

## BRIDGING LEARNING GAPS IN CISCO CLI: THE SMART CLI TOOL (SCLIT) APPROACH

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### ABSTRACT

**Objective:** Networking students frequently face difficulties in mastering Cisco command-line interface (CLI) commands using Cisco Packet Tracer, particularly when it comes to recognizing mistakes, correcting syntax errors, and conducting effective troubleshooting. These challenges often hinder the learning process, reduce student confidence, and increase reliance on instructors. To address this issue, the Smart Command-Line Interface Tool (sCLIt) was developed as a supplementary educational aid to enhance traditional Packet Tracer activities. The objectives of this study are clear. The first one is to assist students in identifying and applying correct Cisco CLI commands. Second is to provide real-time feedback and corrective suggestions for syntax errors, and the third one is to foster greater student independence and confidence in troubleshooting tasks.

**Research Method:** The tool was developed using a prototype-driven approach that involved iterative design, testing, feedback collection, and refinement. A quantitative descriptive design was employed to evaluate sCLIt, with data collected through structured Likert-scale questionnaire and supported by student's final exam results. A total of 30 diploma-level students at Politeknik METrO Tasek Gelugor participated in the survey, while final exam results were analyzed across two different class in the same cohort which one class use the sCLIt and another one did not.

**Findings:** Findings from the survey indicated strong student agreement with the usefulness of the tool, with average mean scores ranging from 4.00 to 4.26 (out of 5). The tool was rated highest for providing real-time feedback on syntax error and suggestions for correction. Students also reported improvements in troubleshooting ability and confidence, though some indicated that instructor guidance remained valuable. Analysis of final exam results showed an overall average of 51.4, with one class achieving higher scores but with greater variability, suggesting that sCLIt benefits most learners but that weaker students may still require additional scaffolding.

**Originality:** The Smart CLI Tool (sCLIt) demonstrates significant potential as a virtual tutor that enhances networking education by offering real-time validation, guidance, and error detection. Its contribution lies in reducing common student errors, building self-directed learning, and complementing traditional instructor support. With further development such as the inclusion of tutorials, command libraries, and adaptive learning features, sCLIt could play a greater role in modernizing networking pedagogy and supporting diverse learners in both classroom and remote learning contexts.

**Keywords:** Cisco Packet Tracer, Smart CLI Tool (sCLIt), self-directed learning, networking pedagogy

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### 1. INTRODUCTION

Students enrolled in the Diploma in Information Technology programme, particularly those undertaking the core subject DFC20293 Network and Data Communication in Semester 2 at Malaysian Polytechnics, often encounter substantial challenges when learning and applying Cisco Command-Line Interface (CLI) commands using Cisco Packet Tracer. Although Packet Tracer provides a realistic

simulation environment, many students struggle to remember correct command syntax, identify errors, and troubleshoot configuration issues effectively. These difficulties frequently disrupt the learning process and may lead to frustration, reduced confidence, and increased dependence on instructors. In traditional laboratory settings, instructors typically assist students by identifying and correcting configuration mistakes during hands-on sessions. However, this approach becomes less efficient in large classes or remote learning environments, where immediate and individualized feedback is limited.

While Cisco Packet Tracer is widely recognized as a powerful networking simulation tool, it does not inherently provide detailed real-time guidance or corrective suggestions for novice learners. When students enter incorrect commands, the system generally displays generic error messages such as “Invalid input detected at '^' marker,” without offering contextual explanations or recommendations for correction. As a result, students often spend excessive time attempting to guess the correct commands, leading to inefficient use of lab time and reduced learning effectiveness.

This lack of intelligent feedback can contribute to several learning barriers, including prolonged troubleshooting attempts, heightened reliance on instructor intervention, decreased self-directed learning, and diminished confidence in performing networking tasks independently. These challenges highlight the need for supplementary instructional support that enhances the learning experience beyond what Packet Tracer currently provides.

To address this gap, the Smart Command-Line Interface Tool (sCLIt) was developed as an interactive educational companion designed to complement Cisco Packet Tracer activities. The tool aims to assist students in identifying correct CLI commands, detecting syntax errors, and receiving immediate corrective feedback. By providing structured guidance during command practice, sCLIt seeks to promote greater independence, improve troubleshooting competence, and strengthen student confidence in mastering Cisco CLI operations. Through this innovation, the study explores how integrating an intelligent support tool into networking education can help bridge existing learning gaps and enhance overall instructional effectiveness.

## **2. LITERATURE REVIEW**

In recent years, the use of Cisco Packet Tracer in networking education has expanded significantly. The software is widely recognized as an effective simulation-based learning tool that provides students with a safe, interactive, and cost-efficient environment to practice network configuration and troubleshooting tasks. Its ability to simulate real-world networking scenarios makes it particularly valuable in technical and vocational education settings. Despite these strengths, previous studies consistently highlight persistent challenges faced by students, particularly in mastering the Cisco Command Line Interface (CLI) and troubleshooting configuration errors effectively. While Packet Tracer offers simulation capabilities, it does not inherently provide intelligent, real-time instructional guidance for novice learners. This limitation creates a learning gap, especially for students who struggle with command syntax, device modes, and troubleshooting processes.

A study by Zarina Zainol and colleagues (2024) examined the integration of Cisco Packet Tracer within the uFuture Learning Management System (LMS) to facilitate remote assessment of students' practical networking skills. The study demonstrated that Packet Tracer effectively supports complex networking configurations such as VLAN implementation and port security while enabling remote and virtual evaluations. Additionally, its integration with e-learning platforms enhances accessibility and flexibility in assessment practices. However, the findings also revealed a significant limitation: successful task completion still depends heavily on students' ability to apply correct CLI syntax independently. The platform provides limited feedback when syntax errors occur, often offering only generic error messages without corrective suggestions. As a result, students may struggle to identify and resolve mistakes

without instructor assistance. This indicates the need for supplementary tools capable of guiding command usage and improving troubleshooting accuracy.

Similarly, Sulaiman (2020) explored the multi-user functionality of Packet Tracer in collaborative learning environments. The study emphasized that collaborative configuration exercises, conducted under instructor monitoring, promote teamwork, creativity, and realistic lab experiences. Real-time supervision enables instructors to provide immediate feedback and ensure that learning objectives are achieved effectively. Nevertheless, the study also identified challenges in fostering independent learning. Students frequently rely on instructors for error correction and clarification, limiting opportunities for self-paced problem-solving. The dependence on continuous instructor intervention highlights a gap in automated support mechanisms within the platform. This reinforces the potential value of intelligent CLI support tools that can assist students without constant supervision.

In addition, Juraev and O. M. (2023) reviewed the pedagogical role of Cisco Packet Tracer in studying computer systems and networking. Their findings indicated that the software enhances visualization of network concepts, improves student engagement, and provides cost-effective access to practical networking experiences. Packet Tracer also encourages collaborative learning and active experimentation in simulated environments.

However, similar to other studies, the authors noted that students often experience difficulties in troubleshooting and error identification. The absence of built-in intelligent mechanisms for detecting incorrect commands or suggesting corrections reduces the platform's effectiveness for beginners. Many learners struggle to interpret error messages and apply appropriate corrective actions, which may negatively affect confidence and learning efficiency. Collectively, these studies highlight a consistent pattern: while Cisco Packet Tracer is an effective and widely adopted educational tool, it lacks intelligent support features for command validation, syntax correction, and guided troubleshooting. The literature clearly indicates a gap in providing real-time instructional feedback that supports independent learning and reduces reliance on instructors.

Addressing this gap requires the integration of supplementary educational aids capable of enhancing command accuracy and troubleshooting skills. The proposed Smart CLI Tool (sCLIt) responds directly to this need by functioning as an intelligent companion to Cisco Packet Tracer. By offering real-time command validation, syntax correction, and contextual guidance, sCLIt aims to strengthen students' self-directed learning abilities, improve confidence in using Cisco CLI, and complement traditional instructor-led instruction. Thus, the development of sCLIt is grounded in documented limitations within existing networking education practices and contributes to ongoing efforts to enhance digital pedagogy in technical training environments.

### **3. METHODOLOGY**

#### **3.1 RESEARCH DESIGN**

This study employed a quantitative descriptive research design to examine the effectiveness of the sCLIt - Smart CLI Tool in assisting students with Cisco Packet Tracer troubleshooting and command usage in a networking fundamentals course. Besides, the development process also followed a prototype-driven, iterative approach where the initial version created with core features such as command database, syntax checker, and environment suggestion. Additionally, there are testing and feedback from students that used the tool in lab sessions and the feedback collected through questionnaires and final examination marks. There is also a refinement phase where the user interface can be enhanced, expanded command library, and added troubleshooting tips based on feedback obtained.

### 3.2 PARTICIPANTS

The participants consisted of 30 diploma-level students enrolled in the core computing subject of networking at Politeknik METrO Tasek Gelugor during Cohort 2, 2024/2025. A purposive sampling method was used to select students who were actively participating in the course and consented to use the sCLIt Smart CLI Tool as part of their learning activities.

### 3.3 PROCEDURE

At the start of the semester, students attended an orientation session introducing the sCLIt Smart CLI Tool and its functionalities. The intervention was conducted over four weeks, which students used sCLIt to identify correct Cisco CLI commands, detect syntax errors, and receive guidance on correct device types or modes for specific commands. Students were encouraged to use the tool regularly to support classroom and lab activities.

### 3.4 MATERIALS AND MEASURES

The primary material was the custom-developed sCLIt Smart CLI Tool deployed on web platform using URL, programmed to troubleshoot, suggesting correct Cisco CLI commands, detecting syntax errors and guide users to use the appropriate mode. In addition, a structured questionnaire using a 5-point Likert scale to measure students' perceptions of the tool's usefulness, ease of use, and impact on learning.

### 3.5 DATA ANALYSIS

The questionnaire was organized into three sections designed to capture both demographic information and user experiences. Section A collected respondent background details to establish the profile of participants. Section B focused on the usage of the Smart CLI Tool and Cisco Packet Tracer, examining how students interacted with both tools during their learning activities. Section C consisted of open-ended feedback, allowing respondents to share qualitative insights and personal reflections regarding their experiences with the tools.

**Table 1:** Scale of Section B Questionnaire

Scale	Description
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Data obtained from this questionnaire will be analysed using SPSS tool to identify the key points in CLI learning and also to see the effectiveness of using sCLIt tool while using Cisco Packet Tracer command line interface.

## 4. RESULTS AND DISCUSSIONS

This innovation and studies aimed to help and guide students to use Smart CLI Tool (sCLIt) as an education engagement tool in the core subject of networking by comparing student's examination performance for 1 cohort (Session 2: 2024/2025) in 2 classes which is DIT2A which not using this tool and DIT2B which use the sCLIt tool. The studies show that this tool is relevant and effective to be used along with Cisco Packet Tracer as an aid for this course specifically.

**Table 2:** Class Statistics Based on examination result

Label	Class	n	Mean	Std. Deviation
Class A	DIT2A	30	48.97	14.26
Class B	DIT2B	32	53.66	17.78

The analysis shows that Class B performed better overall which the mean above 50. Class B outperformed Class A averagely 53.66 versus 48.97. Class B had wider score variation where the midpoint score is 4 points higher, confirming that the central tendency is stronger. Class A has several modes (41-54), meaning no dominant common score while Class B has a clear single mode at 50, suggesting many students clustered around the pass mark. For the standard deviation, Class B's variation is 3.5 points higher which shows that scores are more spread out, with both very low and very high achievers. Class A is more consistent but at a lower average.

#### 4.1 SECTION A: RESPONDENT BACKGROUND

In this section, the study looked at the background of 31 respondents. Most respondents are male with majority of 64.5% and 35.5% are female. The gender distribution was fairly balanced with 20 male and 11 female students. Notably, 100% of the respondents reported have used the Cisco Packet Tracer before. This suggests that all students have experienced using command line interface in the Cisco Packet Tracer and it's not new to them.

#### 4.2 SECTION B: USAGE OF SMART CLI TOOL AND CISCO PACKET TRACER

**Table 3:** Total percentages of respondent's scale for Section B questions

	Statement	Percentages of scale (%)				
		1	2	3	4	5
1	The Smart CLI Tool helped me understand CLI commands more easily.	-	-	12.9	61.3	25.8
2	The tool provided useful feedback when I made command syntax errors.	-	3.2	16.1	38.7	41.9
3	The Smart CLI Tool improved my troubleshooting skills.	-	3.2	16.1	41.9	38.7
4	I felt more confident using CLI commands after using the tool.	-	-	22.6	32.3	45.2
5	Using the tool reduced my dependence on the instructor.	-	6.5	16.1	45.2	32.3
6	Overall, I am satisfied with the Smart CLI Tool as a learning aid.	-	6.5	9.7	38.7	45.2

The feedback on the sCLIt tool was indeed positive, and demonstrated strong potential as a supplementary learning aid in Cisco Packet Tracer. The highest rated aspect is the overall satisfaction and syntax error detection and the lowest rated aspect is reducing dependence on instructor. Students particularly appreciated the syntax correction and overall usability, while some still desired instructor support and expanded features.

Based on Table 3, students generally agreed that sCLIt tool improved their understanding in CLI command with most of the response are 4 (Agree) with 61.3% and 5 (Strongly Agree) with 25.8%. A smaller portion is 3 (Neutral), and no response recorded between 1 and 2. The mean is around 4.2 – 4.3, which shows the students generally agree that the sCLIt helped them understand CLI commands more easily.

Students rated the effectiveness of sCLIt quite high which is  $\sim 4.2 - 4.3/5$ , with the main strength in simplifying CLI learning. Some neutral ratings suggest potential for future enhancements to make it even more engaging.

Next, the feedback shows most students selected 4 or 5 on the syntax error feedback feature very useful, with overall consensus leaning towards Strongly Agree with only 1 student disagreeing on this statement. Compared to the first statement, both have a very close mean score which  $4.19 - 4.2$ . Students rate the tool highly in understanding CLI commands and syntax error feedback. The strength lies in providing guidance and reducing mistakes which means students found that the syntax error feedback very helpful.

For the improvement on troubleshooting skills, the mean score is approximately around 4.13 with majority of the response are 4 (Agree) and 5 (Strongly Agree), a few answered 3 (Neutral) and one answered 2 (Disagree). These few neutral and disagree pull the mean slightly lower. The trend is still positive but slightly less strong compared to Q1 and Q2.

Correspondingly to this, the student's level of confidence in using CLI command after using sCLIt also being recorded with mean approximately around 4.29 with most frequent answer is 5 (Strongly Agree) appeared 11 times and 3 (Neutral) appeared several times but no 1 or 2 at all which show that most students generally felt more confident using CLI commands after using sCLIt. This is one of the stronger-rated aspects of the tool since confidence is crucial in networking practice.

Moving forward is about dependence on the instructor could be reduces when using the tool show a mean of approximately 4.06 with most frequent answers are 4 (Agree) appeared 12 times and lowest scale given is 2 (Disagree) with only two students shows that the tool helped students become more independent, but not as strongly as other aspects like confidence and troubleshooting. Some students may still prefer instructor support despite using the tool.

Lastly, for the overall satisfaction with the sCLIt as a learning aid show the mean of approximately 4.26 with most frequent answers are 5 (Strongly Agree) which appeared 11 times and lowest scale is 2 (Disagree) which is only 2 students answered this. This shows that the students were highly satisfied overall with the Smart CLI Tool as a learning aid. This item had one of the highest mean scores, showing strong acceptance and perceived usefulness.

#### **4.1 SECTION C: OPEN-ENDED FEEDBACK**

The open-ended feedback highlighted several key themes. While many students are satisfied, a significant portion suggested more guidance, error clarity, categorized commands, and interactive features. This shows sCLIt is already strong but could evolve toward AI-assisted and gamified learning. Most feedback centered around Positive Remarks with 36% and Interactive/Advanced Features with 24%, followed by request for More Explanations and Guidance with percentage of 24%. Smaller portions mentioned Command Support and Error Highlighting with 12% and miscellaneous notes around 4%. This also shows that the students find sCLIt to be an effective, confidence-building, satisfying tool for learning CLI commands. Improvements should focus on reducing instructor dependency through more step-by-step guidance, interactive tutorials, and clearer troubleshooting feedback.

#### **5. CONCLUSION**

The Smart CLI Tool (sCLIt) effectively addresses the learning gap in Cisco CLI practice by providing real-time validation, syntax correction, and contextual guidance, resulting in consistently high student satisfaction and demonstrating its value as a supplementary aid to Cisco Packet Tracer. Despite these positive outcomes, the variability in examination results indicates that weaker learners may still require additional scaffolding and structured tutorials, suggesting that sCLIt should function as a complementary innovation rather than a replacement for instructor-led guidance.

Based on student feedback, examination analysis, and the overall findings, several improvements are recommended to enhance the tool's effectiveness: enriching guidance features with step-by-step tutorials and examples, expanding learning resources through command libraries, quizzes, and sandbox environments, and strengthening feedback mechanisms with real-time hints, progress tracking, and interactive elements to maintain student engagement. Additional support for weaker learners is also essential, such as incorporating adaptive learning features that provide personalised assistance. Future work should involve testing the tool with a larger cohort, integrating it into online learning environments, and evaluating long-term skill development. In conclusion, sCLIt emerges as a promising educational innovation that improves students' mastery of CLI commands, enhances troubleshooting abilities and confidence in networking labs, and supports independent learning, while still requiring integration with instructor-led instruction to achieve optimal learning outcomes.

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