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Framework of Computer Science Learning Through Hybrid Service Learning Oriented Visual Toward the Continuum of Visualization Thinking and Generic Skills

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Abstract - **Computer Science learning requires students to think logically and understand its practical implementation in real-life situation clearly. However, the lack of learning activities that bridge the gap between theory and practice hinders their ability to depict learned concepts in real-world scenarios and master generic skills. Therefore, Computer Science education necessitates visualising learning concepts in real-life contexts, such as implementing Service Learning activities. However, in the current post-COVID-19 endemic situation, it is not feasible to implement this approach fully face-to-face. Thus, integrating Service Learning activities through technology-mediated means is essential in Computer Science education. Hybrid Service Learning activities, using technology as a medium, are instructional designs that provide opportunities for students to apply theoretical knowledge practically in real-life situations. Therefore, in this study, Computer Science learning activities were designed with visual materials through a hybrid service learning website to support the continuum of students' visual thinking and their generic skills. Subsequently, the effects of Computer Science learning activities on the continuum of students' visual thinking, level of generic skills, and perception were analyzed. A quasi-experimental study design was used, which involved a total of 27 respondents and took 15 weeks to complete. The research data was analyzed using descriptive analysis and inferential statistics. The results of paired t-test for the continuum of students' visual thinking levels, including visual thinking, visual learning, and visual communication, indicated an improvement with a significant difference of ($p<0.05$) between the pre- and post-activities. In terms of students' generic skills levels, the paired t-test for the pre-Service Learning (PS), during-Service Learning (DS), and post-Service Learning (AS) phases showed a significant difference of ($p<0.05$), which indicated an increase in students' mastery of skills and changes between each phase. Furthermore, students' perceptions revealed positive feedback towards hybrid service learning. Overall, based on the findings of this study, a framework for visual-based hybrid service learning was developed as a guide for Computer Science education to support the continuum of students' visual thinking and their level of generic skills.**

Keyword: **Hybrid Service Learning, Service Learning, Continuum of Visualization Thinking, Generic Skills**

I. INTRODUCTION

The adoption of collaborative learning approaches, with the use of appropriate technological media in the field of education today, represents a continuous step towards empowering education in Malaysia (Doig et al., 2022). Therefore, in Computer Science learning, it is essential to integrate the use of media technology, in line with the educational aspirations of the country and the current trends in learning (Arasu et at., 2024). Students should not only act as technology users but also as knowledgeable designers towards creating technology and generating new ideas (Reimers, 2020). The lack of learning activities to apply the theories studied and the insufficient provision for students to gain real-world experience have resulted in students struggling to articulate the concepts they have learned and apply them in real-life situations. Therefore, in Computer Science courses, students need to be given space and opportunities for exposure to real and clear depictions of the concepts they are learning, as translated into everyday life. This includes providing a learning environment that utilizes their knowledge to solve or improve real-world problems (Marcus et al., 2020). This is well in tandem with the Malaysia Education (Llopiz-Guerra et al., 2024) Development Plan 2015-2025 (Higher Education), specifically the first shift, which refers to enhancing students' learning experiences. Based on this shift, there is a need to enhance experience-based learning and service learning to develop generic skills suitable for the 21st century, while simultaneously capitalizing on the use of media technology to enhance learning tailored to students' needs, in line with the goals of the education system (Mathur et al., 2024).

Therefore, learning through web technology should be provided with learning activities, in such a way that, the outcomes are of higher quality, potential, and optimum impact, enabling students to learn in real-life situations (Amamou & Cheniti-belcadhi, 2018). Thus, the use of web

technology in the students' learning process should provide opportunities for them to apply conceptual/theoretical knowledge to practical situations in real life (Harris, 2017b). This is aligned with the current era's trends and the needs of the present generation that crave learning through web technology, accessible at any time (Marcus et al., 2020). The current Generation Z requires internet access in their daily lives, including learning activities. Therefore, the integration of web-based learning has created a virtual learning scenario that is increasingly popular today (Kaarakainen et al., 2018). Furthermore, providing real-life-based learning experiences is crucial in offering students learning experiences, such as through the implementation of service-based learning strategies. This type of learning experience is essential for the students to not only master knowledge, but also develop their generic skills, enabling them to effectively apply learning concepts in the real world (Chicca & Shellenbarger, 2018).

II. Research Background

The issues related to Computer Science learning persist until now, because the learning process requires students to think logically and apply learned concepts in practical, real-world situations. Based on previous studies, Computer Science learning necessitates hands-on practice, for students to be able to thoroughly understand the way learned concepts are applied in real life (May et al., 2018). Similarly, studies (Mohd Tamring et al., 2022) revealed that, students have limited opportunities to apply acquired knowledge, resulting in difficulties mastering generic skills, through Computer Science learning activities in real-world situations. According to the study (Kaarakainen et al., 2018), the mastery of technical skills in Computer Science learning plays a crucial role for the enhancement of both generic skills and students' knowledge in the relevant field. Because of these issues, several studies indicate that, students face challenges in applying Computer Science learning content to solve real-life problems. Hence, there is a need to emphasize learning opportunities which encompass both theoretical and practical aspects in student learning activities. This approach is expected to help students visualize learned concepts effectively, before applying them in real-life situations, to solve related problems. Therefore, emphasis on learning activities which provide students with theoretical and practical perspectives is necessary. As revealed in studies (Al-araibi et al., 2019), it is crucial for Computer Science students to engage in learning activities that enhance generic skills and understanding, enabling them to master the fundamentals of learning and their applications.

Furthermore, in line with the requirements of 21st-century learning, students also need exposure and learning experiences, based on the real, complex, and dynamic world influenced by developments and revolutions in technology (Wahyuningsih et al., 2021). In addition to the use of media technology, the provision of flexible learning facilities and spaces must be taken into consideration. As stated in the Malaysia Education Development Plan 2015-2025 (Higher Education), which refers to the first shift in producing holistic graduates through initiatives to enhance student learning experiences through community service based on real-life situations, developing skills suitable for the 21st century, and leveraging technology to enhance student learning is of utmost importance (Reimers, 2020). The use of media technology and the internet in teaching and learning is deemed as a crucial element in improving the quality of education in the country, providing opportunities for meaningful learning experiences for students.

Therefore, in preparing students for the workforce, community-based learning activities with real-world issues also play a crucial role. This involves a process and an approach for students to apply the conceptual knowledge learned to practical situations, enabling them to clearly illustrate the implementation of learned concepts in real-life situations. By implementing real-world community-based learning, students are able to transfer the conceptual knowledge learned to real problem-solving in their surroundings (Marcus et al., 2020).

III. Problem Statement

Learning Computer Science requires learning activities that can provide a clear understanding of learned concepts and real experiences to students. Based on several previous studies, the use of visual materials in Computer Science learning activities by students has helped improve their understanding and generic skills even further, reinforcing the visual logic of concepts in their thinking to be applied in practical learning. The learning environment through visual materials can be facilitated with the use of current web and internet technology developments. Through the integration of technology in producing visual materials, it helps strengthen students' mastery of understanding, further applied in real situations through problem-solving to support the mastery of generic skills. Therefore, in studying Computer Science, students need to be exposed to visual learning materials to enhance understanding in their thinking and subsequently be applied in real-world problems, such as through service-based learning strategy activities.

However, this does not work well in Computer Science learning by students. Until now, there are still difficulties for some students to articulate the content of these learning concepts, and there is a lack of exposure and opportunities for students to apply this knowledge in real situations. The lack of learning activities to apply the theories learned and the absence of adequate provisions to help students gain real learning experiences and master generic skills have resulted in students being less able to translate the learned concepts into their application in real-life situations. This situation leads to students lacking real learning experiences in reinforcing the knowledge and generic skills that need to be mastered.

According to Marcus et al., (2020), service learning strategies involve learning experiences that apply acquired knowledge to real-life situations, thereby enhancing students' generic skills. However, activities based on service learning strategies using web technology need to be properly

designed, so that students are able to translate their conceptual understanding of learning into practical applications in real-world scenarios. Therefore, the provision of service learning activities through the integration of web technology, known as hybrid service learning, needs to be carefully considered, for the learning design to have positive impacts on students' knowledge and generic skills. Referring to previous studies regarding the levels of visualization thinking, an individual's development involves several stages, starting with visual thinking elements to visual learning elements, and ultimately visual communication elements. Once students are able to visualize theoretical learned concepts in practical real-world contexts, it helps them enhance both their knowledge and generic skills.

Based on the highlighted concerns, Computer Science learning activities were designed, via hybrid service learning, with visual materials to support the continuum of students' visualization thinking and generic skills, through practical experiences in real-world situations. Through the provision of this hybrid service learning, the effects of integrating web technology in learning with visual materials on the continuum of visualization thinking and the mastery of generic skills among students were subsequently examined. Furthermore, students' perceptions of these learning activities through visual-assisted hybrid service learning were obtained to gather their feedback in support of their visualization thinking continuum. As a result of the impact of this learning design, a basic guide for implementing visual-assisted hybrid service learning was provided, for other researchers to use it as a reference to further enhance the level of visualisation and strengthen the mastery of generic skills among students.

IV. Research Objectives

The research objectives in this study are as follows:

(a) Designing computer science learning activities through hybrid visual service learning to support the continuum of students' visualization thinking.

(b) Identifying the effects of computer science learning activities through hybrid visual service learning on:

- the level of students' visualization thinking continuum
- students' generic skill levels

(c) Obtaining students' perceptions regarding computer science learning activities through hybrid visual service learning to support the continuum of their visualization thinking.

(d) Producing basic guidelines based on the framework of computer science learning activities through hybrid visual service learning that support the continuum of students' visualization thinking and generic skill levels.

V. Conceptual Framework

The conceptual framework of the study refers to the service learning strategy proposed (Kaye, 2010) and the hybrid service learning presented (Waldner et al., 2012). Furthermore, this study was based on Rudolf's (1969) research on visual thinking, in reference to the study (Mcloughlin & Krakowski, 2001) on the continuum of visualization thinking, comprising three elements, namely, visual thinking, visual learning, and visual communication, in Computer Science learning activities. This conducted study utilizes visual materials through web technology to support the development of students' visualization.

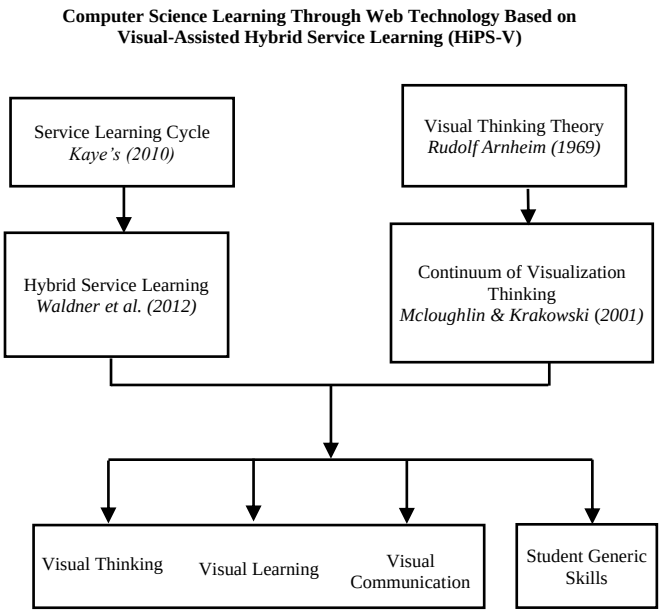

Fig. 1 A Visual Hybrid Service Learning (HiPS-V) Framework

In figure 1, summary, it can be concluded that, the ADDIE instructional system design framework is used in the design of Computer Science learning activities and refers to the study (Waldner et al., 2012), based on visual-assisted hybrid service learning designed to support the development of the continuum of visualization thinking, knowledge improvement, and mastery of generic skills among students.

VI. Development and Validity

Quality and structural aspects should be emphasized in the design of any learning instruction, to make teaching more organized, in order to achieve the teaching and learning objectives. It should be easily accessible and delivered for the students to keep up during the learning process. The design of this visual website development is based on the study presented by Sherimon (2022). The ADDIE design is a standard instructional design used in learning website with suitable electronic content (E-content), which enables students to enhance their skills. Meanwhile, according to the study (Kadirbergenovna, 2022), the development of distance learning, which is a programme serving as a teaching and learning platform in higher education institutions, uses the

ADDIE design model to develop knowledge and skills of students, with clear course contents. Therefore, in creating teaching and learning materials, the ADDIE instructional design was used in this study, which involves several processes, namely analysis, design, development, implementation, and evaluation, for visual web technology. This phase involves the development of learning activities based on the continuum of visualization thinking, in reference to the study (McLoughlin & Krakowski, 2001), with service learning strategies presented (Kaye, 2010). The focus of learning activities is designed to enable students to learn more effectively in terms of both knowledge and skills, thereby enhancing their level of visualization.

TABLE I FIVE PHASES OF THE ADDIE MODEL IN THIS RESEARCH

Phase	Description
Analysis	Focused on preliminary analysis before designing visual web-based learning activities. This analysis involves learning content analysis, user needs, and software and hardware requirements.
Design	Involves the development of learning activities based on the continuum of visualization thinking elements, referring to the study (McLoughlin & Krakowski, 2001) with service learning strategies presented (Kaye, 2010). This design phase focuses on the flowchart of web learning, storyboards, the production of activities, and learning activities through the HiPS-V web.
Development	Involves the development of the visual hybrid service learning HiPS-V. Generally, this visual learning web contains weekly access, and there are learning activities, where students can download notes and participate in provided learning activities.
Implementation	Implementation of the learning website for the Computer Networking course with the integration of visual learning materials. The implementation of this learning took place over a period of 15 weeks, involving a total of 27 students, both local and international, from various faculties and undergraduate programmes in the ICT for Community course, as listed in Table II.
Evaluation	Received feedback from experts in the field of educational technology on the developed learning website. The learning content aspect was assessed by two experts who have extensive experience and knowledge in the field of Computer Science and curriculum. This assessment determines whether the developed learning website can achieve its objectives and meet the learning content. In this phase, the evaluation was carried out to ensure that all navigation functions properly meet the established learning design.

Table I represents the work phases carried out at each stage involving the development of the visual hybrid service learning HiPS-V. In general, this visual learning web contains weekly access, and there are learning activities where students can download notes and participate in learning activities. The learning website produced is displayed in Figures 2 and 3.

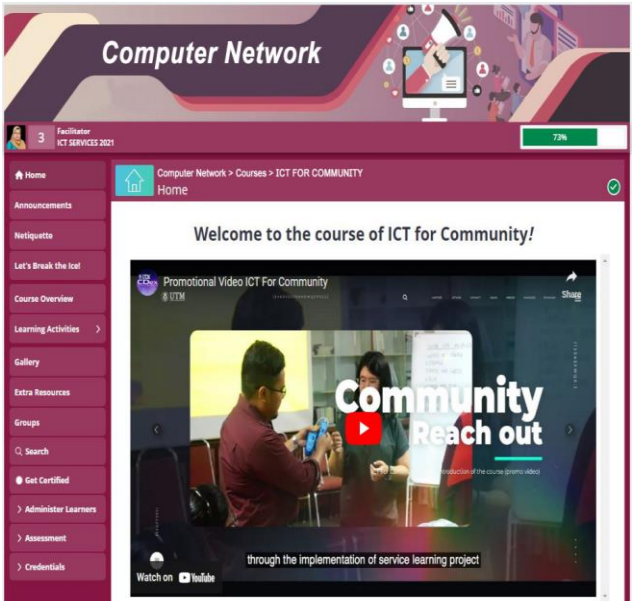

Fig. 2 Design of the Development of the Visual Hybrid Service Learning HiPS-V

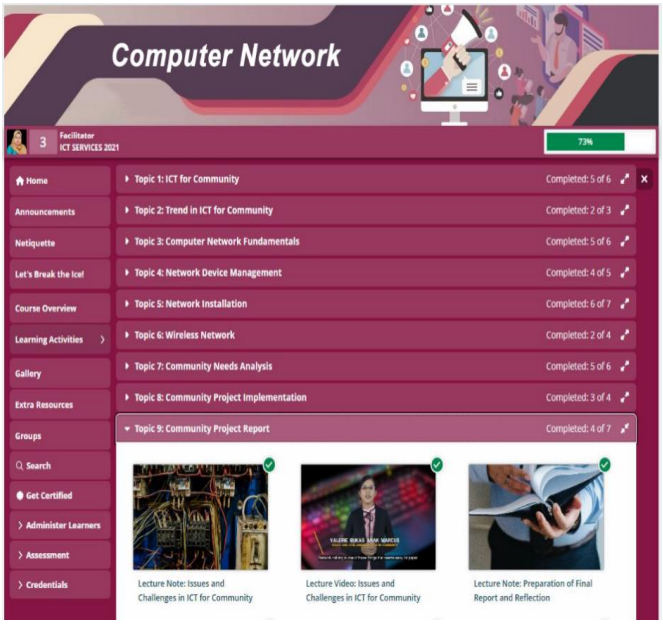

Fig. 3 Students' Learning Topics

Table II represents the developed activities and the overall learning content, involving service learning activities that encompass service learning strategies presented (Kaye, 2010), which include investigation, preparation, action, reflection, and demonstration to enhance the level of mastery of students' generic skills. The design of these learning activities also refers to the elements of the continuum of visualization thinking presented (McLoughlin & Krakowski, 2001), namely visual thinking, visual learning, and visual communication. The following section discusses the developed student learning activities, in details. Table II represents the service learning phase, visual thinking continuum, and student learning activities.

TABLE II SERVICE LEARNING PHASE, CONTINUUM OF VISUALIZATION THINKING, AND LEARNING ACTIVITIES

Week	Topic	Service Learning Phase (Kaye's, 2010)	Continuum of Visualization Thinking (McLoughlin & Krakowski, 2001)	Learning Activities
1 2	Topic 1 ICT for Community			Online learning
3	Topic 2 Trend in ICT		Visual Thinking (Pre V1)	Activity A: • Pre-Mind Map
4 5	Topic 3 Computer Network Fundamentals		Visual Thinking (Post V1)	Activity B: • Post-Mind Map
6 7	Topic 4 Network Device Management			Online learning
8 9	Topic 5 Network Installation			Online learning
10	Topic 6 Wireless Network	Phase 1 Investigation		Activity C: • Pre-Proposal Draft
				Activity D: • Post-Proposal
11	Topic 7 Community Needs Analysis	Phase 2 Preparation	Visual Learning (Pre V2)	Activity E: • Pre-design of Learning Modules • Pre-design of Video Tutorials • Pre-design of Multimedia Materials • Pre-design of Course Materials
			Visual Learning (Post V2)	Activity F: • Post-design of Learning Modules • Post-design of Video Tutorials • Post-design of Multimedia Materials • Post-design of Course Materials
12 13	Topic 8 Community Project Implementation	Phase 3 Action	Visual Communication (Pre V3)	Activity G: • Pre-Service Learning
			Visual Communication (Post V3)	Activity H: • Post-Service Learning
14 15	Topic 9 Community Project Report	Phase 4 Reflection		Activity J: • Pre-Learning Portfolio • Pos Learning Portfolio
		Phase 5 Demonstration		Activity K: • Pre-Final Report and Presentation • Post-Final Report and Presentation

The overall implementation of service learning activities is based on five phases, namely, investigation, preparation, action, reflection, and demonstration, referring to the service learning strategy outlined (Kaye, 2010) and integrated through web technology known as hybrid service learning III, involving the implementation of service learning activities both face-to-face and online, as stated (Waldner et al., 2012). Furthermore, this study was based on the research (Rudolf, 1969) on visual thinking, in reference to studies (Mcloughlin & Krakowski, 2001) on the continuum of visual thinking, comprising three elements, namely, visual thinking, visual learning, and visual communication in computer science learning activities. Learning activities involve a workflow through the development of 10 learning activities carried out using visual materials through web technology to support the development of students' visual thinking and mastery of generic skills.

VII. METHODOLOGY

This research utilized a quasi-experimental approach, and the data collected were both quantitative and qualitative. The research design employed was a quantitative study with a quasi-experimental method using a one-group pre-test-post-test that involved the collection of both quantitative and qualitative data. The rationale for using this approach is that quantitative data and analysis only provide a general understanding related to the research problem, while qualitative data and analysis provide a more detailed explanation of the findings of the study, by exploring the sample's perceptions in-depth, as seen in some studies (Cohen et al., 1960; Creswell, 2009). The combination of

these two types of data, quantitative and qualitative, enables more robust research finding to be generated, thus providing a complex portrayal of a social phenomenon (Tinggi, 2011). In this research, the quantitative data was first collected, to obtain an initial overview of the focus of the study, followed by the qualitative data, to confirm and strengthen related matters. Table III represents the quasi-experimental research design, through a one-group pre-test post-test.

TABLE III QUASI-EXPERIMENTAL RESEARCH DESIGN THROUGH ONE GROUP PRE-TEST POST-TEST

Pre-test	Intervention	Post-test
O_1	X	O_2

Population and Sample

The population of this study comprises a total of 58 undergraduates in ICT courses, who participate in service learning in their respective higher education institutions. These respondents were specifically from one class section in the first semester. A purposive sampling technique was employed in this study, with the consent of the *UTM* iLeaGue (Institute for Life-Ready Graduate UTM) team, which allows for the inclusion of only 27 students as the study sample, comprising both international and local students. Additionally, 9 students participated in brief interview sessions. The focus of this study is on the Computer Science course, which received approval from the faculty.

Research Procedure

This section discusses the closely related research procedures during the study process. There are three proposed phases involved in this research, namely the first phase, the second phase, and the third phase. The first phase focuses on the analysis process, involving steps such as conducting preliminary research on learning services, analyzing, and constructing research instruments, and conducting a pilot study. The second phase involves designing learning activities through HiPS-V. Meanwhile, the third phase implements learning activities through HiPS-V and assesses activities using HiPS-V. Figure 4 depicts the implementation of the study for the one-group pretest-posttest design.

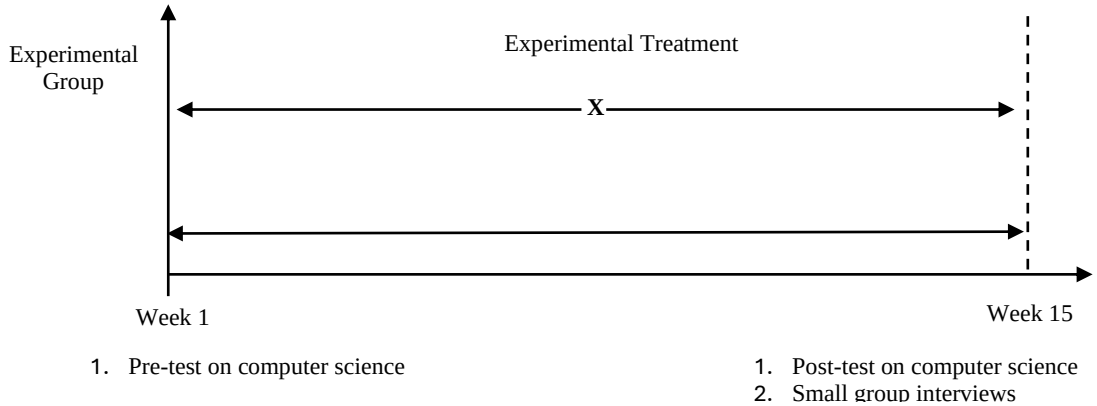

Fig. 4 Implementation of the Study for One Group Pretest-Posttest Design

VIII. FINDINGS

The data analysis of this study encompasses four types of data citation, namely, the effect of Computer Science learning activities with visual materials through hybrid learning services on the continuum level of visualization thinking, comprising three elements, namely, visual thinking, visual learning, and visual communication. Each of these elements involves pre-learning and post-learning activities to observe the effects on students' levels of visualization thinking. The second data analysis is to examine the effects of Computer Science learning activities with visual materials through hybrid learning services on students' generic skill levels. The third data analysis is to gauge students' perceptions of hybrid learning service learning activities in Computer Science learning that support the formation of a visual thinking continuum based on four constructs, namely the use of visual in thinking, integration of visual in learning, application of visual in communication, and hybrid learning services. Therefore, a questionnaire was distributed and followed by brief interviews conducted to support data on students' perceptions of visual learning websites. Furthermore, a research framework is developed for basic guidance based on the Computer Science learning activity framework through visual hybrid service learning HiPS-V that support the continuum of visualization thinking and students' generic skills.

Analysis of Data on Students' Visual Thinking Levels Through Continuum of Visual Thinking Elements

This section involves the analysis of research findings and the differences between pre-test and post-test related to students' visual thinking levels regarding learning activities while using the visual hybrid service learning HiPS-V, with data collection for pre-activities to measure the visualization state of students before the intervention is implemented. Meanwhile, post-activities are conducted after the intervention using the visual hybrid service learning HiPS-V. The following is the data analysis through a Paired samples t-test for pre-activities and post-activities in the continuum of visual thinking levels for the elements of visual thinking, visual learning, and visual communication.

TABLE IV PAIRED SAMPLES T-TEST ANALYSIS FOR PRE-ACTIVITIES AND POST-ACTIVITIES ON VISUAL THINKING LEVELS

Pair	Mean	Standard Deviation	t	Sig. (2-tailed) p	Cohen d (effect size)
Pre-Activity	2.44	.50637	-9.539	0.000	-1.83
Post-Activity	3.22	.57735			
Pre-Activity ~ Post-Activity					
*N=27, students, α = 0.05					

Referring to Table IV, it was found that the mean scores of students in pre-activity and post-activity are significantly different, with values of (M=2.44, SD=0.50) and (M=3.22, SD=0.57) respectively. The difference in mean scores is 0.78 points. Furthermore, from the same table, it can be interpreted that there is a significant difference between the mean scores of pre-activities and post-activity, with a significant value (t=-9.539, p < 0.05). Therefore, it can be concluded that, the intervention of using visuals through mind map generation activities provided to students between pre-activity and post-activity has a significant effect on the level of visual thinking, with a small effect size (d = -1.83).

TABLE V PAIRED T-TEST ANALYSIS FOR PRE-ACTIVITY AND POST-ACTIVITY LEVELS OF VISUAL LEARNING

Pair	Mean	Standard Deviation	t	Sig. (2-tailed) p	Cohen d (effect size)
Pre-Activity	2.37	.56488	-10.696	0.000	-2.05
Post-Activity	3.18	.62247			
Pre-Activity ~ Post-Activity					
*N=27, students, α = 0.05					

Table V presents the mean scores of students' marks in pre-activity and post-activity, which are (M=2.37, SD=0.56) and (M=3.18, SD=0.62) respectively. The difference in mean scores is 0.81 points. Referring to the same table, it can be interpreted that there is a significant difference between the mean scores of pre-activities and post-activity, with a significant value (t=-10.696, p<0.05). Therefore, it can be concluded that, the implementation of visual learning intervention through the production of visual learning materials conducted with students between pre-activity and post-activity has a significant effect on the level of visual learning, with a small effect size (d = -2.05).

TABLE VI PAIRED T-TEST ANALYSIS FOR PRE-ACTIVITY AND POST-ACTIVITY LEVELS OF VISUAL COMMUNICATION

Pair	Mean	Standard Deviation	t	Sig. (2-tailed) p	Cohen d (effect size)
Pre-Activity	2.81	.50637	-4.561	0.000	-0.87
Post-Activity	3.25	.57735			
Pre-Activity ~ Post-Activity					
*N=27, students, α = 0.05					

Based on Table VI, the mean scores of students' marks in pre-activity and post-activity are significantly different, with (M=2.81, SD=0.50) and (M=3.25, SD=0.57) respectively. The difference in mean scores is 0.44 points. Therefore, it can be stated from the same table that, there is a significant difference between the mean scores of pre-activities and post-activity marks, with a significant value (t=-4.561, p<0.05). Thus, it can be concluded that the intervention of applying visuals through visual project presentation activities conducted by students between pre-activity and post-activity has a significant effect on the level of visual communication with a small effect size (d = -0.87). Table VII shows the one-way ANOVA analysis for the level continuum of visual thinking elements visual thinking, visual learning, and visual communication.

TABLE VII ONE-WAY ANOVA

ANOVA					
Continuum Level					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.006	2	.503	1.734	.183
Within Groups	22.630	78	.290		
Total	23.636	80			

It presents the one-way ANOVA test results, and the findings indicate no statistically significant differences on the visual thinking continuum [F (2, 80) = 1.734, p>0.05]. All levels of visual thinking, visual learning, and visual communication have improved. Figure 5 is a diagram generated from the findings of the study through pre- and post-activities continuum of visual thinking.

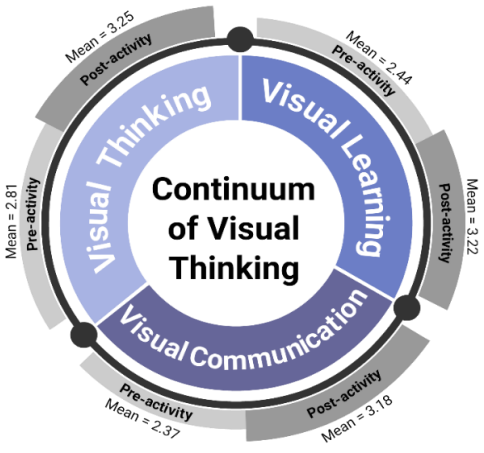

Fig. 5 Continuum of Visual Thinking through Pre- and Post- activities

Analysis of the Impact of Learning Activities on the Level of Students' Generic Skills

Referring to the results of data analysis through the minimum score in pre-service assignments and post-service assignments through Service Learning (SL) activities on the mastery of students' generic skills, based on the graduate attributes that need to be acquired in learning, in this research, students needed to assess only four generic skills during the course, namely, scholarship (SC), leadership and teamwork

skills (TW), adaptability (AD), and global citizenship (GC). A total of 27 students were involved in this Computer Network course. Tables VIII, IX and X show the data analysis through paired t-test for pre-SL assignment and post-SL assignment Before-Service Learning (SL), During-Service Learning (SL), and After- Service Learning (SL).

TABLE VIII PAIRWISE T-TEST ANALYSIS FOR PRE-SERVICE AND POST-SERVICE ASSIGNMENTS BEFORE-SL

Pair	Mean	Standard Deviation	t	Sig. (2-tailed) p	Cohen d (effect size)
Pre-service	1.96	.192	-5.467	0.000	-1.05
Post-service	2.43	.496			
Pre-service ~ Post-service					
*N=27, students, α = 0.05					

Based on Table VIII, the mean scores of students' marks in pre-service assignments and post-service assignments are significantly different, with values of (M=1.96, SD=0.19) and (M=2.43, SD=0.49) respectively. The difference in mean scores is 0.47 points. Thus, it can be concluded from the same table that, there is a significant difference between the mean score of pre-service assignments and post-service assignment scores, with a significant value (t=-5.467, p<0.05). Therefore, it can be concluded that the pre-service intervention through the service learning preparation assignment conducted by students between pre-service assignments and post-service assignments has a significant effect on the level of students' generic skills, with a small effect size (d = -1.05).

TABLE IX PAIRWISE T-TEST ANALYSIS FOR PRE-SERVICE AND POST-SERVICE ASSIGNMENTS DURING-SL

Pair	Mean	Standard Deviation	t	Sig. (2-tailed) p	Cohen d (effect size)
Pre-service	2.88	.405	-5.042	0.000	-0.97
Post-service	3.23	.591			
Pre-service ~ Post-service					
*N=27, students, α = 0.05					

Referring to Table IX, the mean scores of students' marks in pre-service assignments and post-service assignments are significantly different, with values of (M=2.88, SD=0.40) and (M=3.23, SD=0.59) respectively. The difference in mean scores is 0.35 points. Thus, it can be concluded from the same table that, there is a significant difference between the mean score of pre-service assignments and post-service assignment scores, with a significant value (t=-5.042, p<0.05). Therefore, it can be concluded that the during-service intervention through the service learning project assignment conducted by students between pre-service assignments and post-service assignments has a significant effect on the level of students' generic skills with a small effect size (d = -0.97).

TABLE X PAIRWISE T-TEST ANALYSIS FOR PRE-SERVICE AND POST-SERVICE ASSIGNMENTS AFTER-SL

Pair	Mean	Standard Deviation	t	Sig. (2-tailed) p	Cohen d (effect size)
Pre-service	2.94	.403	-3.766	0.000	-0.72
Post-service	3.16	.526			
Pre-service ~ Post-service					
*N=27, students, α = 0.05					

In reference to Table X, the mean scores of students' marks in pre-service assignments and post-service assignments are significantly different, with values of (M=2.94, SD=0.40) and (M=3.16, SD=0.52) respectively. The difference in mean scores is 0.22 points. Thus, it can be concluded from the same table that, there is a significant difference between the mean score of pre-service assignments and post-service assignment scores, with a significant value (t=-3.766, p<0.05). Therefore, it can be concluded that, the after-service intervention through the final report and presentation assignment conducted by students between pre-service assignments and post-service assignments has a significant effect on the level of students' generic skills with a small effect size (d = -0.72). The subsequent Tables XI and XII present a one-way ANOVA analysis and Post Hoc test for the level of students' generic skills, respectively.

TABLE XI ONE-WAY ANOVA

ANOVA					
Service Learning Activity					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	13.142	2	6.571	38.668	.000
Within Groups	13.254	78	.170		
Total	26.396	80			

TABLE XII POST HOC TEST

Multiple Comparisons						
Dependent Variable: Servis Learning Activity						
Tukey HSD						
(I)Activity	(J) Activity	*Mean Difference (I-J)*	*Std. Error*	*Sig.*	*95% Confidence Interval*	
					Lower Bound	*Upper Bound*
Before Activity	During Activity	-.85704*	.11219	.000	-1.1251	-.5890
	After Activity	-.85185*	.11219	.000	-1.1199	-.5838
During Activity	Before Activity	.85704*	.11219	.000	.5890	1.1251
	After Activity	.00519	.11219	.999	-.2629	.2732
After Activity	Before Activity	.85185*	.11219	.000	.5838	1.1199
	During Activity	-.00519	.11219	.999	-.2732	.2629
*. *The mean difference is significant at the 0.05 level.*						

Table XI shows results of this one-way ANOVA, which reveals a significant effect of Visual Hybrid Service Learning HiPS-V on the level of students' generic skills, F (2,80) = 38.66, p < 0.00. Tukey's HSD post hoc test shows the level of students' generic skills to be significantly higher, after the activity, compared with before the activity (p< 0.001), but it is not significant, if compared with during the activity (p>0,05). Figure 6 shows a diagram generated from the findings of the study, through pre- and post-service learning activities.

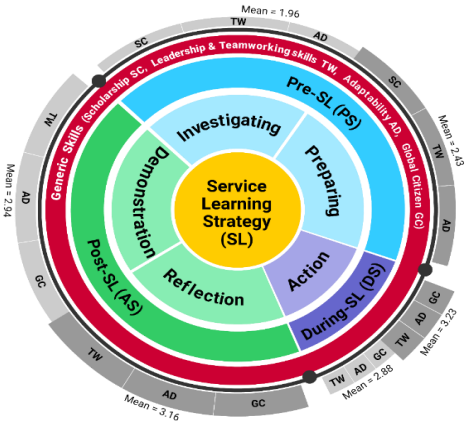

Fig. 6 Diagram of Service Learning through Pre- and Post-activities

Analysis of Student Perceptions of Service Learning Activities in Supporting Visualization Thinking Continuum

This section presents data analysis for perceptions of service learning activities in supporting the visualization thinking continuum of students through a questionnaire, divided into four constructs, namely, the use of visuals in thinking, integration of visuals in learning, application of visuals in communication, and hybrid service learning. Meanwhile, the interpretation of average scores (Likert Scale 5) refers to sources obtained from Azhar (2006) and Ahmad Munawwar (2009) to analyze the responses for each minimum item score given to the students.

TABLE XIII DESCRIPTIVE ANALYSIS OF STUDENTS' PERCEPTIONS ON VISUAL USAGE

No	Students' Perception on Visual Use	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
1	Activities using diagrams enhance my understanding.	–	–	1 3.7%	6 22.2%	20 74.1%	4.70
2	Activities incorporating visual elements help me learn better.	–	–	–	5 18.5%	22 81.5%	4.81
3	This activity, with its extensive use of visual elements, has aided my learning.	–	–	–	4 14.8%	23 85.2%	4.85
4	Activities using visual materials in preparing learning notes.	–	–	–	7 25.9%	20 74.1%	4.74
5	Activities providing images to illustrate learning concepts to me.	–	–	–	6 22.2%	21 77.8%	4.78
6	Activities using visuals for abstract learning content.	–	–	–	4 14.8%	23 85.2%	4.85
						Total Mean	4.79

TABLE XIV DESCRIPTIVE ANALYSIS OF STUDENTS' PERCEPTIONS REGARDING VISUAL INTEGRATION

No	Students' perception of visual integration	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
1	The website provides learning materials using visual displays.	–	–	1 3.7%	2 7.4%	24 88.9%	4.85
2	The website requires me to complete assignments using visual materials.	–	–	–	5 18.5%	22 81.5%	4.81
3	The website uses visual materials that explain the relevance of the learned topic.	–	–	–	6 22.2%	21 77.8%	4.78
4	The website that integrates visual materials makes it easy to understand computer networking topics well.	–	–	–	9 33.3%	18 66.7%	4.67
5	The website that uses visual materials makes learning content clearer.	–	–	1 3.7%	4 14.8%	22 81.5%	4.78
						Total Mean	4.77

TABLE XV DESCRIPTIVE ANALYSIS OF STUDENTS' PERCEPTION OF VISUAL APPLICATION

No	Students' perception of visual application	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
1	The activities provided allow me to communicate with other students.	–	1 3.7%	2 7.4%	10 37.0%	14 51.9%	4.37
2	The activities provided allow me to communicate in every discussion on learning topics.	–	–	1 3.7%	7 25.9%	19 70.4%	4.67
3	The activities provided give space for me to give comments/feedback in assignments.	–	–	1 3.7%	12 44.4%	14 51.9%	4.48
4	The activities provided use visual materials that can explain problem-solving better.	–	–	1 3.7%	5 18.5%	21 77.8%	4.74
5	The activities provided encourage me to use visual materials during presentations.	–	–	1 3.7%	3 11.1%	23 85.2%	4.81
						Total Mean	4.61

TABLE XVI DESCRIPTIVE ANALYSIS OF STUDENTS' PERCEPTIONS OF HYBRID SERVICE LEARNING

No	Perception of students towards hybrid service learning	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
1	Service learning activities through the learning website can enhance my understanding.	–	–	–	4 14.8%	23 85.2%	4.85
2	Service learning activities with the use of visual materials can provide a learning experience for me.	–	–	1 3.7%	4 14.8%	22 81.5%	4.78
3	Service learning activities can help me apply learning concepts to real-world problems.	–	–	1 3.7%	7 25.9%	19 70.4%	4.67
4	Service learning activities help me transfer learning concepts to implementation in real-world situations.	–	–	1 3.7%	5 18.5%	21 77.8%	4.74
5	Service learning activities enable me to share my knowledge with the community.	–	–	2 7.4%	2 7.4%	23 85.2%	4.78
						Total Mean	4.76

Based on Table XIII, the highest mean score for the "use of visual" construct regarding visual thinking is 4.85, indicating that most students agree that the use of visuals helps in learning through visual learning websites. Meanwhile, only 3.7% of students moderately agree with activities using visual displays in learning. In Table XIV, the highest mean score for the "integration of visual" construct regarding visual learning is 4.85, indicating that most students agree that visual learning websites provide visual materials, while 3.7% moderately agree on items 1 and 5, where they moderately agree with the integration of visuals in learning. Referring to Table XV, the highest mean score for the "application of visual" construct for visual communication is 4.81, indicating that students agree that, the provided activities can encourage the use of visual materials during presentations. Only 3.7% of students disagree that, the provided activities allow communication with other students. Furthermore, in Table XVI, the highest mean score for the "hybrid service learning" construct is 4.85, showing that students agree that service learning activities through visual learning websites can enhance their understanding in learning. Only one (1) respondent or 3.7% on items 2, 3, 4, and two (2) respondents or 7.4% on item 5 neither agree nor disagree with service learning activities through visual learning websites.

Figure 7 shows the students' perceptions through open-ended questions, and Figure 7 is a summary of coding themes derived from open-ended responses provided by the respondents. Five themes have been identified by the researcher to facilitate the analysis of responses, including knowledge, practical skills, real-life applications, understanding, and enjoyable learning. Each response theme presented has at least two answers given by the students.

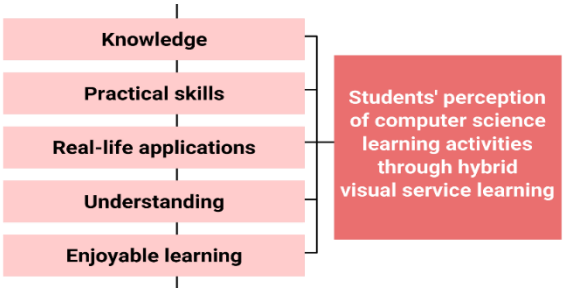

Fig. 7 Summary of Coding Themes for Students' Perceptions in Open Ended Questions

Analysis of Student Perceptions on Service Learning Activities through Interviews

To support perceptions through surveys, interviews were conducted with several students to obtain their responses regarding hybrid visual learning, through online service learning. A total of four questions related to the use of the website during service learning were focused on. Figure 6 shows positive feedback from students involved in service learning to support student visualization.

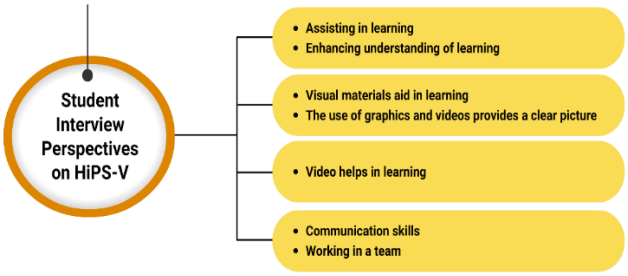

Fig. 8 Summary of Thematic Coding for Students' Responses through Interviews

Figure 8 refers to the thematic coding of students' perceptions, and overall, it shows that they have given positive responses during interview sessions using visual learning websites. Each question posed had at least two different answers based on the conducted interviews. The first question related to the use of learning websites resulted in three different responses expressed by the respondents; the websites assist in learning, the websites enhance the effectiveness of learning, and the websites improve understanding of computer network subjects. The second question, which pertains to activities involving visual materials, revealed two responses; the use of visual materials aids in learning, and the graphics and videos provide a clear understanding during the learning process.

The third question, which represents students' views on the use of instructional videos through websites, elicited responses indicating that students found the websites very helpful in teaching and learning, such as the use of instructional videos in computer network courses. As for the fourth question, which pertains to online learning services, students responded that these service learnings are very

helpful in enhancing generic skills, such as communication skills and working in groups.

Therefore, overall, most respondents provided positive feedbacks on the use of visual websites during the computer network course. Results of the interviews also suggest that, learning through visual websites is able to support the development of visual thinking continuum and enhance mastery of generic skills, through implemented learning service activities.

Data Analysis of Basic Guide According to Computer Science Learning Framework Based on HiPS-V Hybrid Service Learning

This study utilized a data triangulation approach to develop the Computer Science learning framework using the visual hybrid service learning HiPS-V. It involved analyzing data from the continuum of visualization thinking, learning service phases in each activity, as well as perception data and student interviews. Subsequently, triangulation processes were applied to assess how the HiPS-V visual hybrid learning service web could support students in acquiring generic skills throughout the learning service phases. Figure 9 illustrates the outcomes of the complete Computer Science learning framework, based on the HiPS-V visual hybrid service learning.

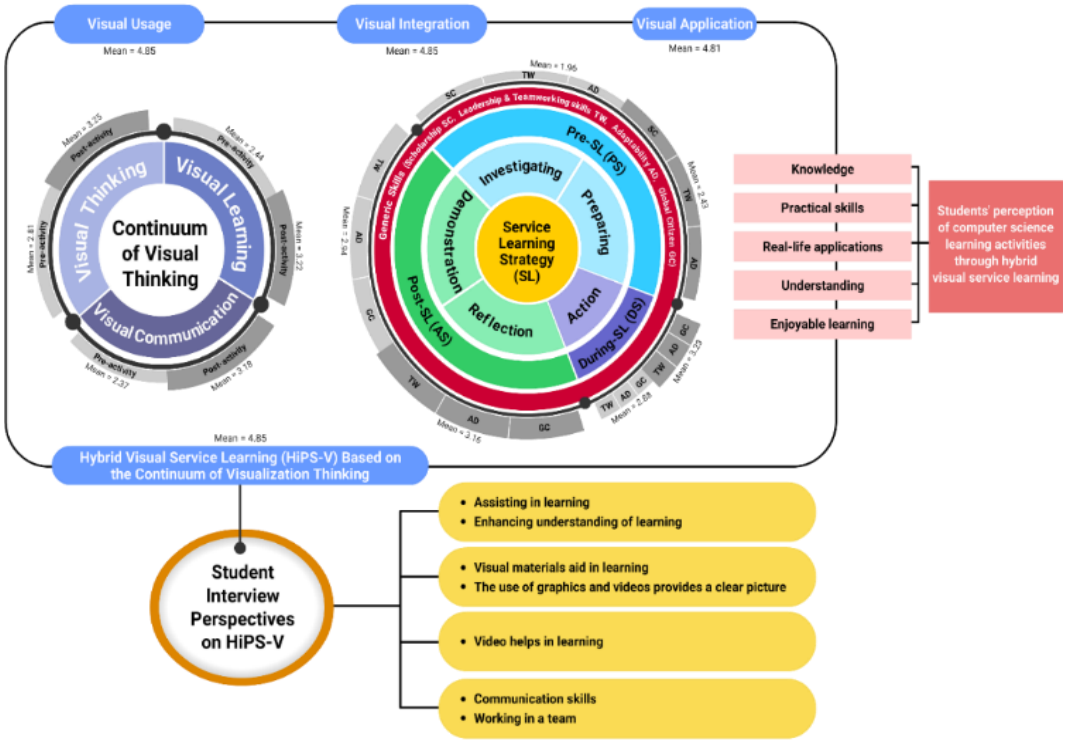

Fig. 9 Design of the Research Framework for Computer Science Learning Activities through the Visual Hybrid Service Learning HiPS-V

Figure 9, which refers to the framework of this study, is based on the design of Computer Science learning activities, through the visual hybrid learning service, based on five phases: the inquiry and preparation phases (Pre-service learning), the action phase (during service learning), and the reflection and demonstration phases (post-service learning) to support the continuum of students' visualization thinking. Based on these visual hybrid service learning phases, elements of the visualization thinking continuum, including visual thinking, visual learning, and visual communication, are integrated into the learning process to have a more significant impact on students' visualization thinking levels. Furthermore, the improvement in students' visualization thinking continuum levels has supported and positively influenced the levels of students' generic skills, namely scholarship (SC), leadership and teamworking skills (TW), adaptability (AD), and global citizenship (GC).

Meanwhile, to further strengthen the findings of the study through the design and development of HiPS-V, the respondents' perceptions regarding Computer Science learning activities through the visual hybrid service learning were obtained. It was found that, they agreed that the use of HiPS-V could enhance their knowledge and improve practical skills mastery. Additionally, they stated that HiPS-V provided them with opportunities to apply learning concepts in real-world situations, enhancing their understanding and promoting enjoyable learning experiences. In addition to these perceptions, interviews were conducted to gather their views on HiPS-V, and it was revealed that, its use could assist them in learning and enhance their understanding. The respondents also expressed that HiPS-V, with visual materials, aided them in the learning process. Moreover, the use of graphics and videos provided them clear illustrations and facilitated their learning. Lastly,

by using HiPS-V, the respondents were found to have gained the mastery of communication skills and teamwork.

In conclusion, it can be inferred that, to implement hybrid services learning more effectively and to support students' understanding and generic skills, as well as their visualization thinking, it requires the integrated incorporation of elements of the visualization thinking continuum throughout the phases of implementing the learning services.

IX. Discussion

The findings of the study indicate that, the intervention conducted through visual learning activities via the learning web (HiPS-V) has had an impact on the continuum of visualization thinking and the effects of Computer Network learning activities by integrating visual materials on students' generic skills. Therefore, examining students' perceptions of hybrid service learning activities in Computer Networks learning revealed an average post-test score increase, compared to the pre-test. A basic guide, based on the framework of Computer Science learning activities through hybrid visual services learning, supporting the continuum of visualization thinking and students' generic skills, has been developed.

The design of the HiPS-V learning web was tailored for Computer Network learning activities with visual materials through a Hybrid Service Learning comprising five phases; investigation, preparation, action, reflection, and demonstration. This structure supports the development of the continuum of students' visualization thinking. The elements of the visualization thinking continuum encompass visual thinking, visual learning, and visual communication, which are incorporated into the Computer Network learning web. The preparation process for the HiPS-V learning web was based on the ADDIE model proposed by Rosset (1987), consisting of five phases, analysis, design, development, implementation, and evaluation. Subsequent to the development of the visual hybrid service learning HiPS-V, the actual study was conducted with the respondents engaged in Computer Network learning for this research.

Learning activities were conducted over a 15-week study period to identify the respondents' levels of visualization and their proficiency in generic skills during the implementation of the Hybrid Service Learning. Their levels of visualization were assessed through pre- and post-activities, using the visual hybrid service learning HiPS-V, which was designed based on the elements of the visualization thinking continuum. Meanwhile, the proficiency in generic skills, encompassing four skills, namely, scholarship (SC), leadership and teamworking skills (TW), adaptability (AD), and global citizenship (GC) was evaluated through pre- and post-assignments in three stages of the learning service activities, before-SL, during-SL, and after-SL by the respondents.

Results regarding changes in the continuum of students' visualization thinking are presented in Tables IV, V, and VI, involving 27 respondents participating in learning activities through the visual hybrid service learning HiPS-V. The displayed tables represent the analysis results based on three elements of the visualization thinking continuum, namely, visual thinking, visual learning, and visual communication, through pre- and post-activities. Table IV, which examines the use of visual materials in learning activities to identify students' levels of visualization thinking, indicates that the intervention has a positive impact on students' visualization thinking levels, placing them in the 'good' category. Overall, it can be observed that, a total of 21 respondents are in the 'good' category, while the remaining 6 are in the 'moderate' category. Through these learning activities, the use of visual materials, specifically through concept mapping activities, proves to support the improvement of students' visualization thinking levels. This is aligned with the study (Atan et al., 2021), which also obtained positive results for learning activities using visual materials, encouraging students to explore abstract/theoretical concepts by transforming them into clearer infographic representations in students' minds. This supports the development of students' visualization thinking levels in understanding concepts by illustrating them through suitable visual representations (Albert et al., 2022).

Meanwhile, Table V also demonstrates a positive effect on the level of visual learning among students in pre- and post-activities through the creation of visual materials, such as infographic modules and demo videos. The learning activities, integrating visuals through the HiPS-V learning web, show positive progress in students' visual learning levels, which develop well through these pre- and post-activities. Students successfully master the integration of visual materials into their learning activities, as observed in studies (Wahyuningsih et al., 2021).

Furthermore, the level of visual communication among students also has a positive impact, through visual project presentation activities. Referring to Table VI, through pre- and post-activities involving the application of visual materials in these activities to identify the level of visual communication, it is shown that 12 respondents improved to a 'good' level, and 15 respondents remained at a 'moderate' level. Through the application of visuals in these visual project presentation activities, it is evident that students can communicate effectively and convincingly by using infographic materials, collaboratively. This is aligned with a study conducted (Kim & Lee, 2016), which states that the use of visual materials in student communication activities encourages the development of students' visual communication skills. Similarly, studies (Vanichvasin, 2021) also found the use of visuals alongside student learning activities to be effective in catalysing improvements in their visual communication skills, as well as supporting better learning outcomes.

Therefore, it can be concluded that, the use of visual materials based on the elements of the visualization thinking continuum through pre- and post-activities using the visual hybrid service learning HiPS-V has a positive impact on

students' visualization levels. This is because, students' visualization skills develop as a result of learning activities through the visual learning web, as emphasized in the study (Mcloughlin & Krakowski, 2001). Furthermore, the use of visual materials in student learning is crucial, not only as heuristic material but also to provide a clearer visual experience for students' visualization, as suggested by earlier research. Referring to previous studies, it was found that the use of visuals in daily life and learning activities can encourage students to interpret experiences and build understanding (Shoshina et al., 2020).

Tables VIII, IX, and X, summarize the study outocome, through the scoring scores for students' mastery of generic skills in four areas: scholarship (SC), leadership and teamworking skills (TW), adaptability (AD), and global citizenship (GC). These tables illustrate the mastery of all four generic skills by students through the conducted service learning activities. In Table VIII, it shows that 12 students achieved a good level of generic skills, and 14 students attained a moderate level. This indicates that the Pre-Service (PS) activities provide an opportunity for students to improve their levels of generic skills, in addition to enhancing their knowledge (Salhi & Qbadou, 2020).

Table IX presents the results of pre-assignment and post-assignment During-Service (DS), representing the mastery of generic skills in terms of leadership and teamworking skills (TW), adaptability (AD), and global citizenship (GC). Based on these findings, it is observed that only 3 students achieved a good level of generic skills, while 23 students attained a moderate level. As indicated in the studies (Vanichvasin, 2021), it is also evident that generic skills can be acquired during the implementation of service learning activities, as students apply the learned content in real-world situations.

Meanwhile, based on Table X, the mastery of generic skills, specifically leadership and teamworking skills (TW), adaptability (AD), and global citizenship (GC), can be supported as most students mastered them at both good and moderate levels through Post-Service (AS) activities. The service learning conducted provided a valuable learning experience for students, enabling them to effectively continue to acquire mastery of generic skills at this stage. This is aligned with studies (Gowanlock, 2020).

Overall, the generic skills of students in this study show positive changes in mastering all four generic skills, namely, scholarship (SC), leadership and teamworking skills (TW), adaptability (AD), and global citizenship (GC). The service learning activities proved to have effectively contributed to enhancing students' generic skills. The findings of this study are in line with those in (Vanichvasin, (2021) research, indicating that conducted service learning can improve students' skills in their learning, especially for those who were previously less actively involved.

Meanwhile, studies (Liu & Chen, 2020), indicate that Computer Science learning is also suitable for implementing service learning activities to support the development of students' generic skills. Besides, it can transfer conceptual knowledge learned to its application in solving real-world problems.

Results shown in Tables XIII, XIV, XV, and XVI regarding students' perceptions after using the visual hybrid service learning HiPS-V, show that the majority of them gave positive responses, with overall minimum values in the range between 4.00 to the highest minimum value of 4.80. The relatively high minimum values of students' perceptions indicate agreement with the use of this visual learning web in enhancing their knowledge and understanding in Computer Network learning. Students' perceptions through this questionnaire are consistent with their opinions expressed through open-ended questions, covering five response themes, namely, knowledge, practical skills, real-life applications, understanding, and enjoyable learning. To support the findings of students' perceptions through the questionnaire, feedback from student interviews also indicated positive responses to the use of the visual learning web, as reflected in their comments as follows:

S2:	*"…. The website has been very effective in my learning about computer networks..."*
S3:	*"...It helps me improve my understanding of the course taken... the use of elements such as the web and online platforms can assist me in grasping those concepts..."*

Therefore, based on these students' perceptions, it is evident that students exhibit a high interest and attention towards the use of visual learning websites, indirectly helping to enhance their understanding, consistent with studies (Çoban, 2020). The use of visuals can assist students in their learning and contribute to the development of their visualization thinking. This also indicates that, the use of visual elements such as text, graphics, audio, and video encourage positive development in students' visualization levels, subsequently improving their understanding. In an earlier study (Arnheim, 1969), it was explained that representing information through visualization can elucidate the abstract relationships within a subject. Visual thinking can be observed through the presentation of visual materials for students to express their ideas more effectively.

Based on service learning activities through visual learning websites, it can be observed that, students' engagement during the activities is demonstrated through their generic skills, as seen in the studies (Gowanlock, 2020). These studies indicate that service learning focuses on practical experiences in real-world situations, collaborating with the community to allow students to gain valuable learning experiences. Similarly, the research (Guney, 2019) highlights that students' acceptance of online learning as a learning medium has a positive impact on the learning process, accelerating and enhancing its effectiveness (Aziz and Ahmed, 2016). Service learning activities provide opportunities for students to further enhance their cognitive and social development, fostering knowledgeable students (Salhi & Qbadou, 2020).

Therefore, in this study, interventions were implemented and student perceptions were gathered through surveys and additional interview sessions to support the overall research findings. The study findings revealed that, the students' perceptions after using the visual learning website for all three continuum elements, namely, visual thinking, visual learning, and visual communication, were excellent. This provides a clear picture that, the visual website (HiPS-V) is effective in assisting students during their learning process, using visual materials. This underscores its importance in learning and contributes to the positive development of an individual's visual abilities. Consequently, the continuum of visualization thinking plays a crucial role in supporting students' visualization levels in their learning process (Guney, 2019; Gowanlock, 2020).

The Computer Science learning framework produced is based on service learning through the visual hybrid service learning (HiPS-V). This framework plays a crucial role as a reference for educators to ensure the smooth implementation of Computer Science teaching and learning methods, through service learning. According to studies (Mtawa & Nkhoma, (2020); Liu & Chen, (2020); Azali & Hassan, (2018) on web-based learning activities with visual materials, this learning approach represents a transformation in education, enhancing the quality of learning for greater effectiveness and efficiency. The development of this framework underwent two expert reviews, and each learning activity through the visual hybrid service learning (HiPS-V) is designed to support visualization levels and enhance students' mastery of generic skills, aligned with studies (Guney, 2019). These studies suggest that the use of visual materials can provide a positive outlook for students through service learning activities.

To ensure the effectiveness of learning through the visual hybrid service learning (HiPS-V), the application of visual materials is necessary, as highlighted in studies by Asilah (2021), which have a positive impact on students. When students use the visual hybrid service learning (HiPS-V) and engage in service learning activities, they are able to illustrate the learned concepts in real-world situations, as also revealed (Salhi & Qbadou, 2020), who emphasize the suitability of Computer Science learning through visual hybrid service learning. Furthermore, the implemented service learning activities provide students with meaningful learning experiences and enhance their knowledge in real-world scenarios.

Based on students' perceptions, it is evident that the learning web with visual materials can assist students in their learning, as found in studies (Gowanlock, 2020), highlighting the positive impact of using visual materials in learning on students' visual development. This is further supported by the overall views gathered from student interviews regarding the visual hybrid service learning (HiPS-V), demonstrating practical applicability in real-world situations. This is aligned with studies (Wahyuningsih et al., 2021), underscoring the effectiveness of integrating visual materials in service learning activities for students to master generic skills successfully.

Therefore, students' performance in Computer Science learning has been proven to improve when they can master the continuum of visualization thinking and generic skills, through service learning activities, as evidenced by the findings of this study. The use of the visual hybrid service learning (HiPS-V) serves as one of the learning mediums, making the teaching and learning process more effective, as highlighted in (Halim & Adnan, 2020), which states that incorporating visual materials in Computer Science learning methods can capture students' interest and enhance academic achievements. Hence, the Computer Science learning framework produced is based on the integration of Service Learning Strategy (Kaye's, 2010), Hybrid Service Learning (Waldner et al., 2012), Visual Thinking Theory (Rudolf, 1969), and Continuum of Visualization Thinking (Mcloughlin & Krakowski, 2001). This integration should serve as an example and guide for educators to diversify teaching and learning methods in Computer Science education.

X. CONCLUSION

Referring to the discussion outlined in this study, there were 10 learning activities implemented over a period of 15 weeks in the actual study with the students. The implementation of these learning activities was based on the elements of visual thinking continuum, namely visual thinking, visual learning, and visual communication, as well as the four generic skills, namely scholarship (SC), leadership and teamworking skills (TW), adaptability (AD), and global citizenship (GC), through the visual hybrid service learning (HiPS-V) provided, to observe the level of visual thinking continuum and the mastery level of generic skills by the students during the service learning. Based on the study findings, all students involved in the computer network learning content focused on experienced an improvement in terms of the level of visual thinking continuum and the level of generic skills very well. Most students showed significant improvement in visual thinking and successfully mastered all four generic skills through the visual hybrid service learning (HiPS-V). Therefore, this research framework has been developed by combining all the study findings to serve as an example and guide for educators in diversifying teaching and learning methods for students in the future. A suggestion for further research is to ensure for future instructional and learning processes to be more detailed than this study, and to produce visual learning materials with a unique quality.

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