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Enhancing job-readiness through short courses: A case study in power engineering

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Abstract

This paper proposes the development and delivery of a short course in collaboration between academia and the power system industry. This short course aims to provide hands-on training for students and early career power system engineers to become familiar with the software package - PSCAD™/EMTDC™. This extra-curricular skill development program benefits both students and industry professionals in the field of power engineering. By surveying the participants during the short course, the responses are analyzed to identify the need for short course programs and the effectiveness of such training programs in expanding the knowledge base and upskilling power systems engineers in modeling and simulation. The survey includes both Likert scale questions (quantitative) and open-ended questions (qualitative), which are analyzed using a mixed-method approach. Additionally, the responses from the industry professionals are compared with the ones from the students to investigate the difference between various target groups. The results show that 1) Simulation practice and studies improve participants' competence not only in the use of the software package but also in the associated knowledge in the field systematically, e.g., power system modeling and analysis. 2) The industry collaboration brings insights and project experiences in an authentic context, which is greatly appreciated by the participants, especially those from the industry. 3) Hybrid delivery provides greater flexibility for participants, and the perceptions of in-person and online participants are not statistically different due to the extensive and dedicated online support.

Keywords—short course, industry-based learning, power engineering education, renewable energy integration.

1. Introduction

Australia is one of the leading countries in deploying renewable energy integration and achieving a net zero emissions goal by 2050. The Australian energy system is undergoing a fast transition due to the expanding renewable energy integration. The transition relies heavily on the highly skilled workforce to facilitate the goal of 100% renewables. Therefore, it is of great importance to scaffold the substantial increase in the skilled labor demand by developing curriculum and training programs in the relevant fields, e.g., refined power engineering programs in higher education institutions. The reconciliation between the educational initiatives in energy systems and the ongoing transformation in the energy sector can result in sustainable development for future energy infrastructure in a long run. To this end, universities need to collaborate with industry and incorporate industrial input as the basis of the curriculum renewal, so that the mismatch between graduates' competency and evolving industry expectations can be eliminated [1, 2]. In the contemporary energy job market, performing grid connection studies using industry software packages is one of the greatly appreciated skills for power engineering students to get employed in energy job markets. However, such a skill is not appropriately integrated into the existing curriculum due to limited timeframe, resources, and accreditation concerns, leading to a mismatch between what is being taught and what is demanded in the energy sector.

The emergence of Industry 4.0 has led to the development of a more sustainable future workforce through collaboration between academia and industry, aimed at producing skilled engineers. Industry representatives and employers can bring insightful ideas and authentic demand into the educational context and the courses and training offered can be more practical to meet the evolving industry needs. As a result, the shortage of qualified professionals can be addressed by introducing a refined curriculum framework. However, developing a new course is time-consuming and resource-intensive due to several considerations, for example, the accreditation issues. Therefore, delivering short courses and micro-credentials becomes a more efficient way to upskill both students and engineers who wish to acquire knowledge and skills within a limited time frame.

The paper tends to address the following research questions:

- RQ1: Is university-industry collaboration an effective strategy to initiate a short course delivery?
- RQ2: Can short courses effectively complement the curriculum framework of power engineering?

This paper presents the design and deliver of an extra-curricular short course program which introduces an industry software package and outlines the perceptions of the participants. The paper is structured as follows: Section 2 (Literature Review) gives a review of university-industry collaboration in curriculum development and discusses how short courses can be developed in an engineering discipline. The description of the short course program is detailed in Section 3 (Short Course Program). Section 4 (Data collection) presents the data collection method and the instrument. Analysis of the data is performed in Section 5 (Results and Discussion). Conclusions and recommendations are drawn in the final section (Conclusion and Future Work).

2. Literature Review

In engineering education, stakeholders, including students, academics, and industry, ought to be involved as their participation can contribute to the curriculum framework from various perspectives. The extensive collaboration among these stakeholders is expected to achieve a strategic alignment for curriculum development, as shown in Figure 1. Most of the overlapping between the stakeholders are bidirectional, but some are implicitly omnidirectional due to the nature of the collaboration. For example, institutions may rely on industry advisory boards to keep their curriculum and program up to date [3]. However, [4] argued that the industry board may not be able to track the course content and assessments promptly. Furthermore, the connection between the academics and board members is not as close as expected due to the limited support and resources.

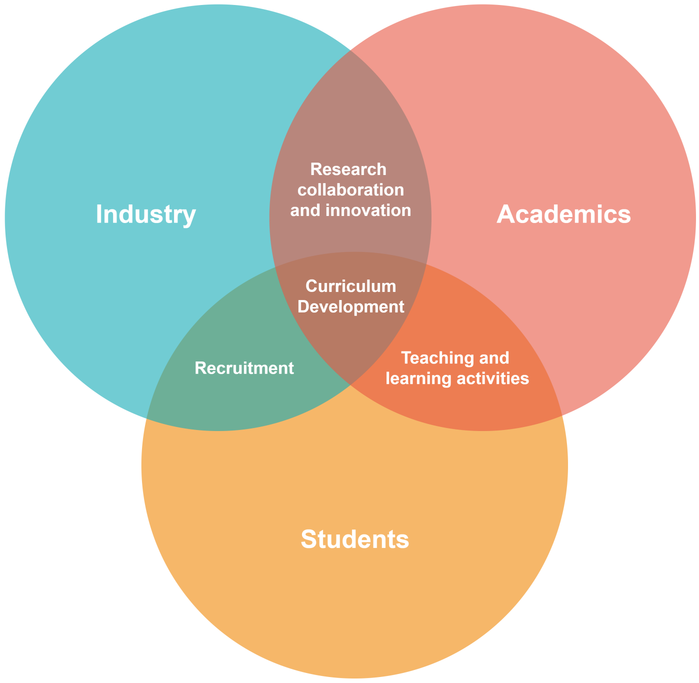


Figure 1. Stakeholders involved in engineering curriculum renewal.

University-industry collaboration has been highly regarded as a key factor in enhancing the quality of engineering education, which can create a mutually beneficial partnership that helps to improve and address the workforce shortage in the industry. The most common forms of university-industry collaboration seen in the literature involve collaborative research and development (R&D) projects, human resources transfer, curriculum design, etc.

University-industry collaboration in R&D has seen a long history of success, as it benefits all parties involved, as well as the whole society in general. According to [5], the potential benefits of university-industry collaboration can be classified into four categories: strategic, operational, economic, and social. These benefits are interrelated and can be influenced by various factors. The most commonly reported factors associated with these benefits are inter-relational, technical and scientific, and strategic. This highlights the importance of effective communication and collaboration between universities and industry partners to achieve these benefits.

[5] and [6] looked at the university-industry relationship at the research level. Literature reviews identified the R&D intensity and size as one the key factors in university-industry collaboration. Leading companies with wide-ranging R&D need to benefit from the knowledge produced at universities, hence increasing research productivity. On the other hand, a university with higher R&D productivity attracts more collaboration from the industry. Also, companies directly hiring researchers from universities bridge the gap that may exist between academic research and their employees. Moreover, highly technical sectors are more likely to establish collaboration with the university, such as, pharmaceuticals, instrumentation, and IT. [7] conducted a case study on university-industry collaborative research projects in Portugal, using interviews and documentary analysis. Results showed that researchers regarded university-industry cooperation highly, as the success of the collaborative research is crucial for their own research. Additionally, researchers were highly motivated to engage with industry, even though the collaboration was insufficient to assess individual academic performance. Often, academics with the highest qualifications and greatest scientific productivity were most prone to engage in bidirectional interaction and pursue collaborative research projects.

University-industry collaboration through research projects strengthens the long-term partnerships between the two parties but they involve limited number of students. While most of the university-industry collaboration happens among researchers, there is a growing trend of universities inviting industry panels to participate in curriculum design to make the collaboration more impactful for students. [8] explored the program advisory boards (PAB) for engineering degrees through interviews with heads of programs at one technical university in Sweden. Although the main expectations of this type of university-industry collaboration are on planning, content, implementation, and assessment, programs expressed varying opinions about the contribution PAB brought. The needs, wishes, and suggestions of the industry are considered, however, the extent of collaboration was confined by university regulations and quality assurance systems. [9] took a deep dive into the renewable energy industry in the EU and Latin America, and conducted surveys and analyses on the industry needs of future engineers, including the type of engineering activity, knowledge base, and qualification. As a part of "The Crux" project, this survey and analysis served as a foundation for the energy engineering curriculum improvements at universities in Latin America and Europe. While this survey acted as preliminary research of the curriculum improvement project, no data on the detailed courses and structure was collected, nor effectiveness study was conducted.

Mears and Omar's case study presented a new Automotive Engineering curriculum at Clemson University utilizing a detailed survey of the industry needs [10]. This study identified the need to renew the curriculum based on the automotive industry transition and growth, as intelligent applications, digital technologies, and human factors have come into the manufacturing process. Thus, a survey of major employers and suppliers was conducted. Apart from the curriculum development input, industry participation also penetrated the curriculum in the following aspects: Technical emphasis (track course), business emphasis, practical experience (plant tours, internships, guest speaking), and R&D (parallel research). Overall, the renewed Automotive Engineering graduate curriculum incorporated more practical aspects of exposure, and intelligent tools that are used by the industry are included in the curriculum. However, again, no data was collected on the effectiveness of the renewed curriculum design. Mikami, Koji et al. have designed a game production curriculum at the Tokyo University of Technology in collaboration with Japan's iconic game industry [11], where new courses, combined lectures, and exercises across the whole value chain were added in game development - planning, programming, CG, graphics, and sound. The industry was involved in both course curricula (technical staff in laboratories, special lectures) and research. Class evaluation was conducted through a questionnaire, where game-related classes were highly rated by more than 400 students. The project work was demonstrated through students' participation in the Global Game Jam. This collaboration was considered an effective way of cultivating human resources for the industry, however, practical issues were identified around "core exercise", employment, the gap in research thesis and expected results, middleware, and the effectiveness of the curriculum was still left unchecked. [12] adopted the Plan-Do-Study-Act (PDSA) cycle model and designed the 2-year Master of Manufacturing Engineering program. The model proposed multiple workshops that allow the industry to help plan and adjust the program structure and tailor the content to meet the industry's needs. The industry were also involved throughout the curriculum via guest lectures, internship, co-supervision of thesis, study visits, and digital/physical resources. The method introduced in the paper was found to be an effective method to lower the gap between university education and industrial needs. However, the industry partners have seen more engagement in specific courses, rather than at the program level. One potential reason is that industry representatives might have more expertise in specific courses than other disciplines in the program.

All of the curriculum design examples include guest lectures as part of the university-industry collaboration. Hoek et al. examined the hands-on experience of guest lectures and academics [13]. The two main challenges identified around the implementation of guest lecture are effectiveness, and recruitment and retention. Effective use of guest lectures ensures students appreciate the relevance and importance of a guest lecture and has explicit links to the learning outcomes and assessment. Recruitment and retention issue follows closely with the effectiveness, to which tips and suggestions are provided. Guest lecture incorporates insights from the industry into the university curriculum, and all body of stakeholders - faculty, the guest speaker, and their host organizations and students - can benefit from it. However, practical issues and the challenges raised still prevail. Overall, guest lecture can engage more students and bring industry awareness into the course as a valuable addition, which is commonly used in engineering courses [14]. But it is unlikely to cover the topic in-depth as the time is constrained to 1-3 hours, and there is limited opportunity for students to follow up with the speaker for continuous engagement.

The collaboration opportunities in short courses have drawn the growing attention of educators and is becoming an increasingly popular choice for both students professionals. Short courses help both university students and seasoned engineers to be more competent in the job market. Those who participate in short course programs can gain quick access to the course content and explore the topics of their interest to bridge a knowledge and skill gap based on their specific needs. Short courses provide flexibility in time and learning format along with the enhancement of professional skills [15]. While short courses are not usually credited to university students, they can be regarded as a complementary component of the curriculum. Table I shows the comparison between accredited university courses and short courses, highlighting the key differences between the two types of courses.

Table I. Comparison between accredited university courses and short courses.

	Accredited university courses	**Short courses**
Assessment	Formative or summative	Not necessary
Length of the course	Depending on the teaching period of a term (several months or a year)	A couple of days to weeks
Content (Depth of study)	Structed course content and learning outcomes	Focus on one topic of interest
Cost	High	More affordable
Entry Requirement	Prerequisites required	Flexible/No prerequisites
Credential	Resulting in a degree/diploma on completion	Offering a certificate/statement of completion
Rigor	More rigorous and demanding	Designed to be delivered in a shorter period of time

3. Short Course Program

The short course developed in an Australian university on "Grid Integration of Renewables using PSCAD" is a 5-day training program, which involves the hands-on practice of PSCAD, a brief introduction to the Australian National Energy Rules (NER) and performing a grid-connection study using a solar farm model. The short course has been run for two iterations in 2022. The first iteration was in-person only, while the second iteration provided both in-person and online options.

3.1. Why PSCAD and NER?

PSCAD/EMTDC (in short "PSCAD"), is the industry standard for power system electromagnetic transient simulations. This is the preferred software used by Network Service Providers (NSPs) in the National Electricity Market (NEM) for grid integration studies. By investigating the job descriptions of 108 job advertisements for power system-related positions, proficiency in simulation software packages such as PSCAD and PSS/E was repeatedly listed as one of the most important technical skills required. Power system engineers are expected to have skills in power system studies and software analysis using industry-standard software packages, making this course ideal for individuals seeking a career in this field. The course may also be of interest to power system consultancy firms, and students from other universities may be interested in enrolling as it is not currently offered as part of any accredited power engineering course at Australian universities.

When performing renewable integration analysis, electromagnetic transient (EMT) models are created using PSCAD, while connection studies are conducted using PSS/E software. Model compatibility with Australian Energy Market Operator (AEMO) should be verified before a connection application is submitted. AEMO, the governing body, is upgrading its PSCAD modeling capability and transitioning from PSCAD V4 to PSCAD V5 with extensive industry support. Power systems students who acquire skills in using PSCAD V5 will be highly job ready in the energy sector, as it offers advantages such as increased modeling efficiency and cost reduction, improved simulation time, and improved IT supportability.

Moreover, the use of PSCAD and PSS/E software is also emphasized in the interviews with industry experts in the Australian energy sector. The following quotations from the interview transcripts highlight how crucial it is for power system engineers to be proficient in conducting grid connection studies using software simulation. Ideally, students who look to pursue a career in energy systems could possess a basic understanding of power system theories as well as basic simulation/modeling skills before graduating.

*"...power system engineers should know three software packages as far as I know, one is PSS/E, the second one is **PSCAD**, and the third one is DIgSILENT PowerFactory …."*

*"…a set of studies and analysis needs to be completed for grid connection…we use software tools such as PSS/E, **PSCAD** and to a lesser extent DIgSILENT PowerFactory"*

*"…when you start working in the power system industry, the first thing is to learn how to use PSS/E and **PSCAD**… apart from the strong knowledge background, the most important step before performing grid connection simulation is to learn PSS/E and PSCAD, and then, how to interpret the simulation results…"*

On top of the simulation skills, the analysis of job advertisements in energy job markets also suggests that knowledge of the national electricity rules (NER) is another highly valued attribute for power systems positions. However, grid code and NER are not properly integrated into the power engineering curriculum. Power system engineers are supposed to analyze and validate the system performance in accordance with NER clauses. Due to the limited time and overwhelming workload of the existing courses, it is challenging to embed the NER contents into the courses. Many industry experts highlight the significance of knowing NER for power system studies as below.

*"...it is helpful if they had some background knowledge of the national electricity rules (NER) because the integration of new generators needs to be compliant with the NER. Specifically, section 5.2.5 of the **NER**...if the curriculum aligns to background on it, this will give the students a better understanding of how the project is assessed in the energy sector, and the compliances need to be proven…"*

*"…if the students are given an insight into the **NER**, that would be useful…"*

*"…there was an introduction to the national electricity market organized by AEMO, which do help me start my power system career, and I think most of the graduate or junior engineers in the energy systems industry should participate in such courses before they work.…provide a brief **overview of what NER is and how it can be applied**…"*

3.2. Course description

The short course is intended to provide a basic knowledge of PSCAD and its application in grid integration studies for renewables. Participants learn to build and analyze different power system models including a grid-connected voltage source converter (VSC) in PSCAD, which then progresses into introducing and investigating applications of PSCAD to validate the various NER clauses found within AEMO connection application checklist for grid integration. Considering the significance of using PSCAD and understanding NER, this overview of AEMO guidelines and NSP requirements along with the PSCAD practice will help prepare participants for their employment in this space. The course aims to equip participants with essential knowledge in PSCAD to analyze power systems, both under steady state and dynamic conditions. After successful completion of the course, participants should be able to,

- model and analyze a simple power system network using PSCAD,

- demonstrate power system control aspects for Single machine infinite bus (SMIB) system, and
- apply the AEMO and NSP requirements to system analysis.

3.3. Program schedule

This course consists of 6 hours of interactive laboratories with lectures embedded per day. Lectures are deliberately integrated with the laboratory sessions to provide participants with the opportunity to recap the basic knowledge of power systems and apply the content delivered in the lectures in simulation analysis. Lecture materials are interleaved with practical lab exercises so that participants can have hands-on experience in the topics discussed. A detailed description of the short course schedule can be seen in Table I. The course schedule is updated in the second iteration of the course, which is refined according to the participants' feedback in the first iteration.

Table II. Detailed program schedule.

Day #	**Content**		**Institution in-charge**	
	1	**2**	**1**	**2**
1	• PSCAD introduction • Power system component modeling • Power system analysis using a Single Machine Infinite Bus (SMIB) model	• PSCAD introduction • Power system component modeling • SMIB • Transmission line modeling • Network model and analysis	U[1]	U
2	• Integrating a VSC into the grid • Active power control for VSC • DC voltage control • Case study: Islanded microgrid with DGs and ESS • Python Automation	• Network model and analysis (contd…) • Introduction to VSC integration • Active power control for VSC • DC voltage control	U	U
3	• NEM network • Generator unit response to frequency disturbance • Frequency control • Active power control	• Solar farm modeling • Power plant controller • SCR • Model validation of solar farm	I[2]	U
4	• Reactive power capability • Generator system response to voltage disturbance (voltage ride-through) • Setpoint change test in different control modes • Voltage, reactive power, and power factor control	• NEM network • Generator unit response to frequency disturbance Reactive power capability • Active & Reactive power (frequency and voltage) control	I	I
5	• Generator system responses to disturbances following contingency events • Impact on network capability	• Setpoint change test in different control modes • Generator system responses to disturbances following contingency events • Impact on network capability	I	I

[1] U: University [2] I: Industry

3.4. Expected outcomes

From the knowledge and skills perspective, the participants are expected to gain the fundamentals of using PSCAD and NER clauses in grid-connection studies. Similar to any other software, proficiency can only be achieved through prolonged practice. Therefore, it is not realistic to expect participants to become experts in the use of PSCAD software by the end of this course. The soon-to-be graduates (i.e., students who are approaching the end of the undergraduate and postgraduate program), who will be potentially employed in the energy sector, can enhance their technical skills and knowledge base after completing the training. Their awareness of the power system industry can be raised through lectures, hands-on practices, as well as exposure to real-world projects in the energy sector. Professionals who have been working in the electric power industry may also benefit from the course by adapting their focus to comply with the up-to-date industry trend.

4. Data Collection

4.1. Participants

For the first run, 32 participants attended the short course. Specifically, the participants consist of 18 students and 14 external trainees who are working in the electric power industry. For the subsequent run, 24 participants attended the short course either in-person or online. A summary of the participants is listed in Table II.

Table III. Participant information.

<table>
<tr><td colspan="5">First Run</td></tr>
<tr><td rowspan="3">In-person</td><td rowspan="3">32</td><td rowspan="2">Student</td><td>UG[1]</td><td>3</td></tr>
<tr><td>PG[2]</td><td>15</td></tr>
<tr><td colspan="2">Domestic Industry</td><td>14</td></tr>
<tr><td colspan="5">Second Run</td></tr>
<tr><td rowspan="4">In-person</td><td rowspan="4">11</td><td rowspan="2">Student</td><td>UG</td><td>1</td></tr>
<tr><td>PG</td><td>3</td></tr>
<tr><td colspan="2">Domestic Industry</td><td>6</td></tr>
<tr><td colspan="2">University Academic</td><td>1</td></tr>
<tr><td rowspan="3">Online</td><td rowspan="3">13</td><td colspan="2">Student (PG)</td><td>2</td></tr>
<tr><td colspan="2">Domestic industry</td><td>8</td></tr>
<tr><td colspan="2">Overseas (Industry)</td><td>3</td></tr>
</table>

[1] UG: Undergraduate student [2] PG: Postgraduate student

4.2. Survey instrument

Given that the pattern of the participants was changed from students-dominated to industry-dominated, the survey questions and the timeline for running the survey are different between the first and second rounds as described in Figure 2.

1) Pre-training Survey (First round only)

In the first run, a pre-training survey was sent to the registered participants one week before the short course. The response rate of the pre-training survey is 100 %. The survey aims to understand the following aspects:

- The training needs of the participants
- The expectation of the participants
- The level of knowledge base and technical skills of the participants before the short course

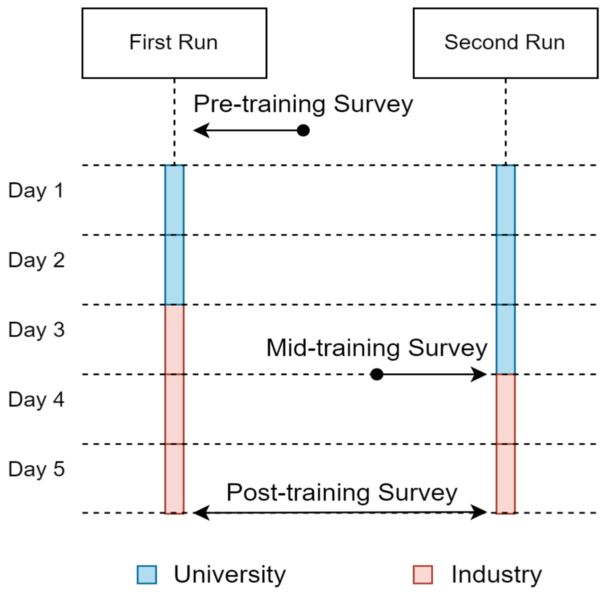


Figure 2. Timeline of survey dissemination.

2) Mid-training survey (Second round only)

For the second iteration, the timeline for survey dissemination is revised as shown in Figure 2. A mid-training survey was run immediately after completing the initial three-day hands-on training sessions led by the university academic. The survey intends to assess the efficacy of the first segment of the short course. Specifically, it investigates the effectiveness of the first part of the course (hands-on training of PSCAD) and discerns any discrepancies in feedback between in-person and online participants. The revised timeline ensures the feedback remains impartial from the second part of the course.

3) Post-training Survey (Both first and second rounds)

The post-training survey was disseminated among the participants at the end of the short course. The response rate of the post-training survey is 87.5 % (28 out of 32) in the first round and 70.8% (17 out of 24) in the second round. The survey aims to understand the following aspects:

- Overall experience in the short course
- How does this short course benefit the participants' future careers?
- The level of knowledge base and technical skills of the participants after the short course
- What is the most helpful part of the short course from the trainee's perspective?
- How would this short course program be improved?

5. Results and Discussion

5.1. Short course design, structure, and delivery

In the first iteration of the short course, notably, the rating for hands-on PSCAD training (Day 1-2) is higher among students than among industry participants, whereas for the NER assessment of industrial application experiments (Day 3-5), the rating among industry participants is higher than that among students, as can be seen from Figure 3. The higher score among students for the first two days might be related to the software learning skill of students explained above. The lower score among students for the last three days could be a reflection of the knowledge gap. A detailed demonstration of the potential knowledge gap is discussed in section 5.4.

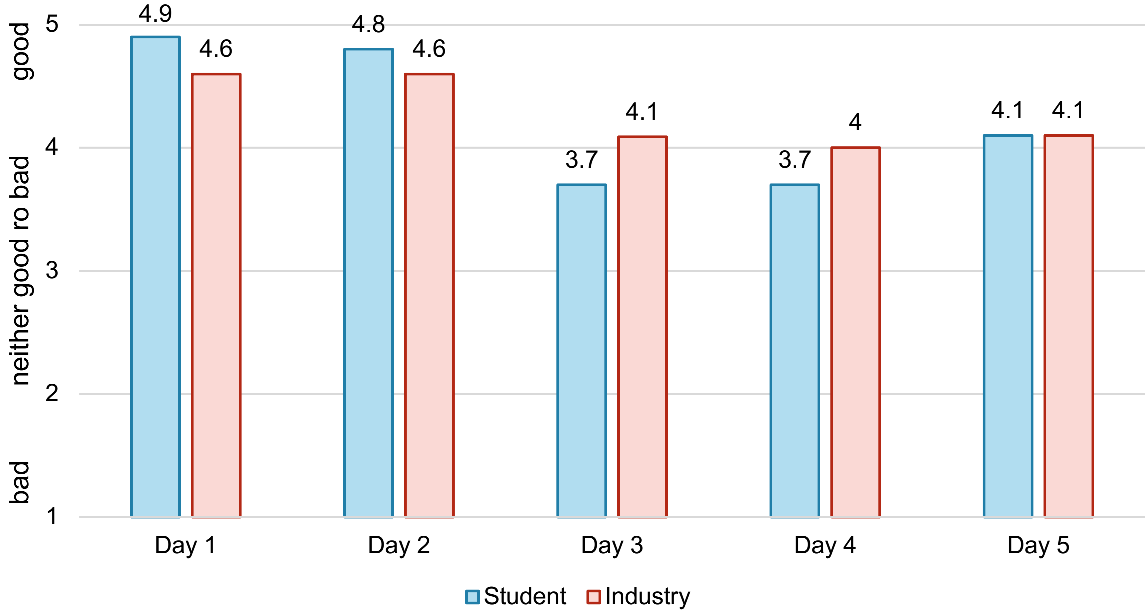


Figure 3. Rating of each day from students and industry.

Because of this significant knowledge gap that's affecting the learning experience of days 3-5 (industrial application experiment), in version 2 of this short course, a change in timeline is applied to the short course structure, as described in section 4.2. Comparing the rating results of each day between versions 1 & 2 in Figure 4, it is clear that the rating for days involving industry application experience has risen, showing a tangible improvement in the learning experience. This can also be seen in the answer to the question regarding the course design, structure, and delivery, illustrated in Figure 4. The participants were asked to rate on a scale of 1-5 (1: Bad, 5: Good) for the following questions:

Q1: How well was the training structured?

Q2: Did the training meet your expectation?

Q3: Were the contents well organized and easy to follow?

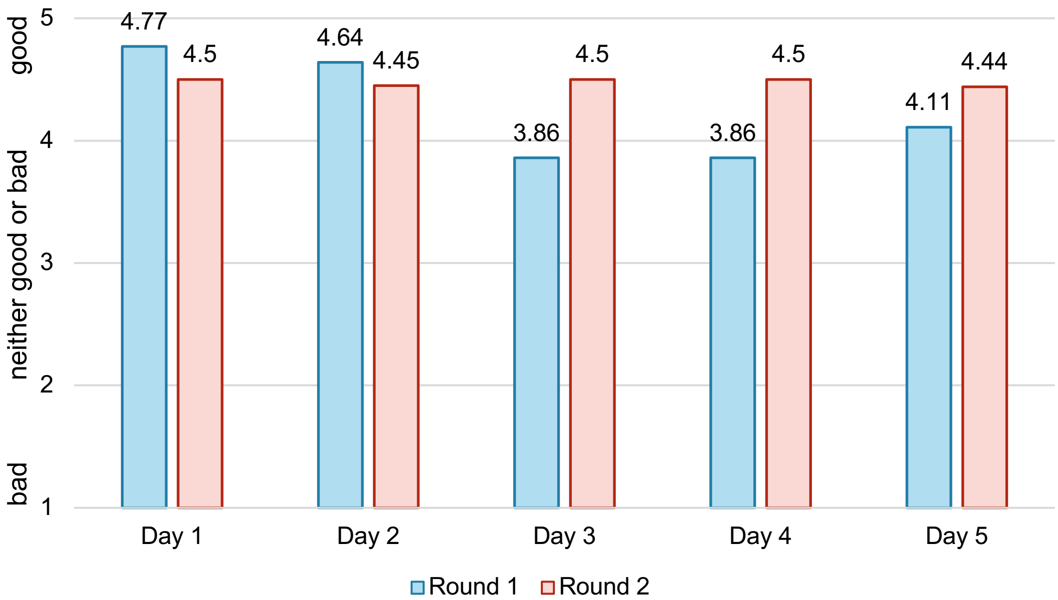


Figure 4. Comparison of rating mean value for each day of the training.

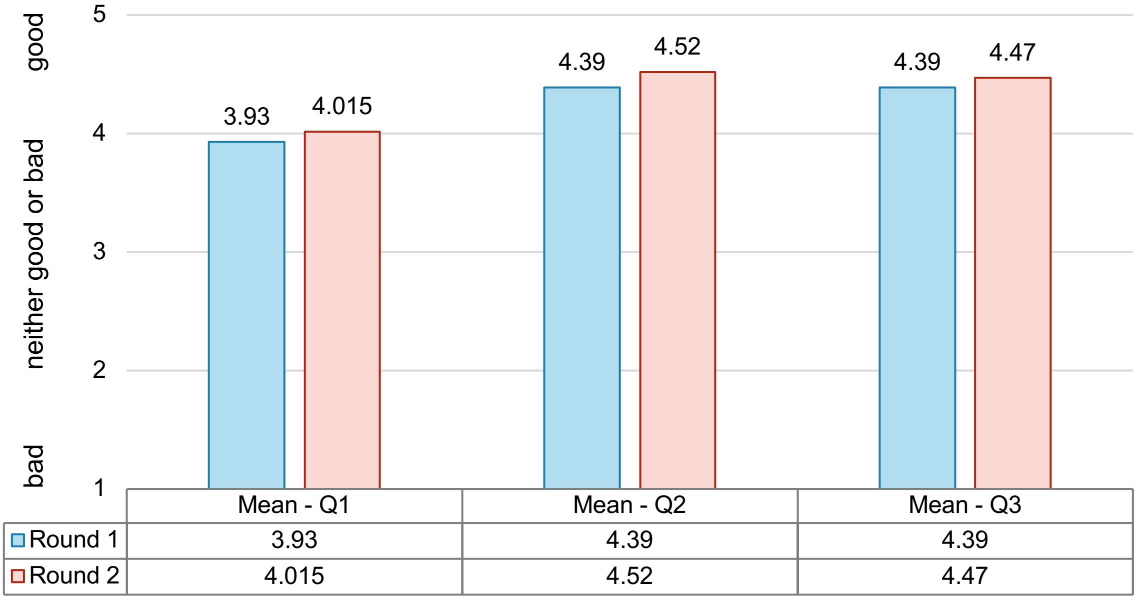


Figure 5. The mean values to questions related to short course design, structure, and delivery.

Overall, both students and industry participants reviewed the course as structured "very well" (3.9 on a scale of 1-5). However, 35% of students, as well as 27% of industry participants found the content might not be easy to follow. This might contribute to the lower rating for the last three days or explain the lower rating among students.

For the duration of the course, while 50% of all participants are satisfied with a week-long short course, more than half of the students would prefer a longer course, whereas some industry participants did report that they would prefer a shorter option (1-3 days)

Additionally, the rating from participants attending the course in person is higher than their online counterparts (Figure 6), especially in the later part where the industrial application experiment is introduced. This not only shows the preference for the in-person course after COVID [16, 17] but also the genuine value added to the course delivery by the interaction with industry professionals.

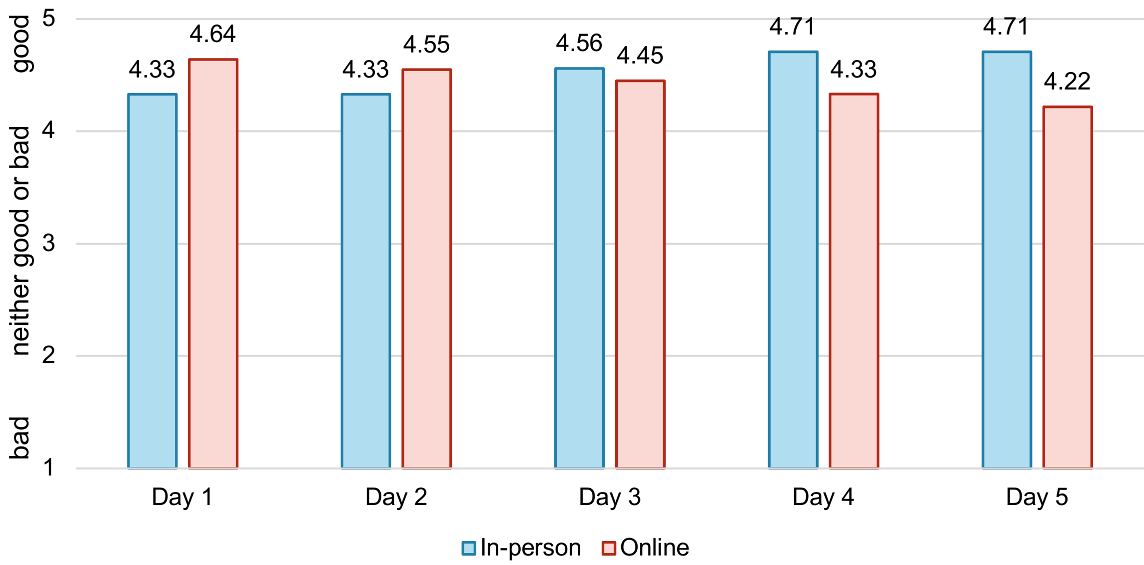


Figure 6. Comparison of a rating between the in-person stream and online stream.

5.2. Contribution to the existing knowledge base and technical skills

In the first iteration, participants were asked to self-evaluate their level of the required knowledge before and after the short course in the pre- and post-training surveys. Participants can rate themselves on five levels including “Excellent” (5), “Good” (4), “Average” (3), “Fair” (2), and “Poor” (1). Descriptive analysis and paired sample comparison are performed to identify if the improvement of the knowledge base and skills is statistically significant. It can be seen in Table IV, the response of the student group and industry participants group are significantly different across almost all the categories, including power system modeling, power system analysis, power electronics, power system control, grid synchronization, NEM/NER, and PSCAD. The only categories without statistically different results between the two subgroups are Programming, PSS/E, and DIgSILENT PowerFactory, which are not the main focus of the short course.

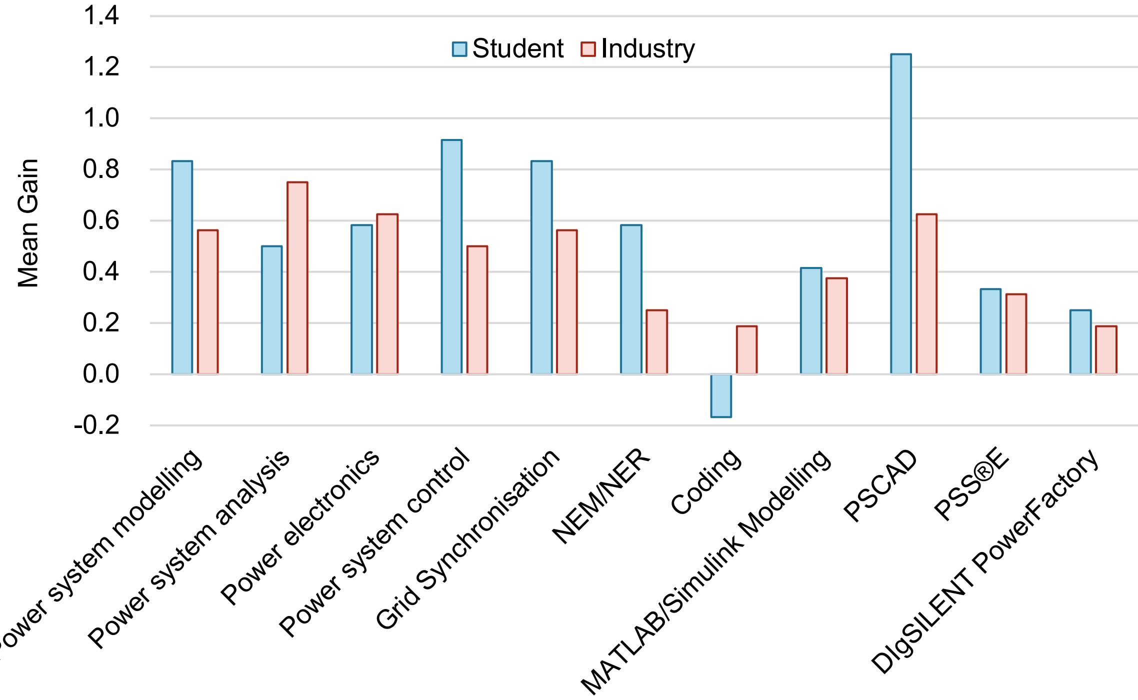
Table IV. Comparison of the level of knowledge and skills before and after the short course.

No.	**Statement**	**Descriptive Analysis**						**Paired Sample Comparison**		
		Student			***Industry Participants***			*Mean Gain*	*Std. Deviation*	*Sig.*
		Pre	*Post*	*Mean Gain*	*Pre*	*Post*	*Mean Gain*			
1	Power system modeling	2.9	3.6	0.7	2.9	3.5	0.5	0.679	0.945	0.001*
2	Power system analysis	3.1	3.5	0.5	3.2	3.9	0.7	0.643	1.096	0.004*
3	Power electronics	2.9	3.6	0.7	2.8	3.4	0.6	0.607	1.031	0.004*
4	Power system control	2.6	3.4	0.8	2.9	3.5	0.7	0.679	0.905	0.000*
5	Grid Synchronization	2.2	2.9	0.7	2.5	3.3	0.8	0.679	0.945	0.001*
6	NEM/NER	2.5	3.1	0.5	3.3	3.4	0.1	0.393	0.737	0.009*
7	Programming	3.2	3.1	-0.1	2.8	2.9	0.2	0.036	0.793	0.813
9	PSCAD	1.7	2.8	1.1	1.9	2.5	0.6	0.893	0.916	0.000*
10	PSS/E	1.5	1.8	0.3	1.7	1.9	0.2	0.321	0.905	0.071
11	DIgSILENT PowerFactory	1.4	1.6	0.2	1.9	2.0	0.1	0.214	0.630	0.083

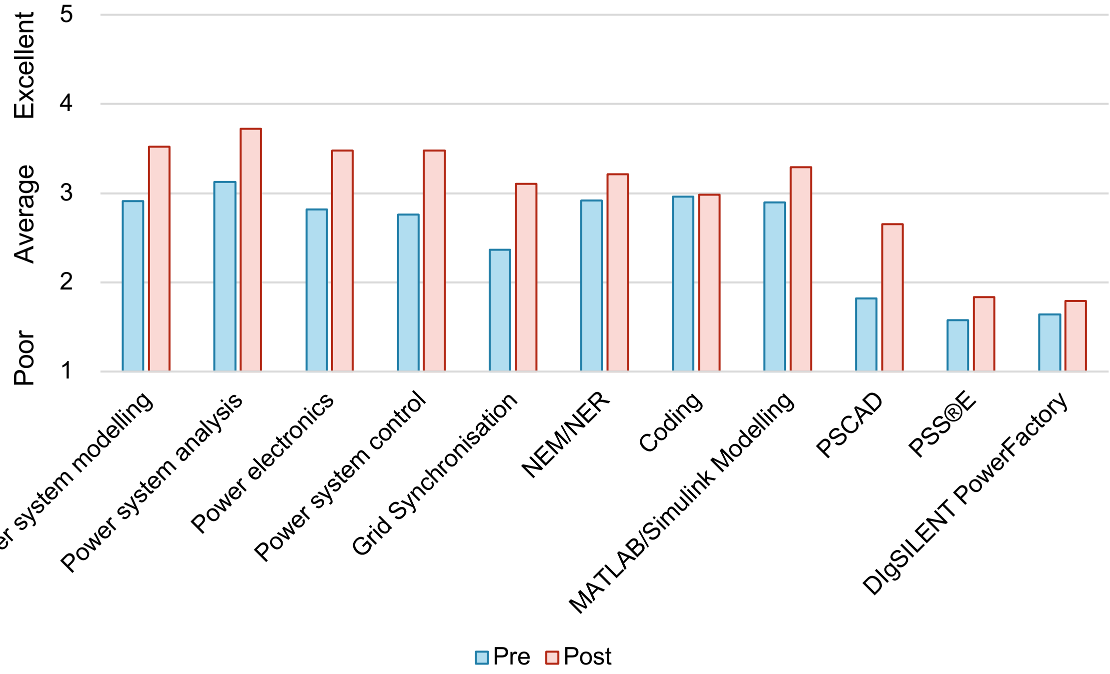
* $p<0.05$ indicates the difference is statistically significant.

To further investigate the differences between subgroups (i.e., students and industry participants), a comparative analysis is conducted. As can be seen in Figure 7(a), the mean gain for students is higher than industry participants in every category, except for power system analysis and coding.

It can be seen from the figure that students benefit more from the “NEM/NER” component of the course compared to industry participants. This could be because the students were not adequately exposed to the content in the existing curriculum, resulting in a less comprehensive understanding of the National Electricity Market (NEM) and National Electricity Rules (NER) before taking the course, while the industry participants, who have more professional experience in the power industry, may have already been familiar with them given that they had more opportunities to work with these standards and clauses in practical applications.



(a)



(b)

Figure 7. Comparison between (a) students and industry participants (b) pre- and post-training evaluation.

In terms of technical skills, students gained more in "PSCAD" than industry participants, both starting at a lower score and ending at a higher score. Starting at lower is understandable, 59% of the students rated themself "poor" at PSCAD prior to the training, they might have never worked with PSCAD before due to the prevalence of MATLAB/Simulink or other software in the university curriculum, while 56% of the industry participants have at least "fair" knowledge of PSCAD.

Interestingly, students also landed a higher score for PSCAD post-training. This might be related to the similarities in the graphic extension of MATLAB Simulink and PSCAD. Given that MATLAB/Simulink is actively integrated into the curriculum, students may have found it easier to learn PSCAD.

Although our course has focused on PSCAD, both students and industrial participants rated themself higher in PSS/E knowledge. This is because we introduced PSS/E along with PSCAD, including their similarities, and differences, during the introduction, and during the modeling and simulation process. The industrial practice of integrating both PSS/E and PSCAD was mentioned quite a few times with examples.

While both students and industry participant groups have seen growth in knowledge of all the other categories, students' mean rating for coding has seen negative growth. This might be caused by a misunderstanding of the category "coding". Prior to the training, students have MATLAB or C++ coding embedded in their curriculum, so it is reasonable that they rate coding skills "average" to "high". However, in industry practices, Python, instead of MATLAB, is mostly used to automate the simulation process of PSCAD. Through this course, the students realized the gap between the skills taught in university and the skills required by the industry, thus, their ratings dropped. In fact, 30% of students rated a lower mark in coding after the training. The reduction in rating among industry participants is not as significant as that of students, however, several participants have rated themself down in more categories than others. This might be the knowledge gap between different roles in the energy industry. Professionals working in solar farms or microgrid design might not have the same knowledge background for grid integration of renewable energy [18].

Considering the results presented rely on the participants' self-evaluation, it is fairly likely that the participants may underestimate or overestimate the level in some of the knowledge/skill items. 57% of participants downrated one or more items after the training. However, the growing trend shown in mean value across most of the categories indicates that the knowledge base and skill set of the participants were effectively improved through the training.

5.3. Impact on software simulation skills

Since industry participants might have more training resources in the workplace, 91% of the participants said their expertise in PSCAD is likely to move from beginner to advance level after the short course, while among students it is 88%. Essentially, after completing the hands-on experiments on Days 3-5, 88% of the students reported that they are confident in PSCAD. In comparison, only 64% of industry participants felt positive about using the software, and 18% reported lack of understanding of the industrial application. This might be resulting from the similarity of the graphic user interface (GUI) between MATLAB/Simulink and PSCAD, which could have contributed to the students' success in learning PSCAD. Also, the survey results demonstrate that students are highly motivated to learn new software packages that are not integrated into the curriculum to improve their employability in terms of technical skills, particularly, when they are aware of the demand for these skills in the industry. 82% of students and 64% of industry participants attempted to learn simulation software on their own, with 43% and 29% respectively finding it not very challenging.

5.4. Reflections of the participants

Selected comments on the open-ended questions are below:

"Having sample models that mirror real-world installations allow a good insight into the theory aspect of power systems."

"Great smooth & gentle training on the software, then dive deep into the real-world practices, and instead of choking in the models … Our industry partner is very experienced, and the presentations are very informative and insightful!"

"... the clause-by-clause analysis and verification in PSCAD allow me to understand the system performance under various scenarios more clearly, which is not achievable by reading through the documentation only..."

From the comments, it is clear that the hands-on experience and step-by-step training were the most appreciated aspects of the short course. Participants found it useful to have mentors helping them go through PSCAD and explain the errors that popped up to get familiar with the software at the beginning. Participants also appreciated the practical examples and industry models that align with the theoretical knowledge imparted. They found it helpful to have real-world examples and sample models that mirrored real-world installations, allowing them to gain insight into the theoretical aspect of power systems.

The university and industry collaboration and support from both parties were other aspects of the course that were appreciated by participants. The industry expert who delivered the course was experienced and knowledgeable, allowing the participants to receive industry viewpoints first-hand, while the university academic formed an understanding of the theory and hands-on aspects of the software package. The highlights in the responses indicate the continuing need for industry input in the curriculum framework at universities, and effective strategies to incorporate industry perspectives into accredited courses to benefit more students. Overall, the responses suggest that the short course was well-received and beneficial to participants, with a good balance of theoretical knowledge and practical experience.

Although the course is well-structured it is quite intensive. After reviewing the responses in the first iteration, it appears that the majority of the participants felt that the course duration should be extended to allow for more detailed and in-depth coverage of the material. Many participants specifically suggested that more theoretical explanations would be helpful in understanding models and simulation results in the second part of the course, which resulted in the renewed structure of the second round, i.e., one extra day for the first part of the course.

"When dived into industrial practices on day 3, we were shocked by the complexity of the model and struggled to apply power system theories to interpret the results we got."

"There are knowledge gaps that prevent me from understanding the results when doing grid code compliance studies."

In the post-training survey, 71% of the students identified knowledge gaps, to the question "Please elaborate on the knowledge gap that you identified during the short course", the range of responses includes:

- Advance power system analysis (detailed modeling of power system components)
- Power system control (frequency & voltage control, power factor regulation)
- Inverter-based generation system (fundamental of solar and wind generation)
- Control of inverter-based generation (power electronics)
- Troubleshooting and parameter tuning on PSCAD models
- Fundamentals of NER and benchmarking studies

The responses from the students demonstrate the knowledge and skill gap that must be addressed in the current power engineering curriculum. To perform grid connection studies, the knowledge outlined above is fundamental, and students are expected to demonstrate their competence in these areas before they enter the industry. Identifying these missing components allows for renewing the curriculum in a backward design approach [19]. By identifying the desired learning outcomes beforehand and then designing relevant teaching and learning activities along with associated assessments, constructive alignment can be achieved in curriculum design.

6. Conclusion and Future Work

The paper describes the design of a short course program that serves as an extra-curricular component to complement the existing power engineering program. The short course allows students to acquire practical experience in industry-relevant projects using PSCAD and knowledge of NEM/NER. The initiative also provides opportunities for students to network with industry professionals, which can benefit their future careers and raise their awareness of the power system industry. Meanwhile, the industry participants can recap power system theories and align their professional experience with the course content. Therefore, both industry and academics are mutually benefited. Through the course evaluation survey, the effectiveness of improving the participants' understanding of renewable integration knowledge and technical skills is demonstrated. The survey results underscore the importance of incorporating short courses into engineering education to bridge the gap between academia and industry and to equip students with the skills and knowledge in demand for successful careers in the field. According to the feedback collected from the participants, there are a few considerations that can be taken into in further curriculum renewal, for example, the length of the short course, a supplementary segment to cover technically-challenging theories to closing the knowledge gap that may prevent the participants from understanding and interpreting the simulation results.

As such, this short course model can serve as a guide for other institutions looking to enhance their engineering curriculum and prepare their students for the challenges of the evolving modern industry through intensive training.

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