoid fear. To measure locus of control and refer to the personality trait mentioned above, Rotter (1966) has developed a widely used tool. The dimensions (internal vs external) of locus of control were compared in many studies among college and university students on academic performance (e.g., Kirkpatrick, Stant, Downes and Gaither, 2008), self-esteem (e.g., Sadaat, Ghasemzadeh, Karami, Soleimani, 2012) and self-efficacy (e.g., Carifio & Rhodes, 2002).
Self-efficacy is also derived from the Social Learning Theory, and as Bandura (1977) explains, "Stressful situations generally elicit emotional arousal that, depending on the circumstances, might have informative value concerning personal competency. Therefore, emotional arousal is a constituent source of information that can affect perceived self-efficacy in coping with stressful situations" (p. 289). The difference between locus of control and the self-efficacy measure can be characterized by the notion that the former measures affect the individual's societal level as it forms the individual. At the same time, the latter finds stimuli-response beliefs in the individual's proximity which are related to personal skills in achieving a task by the management of emotional arousal. Sagone & De Caroli (2014) suggested a comprehensive measurement for the self-efficacy scale to explore the perceived self-efficacy in an academic context based on 30 items with 7-point Likert scale. This scale consisted of four factors, obtained by means of factorial analysis with principal components method: self-engagement, self-oriented decision making, others-oriented problem solving, and interpersonal climate.
When connecting the Social Learning Theory through the locus of control and self-efficacy measures to Kottler's recommendation, one might see the similarity in how the practicality of the small winnings (Stage 6) is related to a rewarding behaviour is hypothesized for delivering

a positive organizational change. Subsequently, this study's original aim was to create a routine for solving design problems by planning a set of small individual design exercises as a mental reward mechanism for students to boost their self-efficacy and internal locus of control. Due to the outbreak of the COVID-19 and the sudden change in the education routines, the planning of the four extra-curriculum workshops stopped. Only the first workshop was held. Therefore, the study's aim was modified accordingly. A single workshop aims to create a design exercise experience as a mental reward mechanism for students to boost their self-efficacy and internal locus of control. It was hypothesized that internal LOC is positively correlating to higher self-efficacy measures.

METHOD

Mainly a quantitative investigation was performed in this study by administering an internet-based questionnaire on demographics, locus of control, and self-efficacy. Reflection of the design workshop teacher was also collected concerning the locus of control and self-efficacy measures.

Participants

Initially, 33 students signed up for the interior design workshop, but many failed to complete the requirements, including filling out the questionnaires and completing the design task. Altogether, this study included 16 architecture-engineering students (M_{age}=23,87, SD_{age}=3,364), out of which ten attended the third year. The demographics of these participants are shown in Table 1. Participation was announced in each year and subject major simultaneously, and it was emphasized that this workshop is an extra curriculum activity and highly valuable for developing a personal portfolio.

Table 1. Demographics of the participants

	Year 1	Year 2	Year 3	Total
Age (SD)	21.33 (1,52)	22.00 (2.64)	25.20 (3.39)	23.87 (3.36)
Number of Participants (M, F)	3 (2, 1)	3 (1, 2)	10 (4, 6)	16 (7, 9)

Note: SD=Standard Deviation, M=Male, F=Female

Data collection instruments

An internet-based questionnaire was administered pre- and post-intervention. In the first part, demographic data (age, gender), academic subject major, and the research consent for participation and publication of results were recorded. Subsequent data were collected on individuals' locus of control (Nowicki-Strickland, 1973). The repeated measures entailed 40 standardized items on a forced-choice category level (Yes, No), resulting in a single Locus of control (LOC) ratio value. The lower LOC value indicated a more internal, while the higher LOC value, a more external position of control.

The next part of the online survey collected information about individual learning styles. This instrument is under consistent development by the primary author, and earlier versions are published in international CDIO proceedings in 2018 and 2020. It was designed to capture individual differences regarding the preference and earlier experience of assignments-oriented and problem-oriented design exercises. The former intended that the design exercise is well defined, and students are not allowed to challenge it; meanwhile, the latter entailed an open

exploration of a problem. The ratings were indicated on a seven-point Likert-scale (1=Undefined project (problem-oriented) to 7=Defined project (assignment-oriented)).
The final part of the online questionnaire portrayed an academic self-efficacy scale (Sagone & De Caroli, 2014) which consisted of 28 items on an adapted 6-point Likert-scale (1=Not at all possible to 6=Completely possible) along with four self-efficacy factors: self-engagement, self-oriented decision making, others-oriented problem solving, and interpersonal climate. The first factor refers to the ability to overcome difficulties with personal contribution, while the second factor refers to the ability to solve problems using personal resources. The third factor refers to the ability to solve critical issues using other people resources, and finally, the fourth factor is measuring a prosocial and collaborative climate in interpersonal relationships.
The interior design workshop objective was to create a new and improved space lobby and adjacent general spaces for the School of Engineering students, Jönköping. The students could choose their preferred technique and medium for presenting their conceptual work. The workshop teacher suggested the design task and reflected on the students' process after the four-week workshop.

Procedure

A four-months extra-curricular workshop was originally planned following the previous investigation by Fischl & Wänström-Lindh (2020). The notion was to introduce small mental rewards for teachers and students in the form of multidisciplinary design projects and is positioned so that all workshops should propagate internal control and enhancing self-efficacy within the more and more undefined (problem-oriented) design projects. Therefore, a series of workshops aimed to be presented to students each month, between February and May 2020. Out of these four workshops, only the interior design workshop was held and completed. Students were administered a pre- and post-intervention questionnaire online, including LOC and self-efficacy questionnaire, questions on enjoyment of a design assignment, and a preferred learning style for a design exercise. After successfully completing the questionnaires and the interior-design project delivery, the student received a diploma for participation. The reflection of the faculty member in charge of the workshop was also collected.

Data Analysis

Locus of control (LOC) scores were gathered pre- and post-intervention, calculated by the Nowicki-Strickland questionnaire (1973) on interval data. Gender was treated as nominal, age as ratio, and school year as interval data. Graphical analysis was performed on the limited dataset, gender and age differences could not be explored. The individual plot-diagram depicting pre- and post-intervention LOC and preferred learning style (Undefined-Defined) measures were categorized into activity quadrants. These quadrants are the results of development over the past years (Fischl *et al.*, 2018, Fischl and Wännström-Lidh, 2020), in which students LOC and affinity for preferred learning styles were categorized:
- Comfortable: students are receiving adequate external demands and external support for completing a defined task.
- Uncomfortable: students are experiencing an undefined task; however, the external support is not arriving for dealing with the complexity, and their level of helplessness is exposed.
- Performative: students are internally driven, routine-oriented, and familiar with the demands of the defined task.
- Creative: this quadrant is sought after; it combines internal control with preference to undefined tasks.
Additionally, to LOC and learning styles graphical analysis, a Pearson correlation was performed to investigate the relationship between LOC and the self-efficacy factors. It was

hypothesized that internal LOC has a positive correlation to self-efficacy factors. Although a paired sample t-test for differences was also performed, it did not return with significant results. The reflection of the workshop teacher was treated as complementary information in a narrative form. It was aimed to enrich the result and discussion sections of this paper.

RESULTS

This paper aimed to investigate the effects of a design workshop in terms of students' locus of control, preferred learning styles (undefined-defined task), and self-efficacy. It was hypothesized that a small design workshop promotes reward mechanism and boosts students' self-efficacy and internal locus of control as well as reposition the learning styles to a more undefined preference. Figure 1 summarizes the findings pre- and post-design intervention regarding learning styles and locus of control.

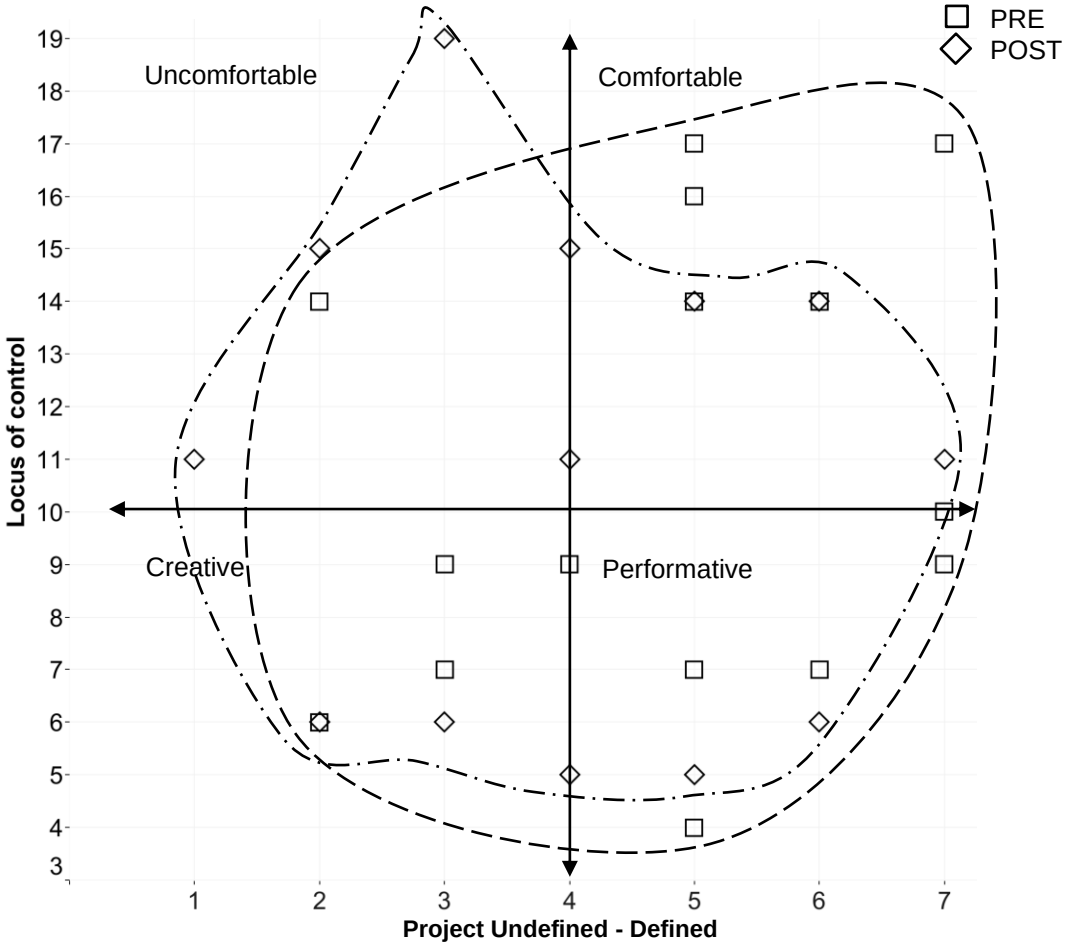

Figure 1. Pre- and post-intervention positions for students' LOC and preferred project definition (N=16). Note: The LOC neutral position is located at the mean level of LOC=10 (LOC<10 more internal, LOC>10 more external). The project definition axis is at a neutral position by 4 due to its 7-point scale (1=More undefined to 7=More defined).

This plot diagram is less sensitive to represent minor changes after the intervention. In Table 2, the mean and standard deviation of the measured variables are presented pre- and post-intervention. It is remarkable that after the design workshop, the learning style preference

shifted to a less defined status, the enjoyment in a design task increased, while the locus of control value decreased, which indicated a less external control need. As for the factors in self-efficacy, slight changes could only be detected. Significant correlations were found between LOC pre-intervention levels and three out of four self-efficacy pre-intervention factors (self-engagement ($r=-.501$, $p<.05$), self-oriented decision making ($r=-.606$, $p<.05$), others-oriented problem solving ($r=-.719$, $p<.01$)). These results indicate that the higher the LOC (more external), the lower the self-efficacy, which fails to reject the hypothesis (internal LOC positively correlates to self-efficacy). The results were not significant for the post-intervention correlation between the LOC and self-efficacy factors but kept supporting the hypothesis.

Table 2. Summary of Mean and SD are reported in pre- and post-intervention (N=16).

	Pre-intervention		Post-intervention	
	Mean	SD	Mean	SD
♦Learning style preference	4.38	1.500	4.19	1.682
♦Enjoying a design task	5.88	.885	6.06	.929
♠Locus of control	10.44	4.242	10.06	4.449
♣Self-engagement	4.77	.688	4.74	.645
♣Self-oriented decision making	4.68	.580	4.58	.648
♣Others-oriented problem solving	4.15	.608	4.39	.997
♣Interpersonal climate	4.98	.571	5.00	.548

Note: ♦The ratings were on a 7-point Likert-scale. ♠The ratings were on a category scale and combined into a ratio. ♣ The ratings were on 6-point Likert-scale.

Reflection: At the beginning of the first week, an introductory agenda was presented with a short description of the stages within the design process, conceptual, schematic, and design development. Through self-engagement, the students were encouraged to start with analyzing the lobby space, find problems, and start conceptualizing and problem-solving to come up with one solution that would be developed and presented with drawings, mood boards, and renderings at the end of the workshop. After the introduction, most students looked for more instruction from a teacher showing signs of uncertainty and inability to perform the task. With intentionally little or no guidance to the problem-solving process, many participants could not continue and dropped out of the workshop.

Students were driven by different self-motivation to continue where some were able to develop on their own and see what their potentials were with little or no tutoring. Others were inspired to complete the project and task motivated by their goals to receive a diploma and reward for completing the workshop. The remainder of the participants were struggling with the idea of individual self-performance and questioned their problem-solving ability. These different groups needed tutoring on separate levels. The first group was looking for very little tutoring and did not question their design and problem-solving skills. The second group was more performance and reward-driven and needed more assistance in accomplishing the task. The third group seemed lost in the idea that they were asked to study, analyze, and solve the problem on their own as well as working within a more openly defined project. They were looking for someone else to give them one right solution and were the least internally driven and were falling behind on the progression of the task at hand.

Throughout the month, the students were encouraged to follow the design process in coherence with the agenda. We met once a week and during the second-week meeting. I noticed a distinct difference in the divergent performance levels. An aggressive timeline and agenda showed that by the second week, the students were to work on schematic designs

with options for problem-solving. Those who followed their own self-oriented internal problem skills and interpersonal cooperation with fellow students and tutors showed more creativity and better solutions.
As we met during the third week, students worked on the design development and discussed work in progress and options for their solutions and problem-solving. My observation was that the students who had been engaged from the beginning with a focus on their self-assured abilities to solve a problem and with little tutoring help showed the most creative options.
The other individuals who also did well at this point were the few who had gotten past their doubts of being able to internally solve a problem and not being taught the solution. Their newly discovered skills within themselves brought out a sense of belief and confidence in their own actions, behavior, and thought process. Finally. in the fourth week, sixteen students of thirty-three who had initially signed up presented their work.

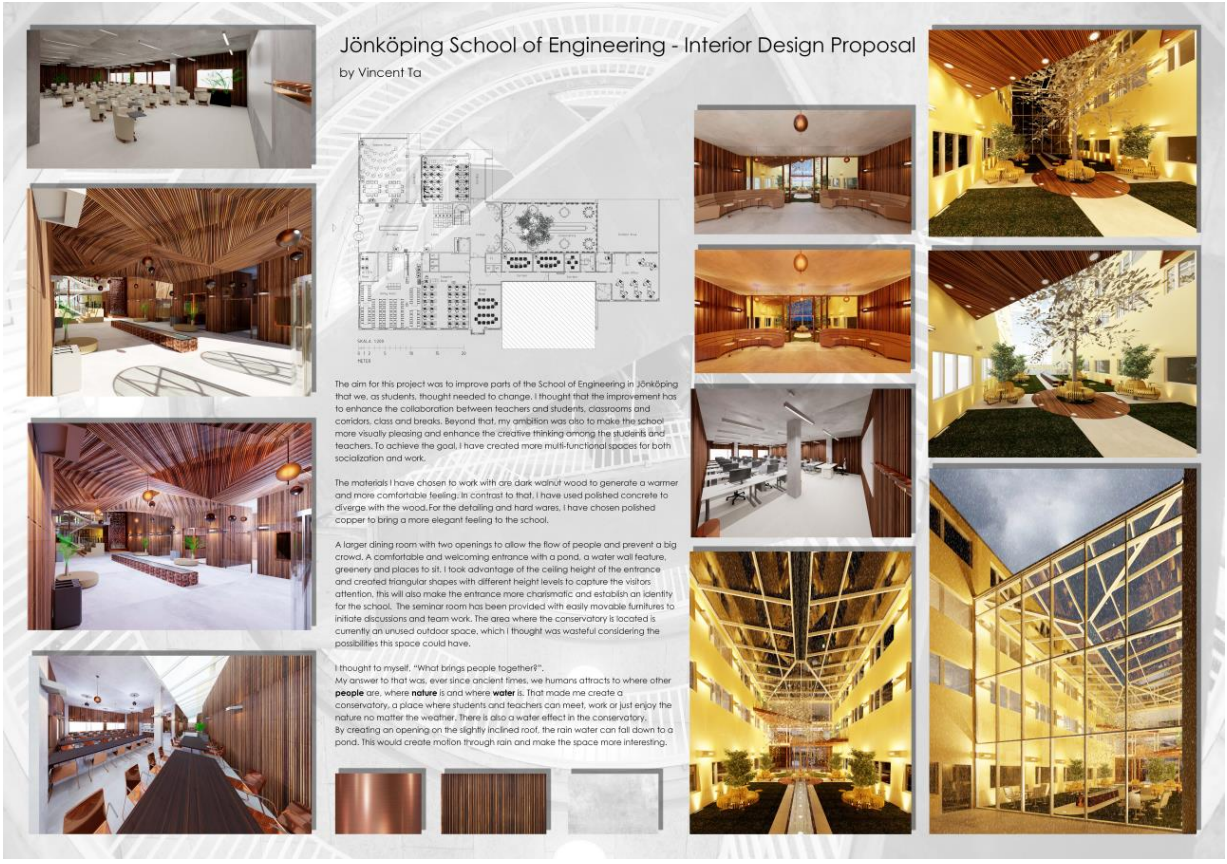

Figure 2. A result of the design workshop by Vincent Ta (a third-year student).

DISCUSSION

The initial goal was to introduce small design challenges for students, but it had been compromised by the coronavirus pandemic. Consequently, the aim became to create a design exercise experience as a mental reward mechanism for students to boost their self-efficacy

and internal locus of control. It was hypothesized that internal LOC is positively correlating to higher self-efficacy measures.

The prerequisite for successfully completing the workshop and being reported in this study was administering the pre- and post-intervention questionnaire. A decrease in participants was partially due to this requirement. Another contribution might be that students' misjudgment of time and individual resources to complete an extra-colloquium besides the general school loading. Furthermore, students might not fully comprehend that the design workshop was part of a study and not a faculty charity. Therefore, those who did not comply with the introduced measures were excluded from this study and failed to receive the extra-colloquium certificate.

The pre-intervention LOC indicated that the students were used to more prescribed assignments, requiring more input from the workshop teacher. The post-intervention measures of learning style moved to a less-prescribed position but stayed relatively central. This incremental change is still preferable, along with the decrease in LOC externality. The post-intervention measures of LOC and self-efficacy factors did not show a significant correlation, and even the self-oriented decision-making factor decreased. An explanation for this decrease could be that students worked in groups rather than individually as it was introduced. Consequently, the part of the self-oriented decision-making skill is likely to suffer from the lack of independent decision making. Unfortunately, the online survey did not register which students worked together, and how many were in a group. According to the workshop teacher's notes, three groups with two members each were identified, and their answer might have been the cause of this result.

The measurement methods employed here were partially untested. The self-efficacy measures were not gathered through focus group interviews, but a novel measurement scale adapted to this study. The original measures for the sub-factors used factorial analysis to identify the items belonging to each self-efficacy factor. The self-efficacy measures, however, were showing rating similarities across its sub-factors. The adoption of a questionnaire-based self-efficacy measure proved to be less time consuming than the qualitative evaluations applied in the previous studies within the same architectural engineering program.

Learning style ratings on a scale from a defined project to undefined seemed to be an effective tool to describe the preference variation from an assignment-based to a project-based orientation. Students traditionally requiring a lot of support from the teachers when completing an assignment-based project; meanwhile, the more open project-based design exercises are fostering creativity and contribute to an increase in self-efficacy.

One of this study's limitation entails the number of participants successfully completing the design exercise, which needs to be addressed in the forthcoming design workshops. A clear instruction may help to avoid the overestimation of one's strength in participation. When a participant is completing the prerequisites, the online measurement instruments need to be optimized for detailed tracking of group making and various decision-making regarding alteration of the project outlines.

CONCLUSION

This paper strengthened the assumption that a small design workshop promoted students' self-efficacy and internal locus of control and learning styles to a more undefined preference. Furthermore, this activity increased the level of enjoyment with a design workshop. The hypothesis regarding a more internal LOC would contribute to higher self-efficacy proved right at the pre-intervention phase. Future investigation should entail a larger sample of participants and a more comprehensive design exercise battery that follows individual and group decision-

making processes. The measurement instrument on LOC, self-efficacy, and learning styles seems still relevant for the architectural engineering domain's characterization.

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BIOGRAPHICAL INFORMATION

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