

# CHANGE FOR GROUP DESIGN EXERCISES IN A LIGHTING DESIGN PROGRAM

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## ABSTRACT

The lighting design education was recently converted to a three-year bachelor program, from a two-year non-engineering track, in which students' group design exercises resembled a design studio process characterized by high uncertainty, self-anchored problem solving and creativity. Consequently, students who attend this program are less disciplined in engineering, which predominates other educational programs at the School of Engineering. The aim of this study was to map the Lighting design students' ability for a problem-solving approach and their ability to control group design exercises to create a strategy for sustainable change, if necessary. The study employed a mix-method approach. In the quantitative data gathering, an online survey collected 18 students' responses using convenience sampling on the locus of control. Additionally, this survey registered the student's perception of the experienced group design exercise in terms of how concrete (assignment-based) or open (problem-based) the design exercise was. The visualization of this data, together with the locus of control measurement, revealed that students in the first year (N=4), tend to be located centrally with no preference for a problem-solving approach. In the meantime, the second-year students (N=6) developed an open (problem-based) approach to problem-solving, while their overall control in life is still more external. Finally, the trend for the students in the third year (N=8) moves to a more assignment-based approach and more to an internal locus of control. The qualitative investigation involved three focus group interviews (N=13) emphasizing on the following themes: open/closed projects, control, the teacher's role, instructions, demands, realism in the projects, project size, project budget, project time, group dynamics, group size, group roles, leadership, personality, and conflicts. Results reflect a shift in confidence in the ability to exert control over one's own motivation and behavior in the group design exercise. The themes were also reflected in the content of the focus group interviews. Based on these findings and according to the adaptation and implementation of a CDIO's design-implemented experiences, the preparation for introducing small gains for students and staff members were proposed.

## KEYWORDS

locus of control, lighting design, learning outcomes, active learning, Standards 5

## INTRODUCTION

In recent times, an engineering education ought to be positioned so that a deep approach to learning and conceptual understanding should complement each other for increasing student motivation, interaction with (each) others, and collaboration. In the meantime, students should be prepared for a career in engineering, which necessitates enhanced (inter)personal skills to communicate, increase problem-solving skills, experimentation, critical and creative thinking in the face of uncertainty. In addition to personal improvements, engineering students should be able to reflect upon societal events and must develop insight into the role of science. It is a demanding task for a student to commence in all these expectations at the same time.

These challenges in engineering education have been introduced earlier in a complex system, as it is highlighted by Crawley, Malmqvist, Ostlund, Brodeur, & Edström (2014). Their approach to settling these conflicts is called Conceive-Design-Implement and Operate (CDIO). In order to facilitate the adoption of this approach in higher education, twelve effective practices were identified as standards which cover the engineering education life cycle and serve as universal guidelines, for instance, to education program reform and evaluation (Crawley et al., 2014, p.35). When evaluating and reforming an engineering program, the emerging field of engineering education research (EER) plays a vital role in achieving usefulness and scholarliness as it was outlined by Edström (2016). Thus, researches that merely focuses on basic science would be less applicable and appropriate to tackle a practical problem, while a specific problem-related study would also mean limitation for understanding a larger picture in which the education context primarily exists. Therefore, finding "*the balance and relationship between scholarliness and usefulness is both a philosophical and practical question*" (Edström, 2016, p.980). In the case of this study, the vision was to provide a practical and useful representation for colleagues and fellow researchers to map a design-implemented experience (Standard 5 in CDIO) principle that incorporates both scholarliness and usefulness. Furthermore, a practical adaptation of a sustainable change process based on Kotter's eight stages (Crawley et al., 2014, p.184) could be canvassed.

Studies on the locus of control (LOC) started with Rother (1966), who introduced the theory and provided a scale to measure. It is accepted by now (e.g., Asante & Affum-Osei, 2019) that there are two main types of control perceptions an individual may possess. On the one hand, individuals with internal LOC believe that an outcome of an event is mainly influenced by their own action and behavior, therefore less likely that chance has to do anything with the outcome. On the other hand, individuals with external LOC rather believe that their life events and behavior are largely affected by external influences, and therefore, they lack control over their situations. These fundamental differences had been investigated in different areas, such as job attitude, job performance, and even in user experience design (e.g., Jang, Shin, Aum, Kim, & Kim, 2016). Studies on LOC and design decisions are scarce to find; the practical assumption here it, that design decisions require internal LOC, which is a resourceful move by the individual on a subjectively appraised objective possibility. Those who act on this opportunity may be more successful in the field of design than those who would not react. In terms of teaching design learners, our earlier investigation (Fischl, Granath, & Bremner, 2018) showed that one-quarter of the students would prefer group design exercises, which are less concrete/pre-described, hence be more open. Subsequently, education should progress to stimulate a gradual internalization of perceived LOC, in which professional skills may be fostered.

This study is a continuation of an earlier investigation (ibid.) about how undergraduate architecture-engineering students perceived control over their life situation and their problem-

solving ability in group design exercises. The Department of Construction Engineering and Lighting Science at the School of Engineering, Jönköping University in Sweden, runs a program in Architectural Engineering and in Lighting design. Both educations are characterized by project works, which facilitate a comparison of the students' progression.

The lighting design education has recently been upgraded from a two-year-long undergraduate non-engineering education to a three-year bachelor program. Even though the lighting design education has been operating for 20 years, it is unique both nationally and internationally. The profession as a lighting designer is still in its early stage. Mostly practicing architects engaged themselves with daylighting and electrical engineers or electricians working with artificial lighting were interested in developing the field. As a consequence, it is shown that people seldom took responsibility for the field as a whole. Today, the profession is still somewhat divided between artistic and engineering approaches (Boyce, 2017, Cuttle, 2011). The lighting design students have not yet fallen into this professional trap as they usually come to the university directly from the upper secondary school. In the lighting design education, there are project courses in which the task always concerns a real building, often also with real stakeholders representing their demands and wishes. The students observe and analyze the environment; they make sketches, perform test lighting, visualize, and then orally present their work. Apart from lighting design, they also prepare light measurement, light calculations, cost estimates, and discuss environmental sustainability along with energy use. Human health and wellbeing are also a concern for the projects. This way, by showing skills on the wide spectrum of tasks, the students retain a great position in the market. During project courses, students are working in groups of three to four assigned by the teachers. They have inspirational lectures and seminars wherein the main part of the teaching is through supervision. Their group work is characterized by a rather open approach. Generally, every group receives the same task on the same site. Hence, they need to find their own ways to deal with uncertainty and defining the problems, formulate their ideas, to elaborate and present projects. The project-based courses are graded individually with a pass or fail. If a written exam is included in the course, the grades can be more differentiated in steps. However, oral feedback from the teacher is often just as valuable and motivated for learning as grades are.

In order to describe and characterize the lighting design education, the aim of this study was to map the Lighting design students' ability for problem-solving approach in relation to their control in group design exercises to create a strategy for sustainable change, if necessary.

## **METHOD**

A mixed-method investigation was performed in this study, wherein lighting design students were involved in focus-group discussions and administered an internet-based questionnaire.

### ***Participants***

Altogether, 75 students were invited from a three-year lighting design program to respond to an internet-based questionnaire. Overall, 30 responses were collected, but due to a technical problem, only less than two-thirds of the responses were completed. Therefore, the response rate became 24% resulting in 18 participants ( $M_{age}=26.2$ ;  $SD_{age}=4.65$ ), out of which half of them were female. Due to the decreased number of valid responses in each schoolyear, the sampling was treated as one cohort instead.

The focus group interviews in total, included 13 students ( $M_{age}=26,8$ ;  $SD_{age}=4.39$ ) from which

year one and three had four students each, while year two had five students. Convenience sampling was employed for finding participants through teachers' personal contacts within the academic courses. Additionally, all of the focus group students contributed to the online questionnaire, measuring locus of control, and were rewarded for their participation with a lunch.

### ***Data Collection Instruments***

A quantitative survey on an individual's locus of control (Nowicki-Strickland, 1973) was completed online, and it consisted of 40 forced-choice category level (Yes, No) standardized items that were computed to a single value. The lower value on LOC  $\leq 10$  indicated a more external LOC, and a higher LOC indicated internally. In addition to this, demographic data (age, gender) and academic subject major were recorded together with a research consent for participation and publication of research results, ensuring an ethically conducted investigation.

The online survey also encountered experimental questions on how well-defined a recent experience group design exercise ( $APA_{rec}$ ) was and what would be the preferred level ( $APA_{pref}$ ) in the future. These ratings were indicated on a seven-point Likert-scale (1=More assignment oriented, 2=Assignment oriented, 3=Slightly assignment oriented, 4=Ambivalent, 5=Slightly problem-oriented, 6=Problem oriented, 7=More problem-oriented). The lowest value corresponds to a defined and assignment/task-based design exercise, which is characterized by tasks that are broken down in order to facilitate learning. Meanwhile, the highest value corresponds to an open and thus undefined design problem, which is not expressed in distinctive parts, but the aim is to develop and creative problem-solving approach without limiting self-reflection.

The focus group interviews were conducted using a protocol to ensure effective communication. The duration of each group interview was limited to 30 minutes. A semi-structured interview was applied, and the interview questions were organized according to Kolb's (1984) experiential learning styles. Questions targeted previous concrete learning experiences in group design exercises and perceived conflict and control during tasks; the questions on reflective observations entailed assignment- and problem-based exercises and issues of grading.

### ***Procedure***

Lighting design students in the bachelor program had responded to an email link for the Nowicki-Strickland (1973) questionnaire, including inquiries on demographic data and the research consent. This questionnaire was formed in Google Forms. After agreeing to the research consent, the participants could complete the entire questionnaire online. The three focus group interviews were conducted in a meeting room with four (and five) students and at least one researcher present at the time. The interviews were audio-recorded, then transcribed and analyzed following a content analysis technique on self-efficacy.

## Data Analysis

The scoring procedure of the Nowicki-Strickland questionnaire (1973) provided interval data and could be treated parametrically. The information on gender was gathered as nominal data while age as ratio and school year as the interval. Statistical analysis in each school year could not be performed. Instead, a graphical analysis was prepared; consequently, gender and age differences were not explored in this limited dataset. The plot-diagram depicting LOC and  $APA_{rec}$  measures was divided into quadrants and described as follows:

1. *Comfortable*: students are receiving external demands and support for completing an assignment/task-based exercise.
2. *Performative*: students are more internally driven, routine-oriented, and familiar with the demands that may be represented in the assignment/task-based exercise.
3. *Being lost*: when high LOC is combined with a more openly defined project, the students experience being lost in the labyrinth of possible project solutions
4. *Creative*: this is the most preferable position; it is a combination of internal LOC and capability of solving problems that appear rather undefined. Self-reflection and performative practice with minimal tutoring may result in a unique solution.

Finally, a content analysis of the transcribed interviews was performed using a deductive technique. The interview data was structured in one main domain, self-efficacy.

## RESULTS AND DISCUSSION

The aim of the study was to map the Lighting design students' ability for problem-solving approach in relation to their personal control in group design exercises for a sustainable change. The collected number of responses through the online questionnaire are summarized in Table 1. The LOC measures gradually decreased as the academic years progressed. This is a favorable trend when one of the purposes of the Lighting design education is to let the students take more control over their everyday activities and learning. In detail, students in the first two years find themselves more on the external LOC, while in the third year, they were more internally controlled. Regarding the assessment of the recent ( $APA_{rec}$ ) and preferred ( $APA_{pref}$ ) assignment-problem affinity measures, in each school year, the students would have liked a bit more defined projects than what they had experienced.

Table 1. Summary of results for the locus of control (LOC), the recent ( $APA_{rec}$ ), and the preferred ( $APA_{pref}$ ) assignment-problem affinity measures.

N	Year		LOC	$APA_{rec}$	$APA_{pref}$	Difference( $APA_{pref}-APA_{rec}$ )
4	1	Mean	11,75	4,75	4,00	-0,75
		SD	4,27	1,26	,82	
6	2	Mean	11,00	5,65	5,5	-0,15
		SD	2,89	,82	,54	
8	3	Mean	8,88	4,38	4,13	-0,25
		SD	3,91	1,51	1,26	
18	Total	Mean	10,22	4,89	4,55	-0,34
		SD	3,67	1,32	1,09	

Note:  $APA_{rec}$  and  $APA_{pref}$  were calculated on a 7-point Likert-scale (1=More assignment oriented, 2=Assignment oriented, 3=Slightly assignment oriented, 4=Ambivalent, 5=Slightly problem-oriented, 6=Problem oriented, 7=More problem-oriented)

The plot diagram shows all the students' responses (Figure 1) in each school year in terms of their LOC and  $APA_{rec}$  measures. The year clusters indicate that the development of the first two years is challenged by the third year's position. This can be explained by the fact that the Lighting design program was originally a two-year-long education, and the third year was added to complete the requirements for a Bachelor program. However, this program is portrayed as a creative one, and somehow it was only experienced by a few students according to this diagram. In terms of yearly development, the creativity quadrant is apparently lacking progression.

In contrast to this, the majority of respondents throughout the three years find themselves in a **being lost** position in which they would prefer more control/supervision/instruction when facing uncertainty in a problem-oriented project. It is an unfortunate combination in which individuals with external (high) LOC are not able to perform well.

The third quadrant (**performative**) is hardly visited by students. This quadrant should include students who gained enough knowledge and practical skills to execute larger projects alone or in groups. The internality in LOC refers to the ability of greater control, yet the assignment type of work would limit creativity. The lighting design program seems to avoid the performative quadrant for the second-year students.

Finally, the **comfortable** quadrant, which is described by external LOC (more teacher contacts and assignment type of problem-solving approach), is also barely activated. In this quadrant, only a third-year student went for the extreme, probably this student took a stand against the education progress after the first two years, namely, spending much time in the being lost zone.

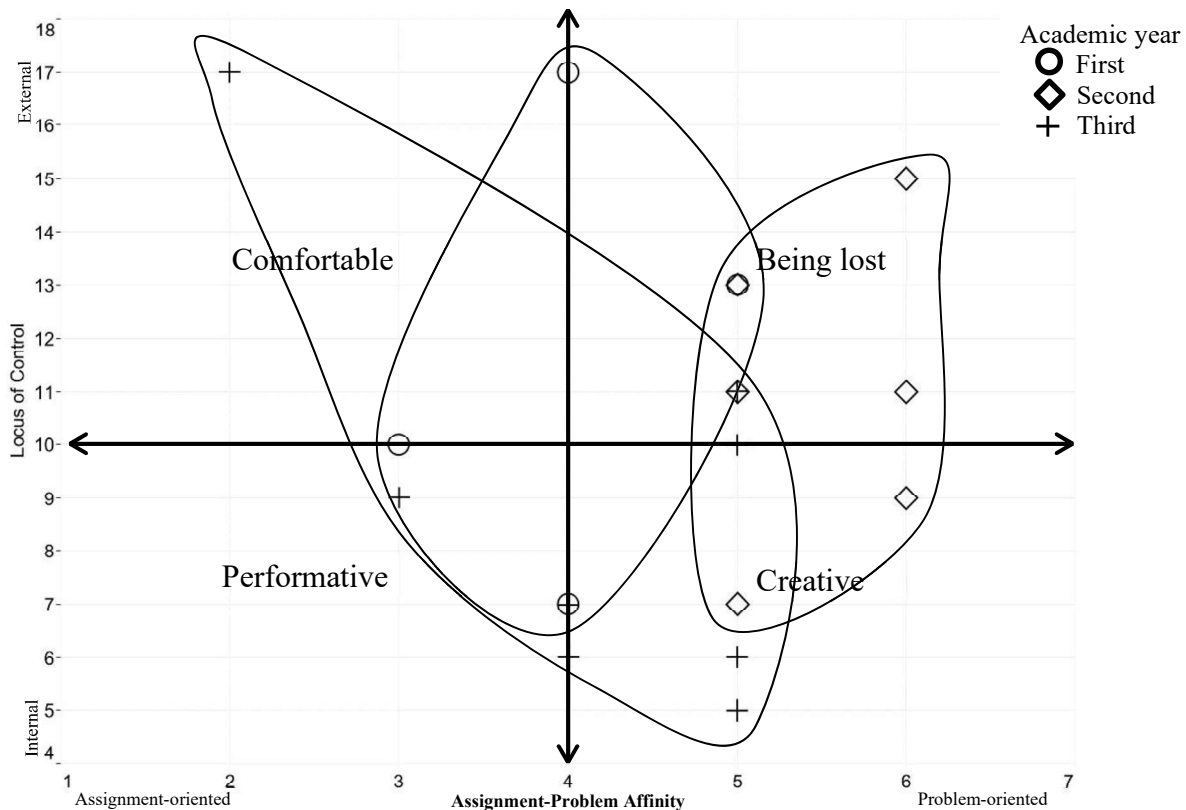


Figure 1. LOC positions with  $APA_{rec}$  for the corresponding student in different academic years

(N=18). Note: The LOC ambivalent position is located at the overall mean of LOC=10 (LOC<10 more internal, LOC>10 more external). The Assignment-Problem Affinity axis is on a neutral position due to its 7-point scale (1=More assignment oriented, 2=Assignment oriented, 3=Slightly assignment oriented, 4=Ambivalent, 5=Slightly problem-oriented, 6=Problem oriented, 7=More problem-oriented).

### Focus Group Results

All groups answered in a similar way to the direct question if they preferred **open** or **closed** projects – they all prefer both, but they all also mentioned that the frames for the project must support them. On the follow-up questions for students who regard open projects as pleasant, - the first- and third-year students were positive; however, the former expressed concern about being too free, while the latter was concerned with the high energy (W) requirements in the project.

Regarding **control**, the first-year students wish that project courses are characterized by freedom, responsibility, and joy. In contrast, the second-year students with clear feedback, continuous supervision, clear and consequent instructions. The third-year students combine this by wishing a free task, but with clear instructions on what documents and specification they shall hand in. **Personality** also interferes with the results. One can have a controlling personality and being a perfectionist. Still, the same person can be very creative and free in their project design; how the student looked on the term "control" therefore varied.

There are several factors, except for those created by **teachers**, that impact if a project is experienced as open or closed. A project can be formulated as open, but the students may interpret this differently. For example, first-year students can feel it being too open because it requires knowledge they have not yet acquired. The second-year students can feel a project, meant as open, being closed because they have to design their lighting according to existing lighting standards and regulations. The third-year students who are accustomed to the regulations can work with the freedom within these frameworks. However, there are other causes that may interfere. One of them is the type of project. In this study, the second-year students stand out. They were overall more negative about their project experience. There might be different causes for this: the progression and maturity, the character of their recent project, or a lack of clear teacher **instructions**. Their recent experience was a realistic outdoor project, initiated as a sharp, almost real project with the local municipality as a client with their **demands**. The second-year students all agreed upon that the limits given by the municipality gave them too little freedom, and to this, they also needed to follow normal lighting regulations.

Regarding **realism in projects**, the first-year students say it makes them feel less free. The second-year students say that the client's expectations and the site conditions made it less open. The third-year students did not complain about the realism in the project and its conditions. Instead, they complain about inappropriate feedback and communication from teachers. A student from the third-year comments the realistic project's conditions and the client's expectations:

"It felt hard to work with the wrong solution to the problem, because the problem was not bad lighting we should improve, by design. The problem was that we worked on a thing we knew wouldn't solve the problem fully."

The students from the third-year mention that if a project is open, the **project time** must be appropriate, open projects take more time. The second-year students, on the other hand, say that demands on students must be in relation to the **size of the project**.

From the quotations, there seems to be a clear progression, especially regarding **group dynamics** and how one relates to instructions and requirements. The students in the second year seem to wish for more **teacher control** than what the first-year students do and seem to have not as good of teaching experience as the others. This can depend on what kind of courses they recently have taken.

A student in the first year says:

"But one must still know, what do you want to deliver? What do you wish to achieve? What do you want this to result in? Otherwise, it will be very hard to put something together."

A sign of the progression and how students mature is indicated in this quotation from a third-year student:

"As you get further into the education, the more you start a project work with a plan."

The **power distribution** within a group can affect the perception of openness of a project. Especially in the first year, they talk a lot about the group constitution. It is natural since they do not know each other yet. Meanwhile, the third-year students focus their discussion on roles that are reflections of they know each other. There are also different culture and climate in each year. Some are more critical than others. Conflicts can ruin a project, but it can also



make a project more open (said by a first-year student). The progression of **roles in a group** is especially interesting since this mirrors the overall progression. In the first-year student's focus at fellowship, they mimic each other's work, and they compete. The second-year students emphasize everyone's responsibility. They talk about themselves as a dynamic group. They also state that roles affect the control they have in the project. Students from the third-year express that they often fall into the same kind of role, nevertheless which project or group. They say that the group leader has a large impact on the groups' feelings of control. The number of group members also came up; three persons were regarded as ideal to really create dynamics.

A third-year student:

"Group work has been easier the last years since you fall into it. You fall in a role, often the same. You know what you and others are good at.... If the roles shall be changed, someone needs to take the initiative to give up their "own" area."

Another third-year student:

"I experience that I have become better on that I already was good at, but I have not improved that I was not good at from the start."

A quotation from a second-year student regards group leadership:

"We need someone that just points with the whole hand when we can start producing."

A third-year student says:

"That will say, you have more control over an undefined task if you have a clear leader who decides in what directions one should work."

When it comes to **instructions**, the first-year students say that if they are unclear, it limits freedom. The second-year students talk about the need for a clear aim and scope of the task. They wish that the teacher clarified what that is expected from them and what they shall deliver. The third-year students reflect upon the project that crashed because of unclear teacher feedback.

A student in the first year got the question of what is the worst thing with an open project. He answered:

"The worst thing is probably that you may not always know what you should learn."

The **role of the teacher** is seen differently between the groups. The first-year students prioritize their support and say that students do not know what help they need. Conversely, the second year's students talk about a previous project failure by blaming the teacher's blurry instructions and inconsequent feedback. The third-year students point out that the teacher shall not be a sounding board, then it gets confusing. If the teachers give ideas, then the students think that must be correct. From this, we can see that students lack critical thinking from a constructive perspective. They are critical to the teachers, but they lack the ability to reflect on the situation from several viewpoints, like discussing their own role in this.

Regarding **feedback**, the first-years students wish for more teacher critique. The second-year group wishes for more consequent critique; the teacher shall not change what he/she says. Also, the third-year students say that teachers sometimes have given them critique they did not understand. There might be a discrepancy between what expectations students have on

teacher feedback, respectively, what teachers think students will need and understand during different stages in their progression.

## CONCLUSION

This study indicated that lighting design students' learning processes in group design exercises could be differentiated according to years of education. The analysis of each academic year revealed that the third-year education does not appear as a seamless development from the previous two years. Nevertheless, the third year's learning characteristics are preferable for an engineering education profile. This profile is described by creativity as a combination of internal control and problem-based approaches in group design exercises. Furthermore, the following themes should be addressed in the future for aligning the first two years for more organic development in group design exercises: *open/closed projects, control, the teacher's role, instructions, demands, realism in the projects, project size, project budget, project time, group dynamics, group size, group roles, leadership, personality, and conflicts*. Based on this investigation, and in order to successfully implement changes in an organization, Kotter's (1995), eight stages for change should be implemented. Due to the nature of the education, which consists of both artistic and engineering approaches, the sense of urgency can be established around a design process approach, which expresses the general participants' common interest, creating a common ground for shared understanding for a change. The second step is to form a powerful alignment across disciplines (design, engineering, lighting science) and create a vision for the new education, keeping in mind the deeper integration of the design process approach. By addressing the results of this study's qualitative investigations for the discrete organizational units, empowerment for the action of the vision can take place in which all participating organization unit can benefit. By introducing small rewards for teachers and students in the form of multidisciplinary design projects, all participants may benefit from the changes. These suggested design projects are positioned so that all should propagate internal control and enhancing self-efficacy within the problem-oriented design projects. Consequently, these small win-win design projects can reward everyone in the organization for continuing the change. When the pilot design projects are evaluated, and the credibility of the new approach is established within and outside of organization, the institution can articulate the connection between new behaviors and organizational success.

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## REFERENCES

- Asante, E., & Affum-Osei, E. (2019). Entrepreneurship as a career choice: The impact of locus of control on aspiring entrepreneurs' opportunity recognition. *Journal of Business Research*, 98, 227–235. <https://doi.org/10.1016/j.jbusres.2019.02.006>
- Boyce, P. R. (2017). Editorial: The divorce of the art and science of lighting. *Lighting Research and Technology*, 49, 671. <https://doi.org/10.1177/1477153517730725>

- Cuttle, C. K., 2011. Perceived adequacy of illumination: A new basis for lighting practice. In: Ritter, J (ed.), Proceedings from PLDC 3rd Global Lighting Design Convention. Madrid, 19-22 October 2011: VIA-Verlag.
- Crawley E. F., Malmqvist J., Östlund S., Brodeur D. R., Edström K. (2014). Rethinking Engineering Education: The CDIO Approach. 2nd ed. New York: Springer
- Edström, K. (2016). Aims of Engineering Education Research - The Role of the CDIO Initiative. In J. Björkqvist, K. Edström, R. J. Hugo, J. Kontio, J. Roslöf, R. Sellens, & S. Virtanen (Eds.), Proceedings of the 12th International CDIO Conference (pp. 974-985). Turku: Turku University of Applied Sciences.
- Fischl, G., Granath, K., Bremner, C. (2018). Mapping architectural engineering students' learning in group design exercises. . In Bean, C. Bennedsen, J. Edström, K. Hugo, R. Roslöf, J. Songer, R. Yamamoto, T. (Eds.), Proceedings from 14th International CDIO Conference, Kanazawa Institute of Technology, Kanazawa, Japan, June 28 - July 2, 2018
- Jang, J., Shin, H., Aum, H., Kim, M., & Kim, J. (2016). Application of experiential locus of control to understand users' judgments toward useful experience. Computers in Human Behavior, 54, 326–340. <https://doi.org/10.1016/j.chb.2015.08.010>
- Kolb, D (1984). Experiential learning. Englewood Cliffs, NJ: Prentice Hall
- Kotter, J. P. (1995). Leading change: Why transformation efforts fail. Harvard Business Review, March-April
- Nowicki, S. & Strickland, B. (1973). A locus of control scale for children. Journal of Consulting and Clinical Psychology, 40(1), 148-154.
- Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs (General & Applied), 80, 1-28.

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