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Cognitive Skill Enhancement through Simulation Based Teaching in Basic Pneumatics and Hydraulics

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Abstract

TVET education is very important in the overall development of society. TVET helps produce a competent workforce across various industrial sectors. Therefore, this study was conducted to examine the effectiveness of simulation-based learning in enhancing the cognitive skills of students in Basic Pneumatics and Hydraulics courses, based on three main objectives: students' prior knowledge level, the effects of simulation use, and the challenges of using this method. This quantitative study involved 60 students from the Department of Technical and Engineering Education using a survey method. A five-point Likert scale was used, covering respondent demographics and research questions. Data were analyzed using SPSS version 26 (Statistical Package for Social Science) to calculate frequency of the collected data. Findings revealed that diploma graduates possessed stronger basic knowledge and exposure to engineering compared to matriculation students. The results also showed a significant relationship between teaching methods, student motivation, and academic achievement. Effective teaching methods can increase students' motivation to learn and indirectly improve their academic performance. Students' competence in simulation-based learning was also linked to self-directed training and student maturity. This study is expected to assist teachers and students in mastering TVET and offers suggestions for further research for future researchers.

Keywords: Simulation-Based Teaching, Pneumatic, Hydraulic, Cognitive, Skill

Introduction

The field of engineering plays a pivotal role in human development, as it contributes significantly to enhancing products, processes, and services that drive economic growth and improve quality of life. At the university level, engineering encompasses multiple branches, including mechanical, electrical, and civil engineering. Mechanical engineering, in particular, integrates both theoretical and practical learning related to power, force, energy, materials, and machinery. One of the fundamental components within this discipline is the study of

pneumatics and hydraulics. Pneumatics refers to a technology that employs compressed air to generate mechanical motion, while hydraulics utilizes pressurized fluid as a source of energy to produce mechanical power.

Instructional media serve as essential teaching aids in the learning process. Defined broadly, any tool capable of stimulating students' thinking, emotions, and skills can function as an instructional medium (Ali, 1998). The primary aim of such media is to facilitate effective learning. Therefore, the choice of instructional media must align with the subject matter, ensure accuracy and relevance, and remain consistent with learning objectives. Effective media should also simplify the transfer of knowledge, making content more accessible to students (Syaefrudin, 2016). In the context of 21st-century education, various teaching strategies have emerged to support active learning, including games, discussions, project-based approaches, demonstrations, lectures, and simulation-based learning.

The integration of simulations as instructional aids enables students to analyze pneumatic and hydraulic circuits in a virtual environment before engaging in real laboratory practice. This systematic approach enhances comprehension and minimizes errors during practical tasks. Simulation-based learning is inherently student-centered, encouraging active participation throughout the process. Studies by Xia et al. (2016) and Alim et al. (2015) highlight the positive outcomes of simulation-based instruction, such as promoting active learning, strengthening problem-solving skills, fostering teamwork, boosting confidence, and increasing learner satisfaction.

Weinstein and McDonald (1986) conceptualized students as information processors, requiring appropriate methods to store and retrieve knowledge effectively. In technical fields, students often struggle to visualize theoretical concepts without the support of clear, illustrative media. For courses involving circuit design and practical applications, simulations provide critical support by bridging the gap between abstract theories and tangible practice. Evidence from previous research indicates that technical students frequently encounter difficulties in comprehending the mechanisms of engineering systems, including pneumatics and hydraulics. In response, modern instructional media for these subjects can be classified into two main types: hydraulic magnetic symbols and fluid simulation software.

Hydraulic magnetic symbols consist of magnetic components attached to a whiteboard, allowing instructors to demonstrate pneumatic and hydraulic circuits step by step. This approach offers a rapid and interactive way to visualize circuit logic. In contrast, fluid simulation software allows students to model and test the behavior of pneumatic or hydraulic systems virtually on a computer. Both methods serve as preparatory tools, equipping students with conceptual understanding before they proceed to hands-on experiments.

Engineering as a whole is a broad and complex discipline, encompassing art, skill, professional practice, and technology that draw upon science, mathematics, economics, social sciences, and applied knowledge. Its applications permeate everyday life, from heavy machinery braking systems and bridge construction to industrial manufacturing equipment and automotive engines.

Nevertheless, engineering is not an easy discipline to master, as it demands both conceptual understanding and practical competence, which can only be developed through continuous hands-on training and experiential learning. Consequently, the use of effective instructional media becomes critical in teaching and learning processes. By employing appropriate media, students can better grasp theoretical principles, system mechanisms, and the flow of inputs and outputs. In pneumatics and hydraulics, for example, learners must be able to visualize how a system operates—from input, through process, to output—in order to fully understand its function.

In light of these considerations, this study seeks to examine three central aspects: (i) the level of students' prior knowledge, (ii) the effects of simulation-based learning on their cognitive development, and (iii) the challenges encountered in using simulation as a pedagogical tool in the basic pneumatics and hydraulics course.

Literature Review

Simulation-Based Learning in Enhancing Cognition

Technology-based learning is increasingly recognized as an effective means of stimulating interest and supporting the learning styles of today's digital generation. It has been shown to positively influence student achievement across various levels of education. Society continues to search for innovative ways to deliver knowledge more easily, quickly, and effectively. In the field of education, numerous forms of technology have been integrated into teaching and learning systems. The technological revolution has enabled the use of new approaches in the teaching and learning process, such as those described by Piovesan et al. (2012).

Simulation-based learning has emerged as one of the most effective and popular technology-assisted teaching approaches today. A simulation is defined as a situation that closely resembles real-life conditions. Within a simulation, participants (students) interact with one another according to assigned roles in order to make decisions, solve problems, address issues, or complete specific tasks. Mee (1994) emphasized that a simulation is a controlled situation intentionally created to replicate reality, with the primary goal of training problem-solving skills.

Simulation software provides a virtual environment with multiple features and functions that allow students and educators to design and test complex scenarios (Srikanth Reddy et al., 2020). According to Gonz (2020), well-designed simulations aim to create highly engaging experiences in which learners can interact and explore visually appealing scenarios. In an interview study conducted by Mohd Syahrizad Elias and Ahmad Zamzuri Mohamad Ali (2014), the use of simulation tools was reported to encourage active learning and to improve students' understanding of complex analytical concepts.

The Influence of Simulation on Motivation and Achievement

One of the major challenges in contemporary education is students' difficulty in engaging with and responding to learning. Conventional teacher-centered approaches often leave students uninterested and passive, particularly those with lower levels of prior knowledge. Such students may feel bored, disengaged, and unmotivated to learn.

The ARCS model of motivation provides a framework to address this issue by designing learning environments that actively stimulate and sustain student motivation (Keller, 1987). The use of appropriate instructional tools in dynamic learning settings has been shown to enhance students' attention and motivation (Keller, 1987).

It should be noted, however, that the use of inappropriate instructional aids can negatively affect students' cognitive development. Cognitive development refers to the growth and change in mental processes such as thinking, understanding, knowledge acquisition, reasoning, problem-solving, imitation, numerical sense, and spatial relationships (Gizzonio et al., 2022). When cognitive development is hindered, the overall learning process and student performance may also be compromised.

Therefore, teaching and learning approaches must evolve to become more innovative, creative, and enjoyable. One promising approach is the use of interactive computer-assisted learning media, including simulation applications (Budijono & Kurniawan, 2018). Simulation-based instruction has been found to capture students' attention and stimulate their interest in learning. Students exposed to simulation-assisted teaching strategies generally perform better than those taught exclusively through conventional face-to-face instruction. Vockel and Van Deusen (2014) argued that computer simulations are effective tools for fostering higher-order thinking skills. This finding is supported by Saifullizam Puteh (2015), who noted that well-structured computer simulations can significantly enhance higher-order cognitive skills.

Zaiha Nabila (2014) further emphasized that competent teachers possess systematic and well-developed knowledge for delivering content effectively in the classroom. This competency can be measured by their ability to employ diverse instructional strategies both in classroom teaching and in workshop-based activities (Muin, 2011). Jatilaksana (2017) also supported this view, highlighting that student achievement is influenced not only by individual learning but also by the way instructors communicate and structure content. Thus, students' comprehension is strongly linked to instructional strategies.

Overall, integrating simulation and technology as instructional aids makes the teaching and learning process more engaging and effective. This perspective is reinforced by Tan (1998) and Ng Lee Fong (2014), who asserted that the use of computers in teaching and learning not only helps teachers achieve educational objectives but also offers students the opportunity to explore new methods of learning.

Virtual Reality (VR) in Simulated Environments

Virtual reality (VR) refers to the use of computer technology to create simulated environments (Rasheed Ch & Khushnood, 2019). The integration of VR technology greatly assists students in improving their understanding of subject content and indirectly enhances their overall knowledge. As a result, students' interest in teaching and learning increases, along with their ability to interact and collaborate more effectively with peers. VR technology is considered a cost-effective advancement, as it does not require high expenditure. Students simply engage with virtual simulations through VR technology. The primary purpose of VR is to enhance, motivate, and stimulate students' interest in specific contexts while enabling them to gain practical, hands-on learning experiences (Y. Zhang et al., 2019). For teachers, VR

can serve as a medium to simplify content delivery as well as an effective instructional tool to improve the quality of student learning.

However, several limitations need to be considered before implementing this technology. Issues identified include motion-related illnesses, vision-related problems, and other potential health side effects. Excessive use of VR may cause eye strain and pose risks to vision. Students, teachers, and VR users often experience cybersickness. A study by Weech et al. (2019) reported that prolonged exposure to virtual entertainment in VR could induce cybersickness. The symptoms of cybersickness include eye strain, headaches, dizziness, paleness, sweating, dry mouth, stomach discomfort, disorientation, loss of balance, nausea, and vomiting.

Methodology

Introduction

Research methodology is one of the most important components of any study, as it determines the overall direction and ensures that the processes undertaken are grounded in a systematic and scientific framework. In the context of this study, methodology plays a central role in addressing the stated objectives, namely to evaluate the effectiveness of simulation-based learning in enhancing students' cognitive skills in the basic pneumatics and hydraulics course. The chosen method directly influences the accuracy of the findings, the justification of the research questions, and the reliability of the conclusions drawn.

This study employs a quantitative approach using the survey method. The selection of a quantitative design aligns with the purpose of the research, which is to obtain a general overview of students' prior knowledge, the impact of simulation on learning, and the challenges faced in applying this method. This approach was chosen because it enables the measurement of phenomena objectively, relies on numerical data, and allows statistical analysis to be conducted in order to generate more valid findings (Creswell & Creswell, 2018).

Research Design

The research design refers to the overall strategy adopted to ensure that data collection is carried out in an orderly, systematic manner and that the research objectives are clearly addressed. According to Mohd Najib (1999), a good research design is one that can efficiently resolve the research problem while taking into account the strengths and limitations of each research approach.

This study adopts a quantitative descriptive design based on the survey method. Through this approach, the researcher is able to describe and assess students' perceptions of three main aspects: (i) their level of prior knowledge before taking the basic pneumatics and hydraulics course, (ii) the effects of using simulation in teaching and learning (T&L), and (iii) the challenges faced by students when applying simulation-based methods.

Data Collection Methods

This study was conducted at Universiti Teknologi Malaysia (UTM), specifically at the Faculty of Social Sciences and Humanities under the School of Education. The location was selected because it houses students enrolled in technology and education programs that offer the basic pneumatics and hydraulics course.

The study population comprised students from the School of Education, Department of Technical and Engineering Education (JPTK), who were enrolled in the basic pneumatics and hydraulics course during Semester 1 of the 2022/2023 academic session. Referring to Krejcie and Morgan's (1970) sampling table, a minimum of 60 participants was required. Therefore, this study selected 60 respondents drawn from three academic programs.
The main instrument employed in this research was a structured questionnaire, developed based on previous studies and validated by subject-matter experts. The questionnaire consisted of three sections:
(A) Demographics,
(B) Knowledge and the impact of simulation, and
(C) Challenges in using simulation.

The questionnaire items were measured using a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). This scale was chosen because it is easy for respondents to understand and suitable for assessing attitudes and learning experiences. A pilot study was conducted with 10 students to test item clarity, language comprehensibility, and completion time. The results of the pilot test were used to refine and improve the instrument before full distribution. Content validity was established through expert review by two specialists in technical education and one lecturer for the pneumatics and hydraulics course. Feedback from these experts was used to revise any ambiguous or less appropriate items. Cronbach's Alpha was employed to determine the reliability of the questionnaire, with values above 0.7 considered indicative of good reliability (Sekaran, 2003). The pilot study produced reliability values sufficient for use in the actual study.

Research Procedures
The research procedures were carried out in several stages: instrument preparation, pilot testing, distribution of questionnaires to respondents, data collection, and data analysis using SPSS. Respondents were provided with an initial briefing and assured of confidentiality.
Data were analyzed using descriptive statistics, including frequency, percentage, mean score, and standard deviation. The interpretation of mean scores was categorized as follows: 1.00–2.00 = Low, 2.01–3.50 = Moderate, 3.51–5.00 = High. Statistical analysis was conducted using SPSS Version 26 to facilitate efficient data processing.

Result and Discussion
The findings of the study revealed that the majority of respondents were matriculation leavers, comprising 56 out of the total 60 participants. Meanwhile, only two respondents each were from STPM and diploma backgrounds.

The research instrument was divided into three sections to examine simulation-based learning in enhancing the cognitive skills of students enrolled in the basic pneumatics and hydraulics course. The aspects of cognitive skill development assessed included: (i) students' level of prior knowledge before taking the basic pneumatics and hydraulics subject at university, (ii) the effects of using simulation in teaching and learning (T&L) among students taking the course, and (iii) the challenges faced in applying simulation as a method to enhance cognitive skills in the course.

All respondents were required to answer the questionnaire items using a Likert scale, ranging from "Strongly Disagree," "Disagree," "Somewhat Agree," "Agree," to "Strongly Agree." The analysis was carried out by the researcher based on frequency values in percentage (%) and the mean score for each construct item, using the SPSS software package.

Students' Knowledge Level Before Taking the Basic Pneumatics and Hydraulics Course at University

Table 1
Students' Knowledge Level Before Taking the Basic Pneumatics and Hydraulics Course at University

No.	Item.		STS	TS	KS	S	SS	Min	Interpretasi
1	Saya pernah didedahkan kepada konsep pneumatik dan hidraulik sebelum ini.	*f*	20	28	2	7	3	3.34	Sederhana
		%	33.3	46.7	3.3	11.7	5.0		
2	Saya tahu prinsip kerja sistem pneumatik.	*f*	0	6	8	45	1	4.47	Tinggi
		%	0.0	10.0	13.3	75.0	1.7		
3	Saya tahu prinsip kerja sistem hidraulik.	*f*	25	24	5	3	3	4.11	Tinggi
		%	41.7	40.0	8.3	5.0	5.0		
4	Saya boleh berikan contoh penggunaan sistem pneumatik dalam kehidupan seharian. Contoh: Pemampat udara, brek kereta, pengendalian robotik dan lain-lain.	*f*	2	5	3	18	32	4.31	Tinggi
		%	3.3	8.3	5.0	30.0	53.3		
5	Saya boleh berikan contoh penggunaan sistem hidraulik dalam kehidupan seharian Contoh: Kenderaan berat, mesin pembinaan, mesin industri, dan lain-lain.	*f*	31	15	13	1	0	3.86	Tinggi
		%	51.7	25.0	21.7	1.7	0.0		
6	Saya tahu sistem pneumatik dan hidraulik dapat digunakan dalam industri atau aplikasi teknologi.	*f*	0	0	0	11	49	4.03	Tinggi
		%	0.0	0.0	0.0	18.3	81.7		
7	Saya menganggap pengetahuan mengenai pneumatik dan hidraulik penting dalam bidang kerjaya saya.	*f*	0	0	20	38	2	4.42	Tinggi
		%	0.0	0.0	33.3	63.3	3.3		
							Purata	**4.07**	**Tinggi**

Table 1 presents the findings related to the research question concerning students' knowledge level prior to enrolling in the basic pneumatics and hydraulics subject at university. The overall average mean score for this first research question was 4.07, which indicates a

high level. Almost all items recorded high mean scores except for the first item, which stated, *"I have been exposed to the concepts of pneumatics and hydraulics before."*

This first item only recorded a mean score of 3.34, which falls within the moderate level. Specifically, 20 respondents (33.3%) selected *Strongly Disagree*, 28 respondents (46.7%) chose *Disagree*, two respondents (3.3%) selected *Somewhat Agree*, seven respondents (11.7%) chose *Agree*, and only three respondents (5%) selected *Strongly Agree*. Apart from this first item, all other items demonstrated high mean scores.

In this section, six items recorded high-level mean scores, namely items two, three, four, five, six, and seven. The item with the highest mean score was item two, with a mean of 4.47. This item, which stated *"I know the working principles of pneumatic systems,"* showed that 45 respondents (75%) selected *Strongly Agree*, eight respondents (13.3%) chose *Agree*, six respondents (10%) selected *Somewhat Agree*, and one respondent (1.7%) selected *Disagree*, while none selected *Strongly Disagree*.

The second highest mean score was recorded for item four, with a mean value of 4.31. This item stated, *"I can provide examples of pneumatic system applications in daily life."* For this item, 32 respondents (53.3%) selected *Strongly Agree*, 18 respondents (30%) chose *Agree*, three respondents (5%) selected *Somewhat Agree*, five respondents (8.3%) chose *Disagree*, and only two respondents (3.3%) selected *Strongly Disagree*.

The Effects of Using Simulation in Teaching and Learning (T&L) Among Students Taking the Basic Pneumatics and Hydraulics Course
Table 2
The Effects of Using Simulation in Teaching and Learning (T&L) Among Students Taking the Basic Pneumatics and Hydraulics Course

No.	Item.		STS	TS	KS	S	SS	Min	Interpretasi
1	Penggunaan simulasi dalam PdPc membantu pelajar mengurangkan masa yang diambil untuk memahami konsep-konsep kompleks dalam pneumatik dan hidraulik.	*f*	0	0	5	15	40	4.71	Tinggi
		%	0.0	0.0	8.3	25.0	66.7		
2	Penggunaan simulasi dalam PdPc meningkatkan minat dan motivasi pelajar dalam mempelajari topik pneumatik dan hidraulik.	*f*	0	8	5	13	34	4.73	Tinggi
		%	0.0	13.3	8.3	21.7	56.7		
	Penggunaan simulasi	*f*	0	10	13	12	25	4.65	Tinggi

3	dalam PdPc memberi peluang kepada pelajar untuk mengaplikasikan pengetahuan mereka dalam praktikal di industri pneumatik dan hidraulik.	%	0.0	16.7	21.7	20.0	41.7		
4	Penggunaan simulasi dalam PdPc memperbaiki kemahiran praktikal pelajar dalam menggunakan alatan dan peralatan pneumatik dan hidraulik.	*f*	0	8	8	14	30	4.67	Tinggi
		%	0.0	13.3	13.3	23.3	50.0		
5	Penggunaan simulasi dalam PdPc mempengaruhi keupayaan pelajar untuk menyelesaikan masalah berkaitan dengan sistem pneumatik dan hidraulik.	*f*	0	1	45	13	1	4.58	Tinggi
		%	0.0	1.7	75.0	21.7	1.7		
6	Penggunaan simulasi dalam PdPc membantu pelajar memahami konsep pneumatik dan hidraulik dengan lebih baik.	*f*	0	0	1	9	50	4.78	Tinggi
		%	0.0	0.0	1.7	15.0	83.3		
7	Pelajar yang menggunakan simulasi dalam PdPc mempunyai prestasi pembelajaran yang lebih baik berbanding pelajar yang tidak menggunakan simulasi.	*f*	15	13	8	12	12	3.28	Sederhana
		%	25.0	21.7	13.3	20.0	20.0		
							Purata	**4.49**	**Tinggi**

Table 2 presents the findings related to the research question on *"The Effects of Using Simulation in T&L Among Students Taking the Basic Pneumatics and Hydraulics Course."* Based on the data obtained, almost all items recorded high mean scores except for item seven, which was at a moderate level and had the lowest mean score of 3.28. Nevertheless, the overall mean score across all items remained at a high level, with an average of 4.49.

As shown in Table 4.5, item six recorded the highest mean score of 4.78. The statement for this item was *"The use of simulation in T&L helps students to better understand pneumatic and hydraulic concepts."* For this item, none of the respondents selected *Strongly Disagree* or *Disagree*, although one respondent indicated *Somewhat Agree*. A total of 50 respondents

(83.3%) selected *Strongly Agree*, nine respondents (15%) chose *Agree*, and only one respondent (1.7%) selected *Somewhat Agree*.

The second-highest mean score was recorded for item two, with a mean of 4.73. The statement for this item was *"The use of simulation in T&L increases students' interest and motivation in learning pneumatics and hydraulics topics."* For this item, 34 respondents (56.7%) selected *Strongly Agree*, 13 respondents (21.7%) chose *Agree*, five respondents (8.3%) selected *Somewhat Agree*, and eight respondents (13.3%) chose *Disagree*. None of the respondents selected *Strongly Disagree* for this item.

The item with the lowest mean score was item seven, which stated that *"Students who use simulation in T&L perform better than students who do not use simulation."* This item recorded a mean of 3.28, which falls within the moderate level. Specifically, 15 respondents (25%) selected *Strongly Disagree*, 13 respondents (21.7%) chose *Disagree*, and eight respondents (13.3%) selected *Somewhat Agree*. Meanwhile, 12 respondents (20%) chose *Agree* and another 12 respondents (20%) selected *Strongly Agree* for this item.

Challenges of Using Simulation Methods in Enhancing Students' Cognitive Skills for the Basic Pneumatics and Hydraulics Course

Table 3

Challenges of Using Simulation Methods in Enhancing Students' Cognitive Skills for the Basic Pneumatics and Hydraulics Course

No.	Item.		STS	TS	KS	S	SS	Min	Interpretasi
1	Pelajar berasa lebih yakin dalam mengaplikasikan konsep pneumatik dan hidraulik setelah menggunakan kaedah simulasi.	*f*	0	0	2	19	39	4.43	Tinggi
		%	0.0	0.0	3.3	31.7	65.0		
2	Pelajar boleh emahami Kaedah penggunaan perisian simulasi.	*f*	0	0	4	19	37	4.51	Tinggi
		%	0.0	0.0	6.7	31.7	61.7		
3	Pelajar boleh Mengendalikan perisian simulasi.	*f*	1	15	27	14	3	2.98	Sederhana
		%	1.7	25.0	45.0	23.3	5.0		
4	Penggunaan simulasi dalam PdPc meningkatkan kebolehan pelajar untuk berkomunikasi dan bekerjasama dalam kerja berkumpulan yang Melibatkan sistem pneumatik dan hidraulik.	*f*	0	18	15	14	13	3.87	Tinggi
		%	0.0	30.0	25.0	23.3	21.7		
	Peralatan simulasi yang	*f*	0	0	0	15	45	4.74	Tinggi

5	disediakan di universiti membantu pelajar memperoleh pemahaman yang baik terhadap konsep asas pneumatik dan hidraulik.	%	0.0	0.0	0.0	25.0	75.0		
6	Perisian simulasi bendalir membantu pelajar memahami konsep asas pneumatik dan hidraulik.	*f*	0	0	5	14	41	4.64	Tinggi
		%	0.0	0.0	8.3	23.3	68.3		
7	Pelajar mempunyai akses simulasi yang mencukupi untuk meningkatkan kemahiran kognitif mereka dalam kursus asas pneumatik dan hidraulik.	*f*	2	12	8	21	11	4.08	Tinggi
		%	3.3	20.0	13.3	35.0	18.3		
							Purata	**4.18**	**Tinggi**

Table 3 presents the findings related to the third research question, namely the *Challenges of Using Simulation Methods in Enhancing Students' Cognitive Skills for the Basic Pneumatics and Hydraulics Course*. The overall mean score for this section was 4.18, which is considered high. All items recorded high levels except for item three, which obtained a mean score of 2.98 and was categorized at a moderate level.

Item three stated, *"Students are able to operate simulation software."* For this item, 27 respondents (45.0%) strongly agreed, while 14 respondents (23.3%) agreed. Meanwhile, 15 respondents (25.0%) selected *Somewhat Agree*, three respondents (5.0%) chose *Disagree*, and only one respondent (1.7%) selected *Strongly Disagree*.

The item with the highest mean score was item five, with a mean of 4.74, indicating a high level. This item stated, *"The simulation equipment provided by the university helps students gain a good understanding of the basic concepts of pneumatics and hydraulics."* For this item, all respondents answered either *Agree* or *Strongly Agree*: 15 respondents (25%) chose *Agree* and the remaining 45 respondents (75.0%) selected *Strongly Agree*. None of the respondents chose *Somewhat Agree*, *Disagree*, or *Strongly Disagree*.

Similarly, item six, which stated *"Simulation software helps students understand the basic concepts of pneumatics and hydraulics,"* recorded the second-highest mean score of 4.64. For this item, 41 respondents (68.3%) strongly agreed, 14 respondents (23.3%) agreed, and five respondents (8.3%) selected *Somewhat Agree*. None of the respondents chose *Disagree* or *Strongly Disagree*.

Table 4
Summary of Findings

Bil	Persoalan Kajian	Min	Tahap
1	Sejauhmanakah tahap pengetahuan pelajar sebelum mengambil subjek asas pneumatik dan hidraulik?	4.07	Tinggi
2	Apakah kesan penggunaan simulasi dalam PdPc di kalangan pelajar yang mengambil kursus asas pneumatik dan hidraulik?	4.49	Tinggi
3	Apakah cabaran-cabaran menggunakan kaedah simulasi dalam peningkatan kemahiran kognitif pelajar bagi kursus asas pneumatik dan hidraulik?	4.18	Tinggi

Based on Table 4, the overall mean score for all four research questions was found to be at a high level. The second research question, "What are the effects of using simulation in teaching and learning (T&L) among students taking the basic pneumatics and hydraulics course?" recorded the highest mean score of 4.49, categorised as very high. In contrast, the first research question, "To what extent is students' knowledge level before taking the basic pneumatics and hydraulics subject?" obtained the lowest mean score at 4.07 compared to the other questions.

The third research question, "What are the challenges of using simulation methods in enhancing students' cognitive skills in the basic pneumatics and hydraulics course?" recorded a mean score of 4.18, which is still at a high level, though it ranked second-lowest among the three main research questions.

The findings were analysed with reference to three main aspects: (i) students' prior knowledge before taking the course, (ii) the effects of using simulation in T&L, and (iii) the challenges encountered in using simulation. These findings are also compared with previous studies to provide a more comprehensive perspective, followed by implications for stakeholders and suggestions for further research.

Students' Prior Knowledge

The findings indicate that students' basic knowledge of pneumatics and hydraulics ranged from moderate to high. Items measuring knowledge of the working principles of pneumatic systems recorded the highest mean scores, whereas students' prior exposure to pneumatic and hydraulic concepts showed the lowest mean.

This suggests that diploma graduates had an advantage in terms of practical experience and foundational knowledge compared to matriculation leavers. These findings support Ahmad Arifin Sapar (2013), who reported that prior knowledge is a key factor influencing students' mastery. This is also consistent with constructivist theory (Piaget, 1972), which emphasizes that new knowledge is built upon existing knowledge.

For matriculation leavers, the absence of prior exposure to pneumatics and hydraulics meant they were fully dependent on university instruction. Nevertheless, the moderate mean scores indicate potential for improvement once exposed to simulations. This underscores the need for more interactive, student-centered pedagogical approaches to help them grasp abstract concepts more effectively.

Effects of Using Simulation

The use of simulation in T&L was found to have significant positive effects on students' motivation, comprehension, and achievement. The high mean scores confirm that simulations make learning more engaging and interactive. One of the most prominent aspects was the effectiveness of simulation in helping students understand the fundamental concepts of pneumatics and hydraulics. This finding is in line with Abu Ziden et al. (2011), who found that simulation provides meaningful experiences by linking theory to practical application. Valvo et al. (2012) also emphasized that computer simulations in engineering enhance technical understanding through repeated independent practice.

Furthermore, the findings revealed that simulations increased students' motivation. This aligns with Keller's (1987) ARCS Model, which highlights four motivational factors—Attention, Relevance, Confidence, and Satisfaction—that can be achieved through simulation-based learning. Prihatiningtyas (2013) similarly found that students exposed to simulations were more enthusiastic and better prepared to apply their knowledge in real-world contexts.
However, one item recorded only a moderate mean score, namely the comparison between the performance of students using simulations and those who did not. This suggests that other factors—such as students' attitudes, maturity, and learning strategies—also play a role in determining their success, beyond the use of simulation alone.

Challenges of Using Simulation

The study also revealed that the main challenge in using simulation was students' ability to operate the software. The item related to this aspect recorded the lowest mean score, suggesting that students still require additional training. The lack of practice outside of class hours was identified as the main factor contributing to this weakness. This finding supports Aminah (2008), who reported that Malay students are less inclined to engage in extra practice and tend to rely heavily on instructors.

In addition, the results showed that simulation did not have a significant impact on improving communication and collaboration skills among students. This is closely linked to the differing backgrounds of diploma and matriculation students. Diploma students were more experienced in group learning, while matriculation students tended to adopt independent learning styles. Similar patterns were reported by Muqsith (2020).

Nevertheless, the majority of students agreed that the simulation equipment and software provided by the university greatly assisted them in understanding the basic concepts of pneumatics and hydraulics. This demonstrates that institutional support in providing quality learning resources is a crucial factor for the effectiveness of simulation.

Conclusion

Overall, this study demonstrates that simulation-based learning has a clear positive impact on enhancing the cognitive skills of students enrolled in the basic pneumatics and hydraulics course. In terms of prior knowledge, diploma graduates were found to have an advantage compared to matriculation leavers; however, all students acknowledged the importance of pneumatic and hydraulic knowledge for their future careers. With regard to the effects of simulation, the findings revealed improvements in student motivation, conceptual understanding, and problem-solving ability, although some uncertainty remained when comparing performance outcomes with traditional methods. In terms of challenges, the main limitations were students' difficulties in operating the software and variations in learning styles based on educational background. In conclusion, the use of simulation in teaching and learning is an effective pedagogical strategy, but it needs to be complemented with additional practice, instructor guidance, and collaborative learning approaches to ensure optimal effectiveness.

This study confirms that simulation-based learning is an effective pedagogical approach for improving students' knowledge, motivation, and cognitive skills in the basic pneumatics and hydraulics course. Although challenges remain in terms of software mastery and differences in learning styles, the effectiveness of simulation is evident in strengthening both theoretical understanding and practical application. Ultimately, the integration of simulation into teaching and learning not only equips students to be better prepared for industry demands but also supports Malaysia's TVET educational aspirations to produce a highly skilled and competitive workforce.

References

Bakar, A. R. (2017). *TVET for Human Resource Development. Technical Vocational Education & Training (Tvet) in Malaysia : Selected Works*, 11–24.

Husain, M. Y., Rasul, M. S., Mustapha, R., Malik, S. A., & Rauf, R. A. A. (2013). Tahap kemahiran employability pelajar kejuruteraan dari perspektif majikan. *Jurnal Teknologi (Sciences and Engineering)*, *62(1), 31–39.*

Lele, A. (2019). Industry 4.0. *Disruptive Technologies for the Militaries and Security, Smart Innovation, Systems and Technologies, 205–215.*

Makki, B. I., Salleh, S., Memon, M. A. & Harun, H. (2015). The relationship between work readiness skills, career self-efficacy and career exploration among engineering graduates: a proposed framework. *Research Journal of Applied Sciences, Engineering and Technology, 10(9): 1007-1011.*

Buntat, Y., Saud, M. S., Hussain, H. A. (2020). *CABARAN POLITEKNIK SULTAN AHMAD SHAH (POLISAS) MEMBANGUNKAN MODAL INSAN SEJAJAR DENGAN KEPERLUAN SEKTOR INDUSTRI*

Julie, A., PooreDeborah, L., CullenGina, L. (2008). United States Department of Health & Human Services(HHS),n.d.Robinson, Gorman, Slimmer, andYudkowsky, *Simulation-Based Interprofessional Education Guided by Kolb's Experiential Learning Theory.*

BADA, Steve Olusegun. (2015) Constructivism Learning Theory: A Paradigm for Teaching and Learning. IOSR *Journal of Research & Method in Education (IOSR- JRME) e-ISSN: 2320–7388,p-ISSN: 2320–737X Volume 5, Issue 6 Ver.*

Madar, A. R., & Md. Yunos, J. (2021) *GAYA PEMBELAJARAN VISUAL PELAJAR TEKNIKAL MENERUSI PEMBANGUNAN KOSWER BERORENTASIKAN GRAFIK DAN ANIMASI*

U.S. Department of Labor. (1991). What work requires of schools. A Scans Report For America 2000: (The Secretary's Commission On Achieving Necessary Skills).Warraich, N. F. & Ameen, K. (2011). 'Employability Skills of LIS Graduates in Pakistan': needs and expectations. Emerald Library Management, 32(3), 209-224.

Zaharim, A., Omar, M. Z., Yusoff, Y. M., Muhamad, N., Mohamed, A., & Mustapha, R. (2010). Practical Framework of Employability Skills for Engineering Graduates in Malaysia. IEEE EDUCON Education Engineering 2010- The Future of Global Engineering Education, 921–927.

Zaidul, A., Suffian, S. A. (2015). Kepentingan Elemen Agama Dalam Kemahiran Employability Di Kalangan Mahasiswa : Kajian Terhadap Graduan Akademi Islam Kolej Universiti Islam Antarabangsa Selangor, 3.

Zakaria, H. Bin, Nasroddin, S. N. B., & Hashim, Z. Bin. (2016). Softskills – Kepentingannya Dalam Memenuhi Kebolehpasaran Pekerjaan Terhadap Graduan Politeknik Johor Bahru (Pjb). THE Journal : Tourism and Hospitality Essentials Journal, 5(2), 921.

Ghafar, M. (1999). 'Penyelidikan Pendidikan' Skudai Johor : UTM.

Nisa, K., & Murniawaty, I. (2020). Pengaruh Atribut Personal, Lingkungan Keluarga, dan Pengetahuan Kewirausahaan terhadap Minat Berwirausaha Mahasiswa. *Economic Education Analysis Journal Terakreditasi SINTA5*, *9*(1), 84– 99.

Noordin, M. K., Azmi, A. N., Kamin, Y., Nabil, A., & Nasir, M. (2018). Towards Industrial Revolution 4.0: Employers' Expectations on Fresh Engineering Graduates. *International Journal of Engineering & Technology*, *7*(4.28), 267– 272.

Noraini Idris. (2010). 'Penyelidikan dalam Pendidikan'. Kuala Lumpur: McGraw HillMalaysia Sdn Bhd.

Norman, H., Zainon, R., & Yahya, R. (2017). Personaliti Graduan Yang Menjadi Tarikan Organisasi. *Journal of Business Innovation*.Oloyo, R. A. (2019). Cultivation of Polytechnic-Industry Linkage for Development and Delivery of Curriculum for Technical Education: A Case Study of The Federal Polytechnic, Ilaro. *Journal of Educational and Developmental Psychology*, *9*(1), 69.

Safein @ Shafie, H., Yunus, R., & Mohd Lawi, R. (2020). *Kajian Kepuasan Majikan Terhadap Graduan Politeknik Kota Bharu 2018 Jabatan Pendidikan Politeknik Dan Kolej Komuniti Kementerian Pendidikan Malaysia*. *August*, 175– 195.

Saidin, S. S., Ismail, I., dan Khari, Z. M., (2018).Keberkesanan Latihan Industri Sebagai Faktor Kebolehpasaran Graduan Kolej Komuniti Baling. E-Proceedings National Innovation and Invention Competition through Exhibition 2018.

Sani, S. (2005). Nilai Tambah Dalam Kurikulum Sains Sosial dan Sastera: Satu Perspektif (Added Value in the Social Science and Literature Curriculum: A Perspective). *Akademika*, *66*, 115–125.

Suff, P., & Reilly, P. (2005). *In the Know : Reward and Performance Management ofKnowledge Workers*.

U.S. Department of Labor. (1991). What work requires of schools. *A Scans Report ForAmerica 2000: (The Secretary's Commission On Achieving Necessary Skills)*.

Warraich, N. F. & Ameen, K. (2011). *'Employability Skills of LIS Graduates in Pakistan'*:needs and expectations. Emerald Library Management, 32(3), 209-224.

Zaharim, A., Omar, M. Z., Yusoff, Y. M., Muhamad, N., Mohamed, A., & Mustapha, R. (2010). Practical Framework of Employability Skills for Engineering Graduates in Malaysia. *IEEE EDUCON Education Engineering 2010- The Future of Global Engineering Education*, 921–927.

Zaidul, A., Suffian, S. A. (2015). Kepentingan Elemen Agama Dalam Kemahiran Employability Di Kalangan Mahasiswa : Kajian Terhadap Graduan Akademi Islam Kolej Universiti Islam Antarabangsa Selangor, 3.

Zakaria, H., Nasroddin, S. N. B., & Hashim, Z. (2016). Softskills – Kepentingannya Dalam Memenuhi Kebolehpasaran Pekerjaan Terhadap GraduanPoliteknik Johor Bahru (Pjb). *THE Journal : Tourism and Hospitality Essentials Journal*, *5*(2), 921.

Abidin, M., Norman, M., & Mohd Noor, N. (2021). Keberkesanan Penggunaan Realiti Maya Dalam Kurikulum Pendidikan Malaysia. *Jurnal Dunia Pendidikan, 3*(1), 729- 737. Retrieved from https://myjms.mohe.gov.my/index.php/jdpd/article/view/13012