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Efficacy of Learning Scaffolds in Teaching IT Students in the Zone of Proximal Development

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Abstract: This paper exhibits the learner sited in the zone of proximal development as it aimed to display the performance efficacy in the two levels of the zone of proximal development, the actual development level, where a learner performs independently, and the level of potential development, where a learner performs with the assistance of a more skilled individual. Execution viability in this study mounts learner experiences using learning scaffolds and determines efficacy performance using a pretest and posttest scheme and the mean scores of a controlled and experimental course learning activities. The study employed descriptive-quantitative design to ascertain efficacy in learners' feat. The experimental method of research was employed across researcher-identified tracking phases. It consisted of 65 student participants belonging to three sections taking Computer Programming course under the 1st year level of the Bachelor of Science in Information Technology program curriculum and were purposely selected based on qualifiers. The study revealed that the utilization of scaffolding strategies appears to be operative amidst the tracking phases from zero or little knowledge to the widening of the competency of a learner as results reflect incremental percentage frequency distribution in the learner experiences and considerably significant differences in the mean scores of a pre-test and post-test, and in the mean scores of the controlled and experimental laboratory activities. Henceforth, the researcher recommended that learners in areas across and outside information technology courses and curriculum may protrude distinctive scaffolding strategies as they manifest.

Keywords: learning scaffolds, zone of proximal development, level of potential development, actual development level

1. Introduction

This paper exhibits the idea of the Zone of Proximal Development (ZPD) developed by Russian psychologist Lev Semenovich Vygotsky. ZPD is defined by Vygotsky in his work, *Mind in Society: Development of Higher Psychological Processes (1978)*, as "*the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peer*." Educators and the experts of the corporate world in the workforce environment agree that student learners this day possess 21st century skills. In the identification of the critical areas of the 21st century skills, collaboration and teamwork, creativity and imagination, critical thinking, and problem solving, learners are challenged to be more competent and skilled. Accordingly, this study reflects on learner performance as Vygotsky have placed, on how students in the verge of learning process in tertiary level progress in the ZPD, particularly in its two aspects, the level of potential development where they are expert guided, and the actual development level, where they perform on their own skills and abilities. The ZPD is originally developed to account for the learning potential of children and investigates ZPD applications to the concept of teacher professional development (Shabani, K., Khatib, M., & Ebadi, S., 2010). It is also defined as the range of tasks that a learner can perform with the help and guidance of others but cannot perform independently. Within the ZPD are two levels, the *actual development level*, which is the upper limit of tasks that a learner can perform independently. And the second level is the *level of potential development*, where the upper limit of tasks that a learner can perform with the assistance of a more

competent individual. The study examines students taking the Bachelor of Science in Information Technology program under the Computer Programming course mining in the two levels of ZPD through course learning activities.

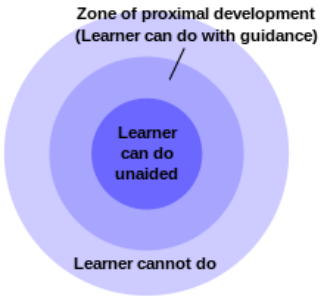

Figure 1. Zone of Proximal Development
(Source: https://en.wikipedia.org/wiki/Zone_of_proximal_development)

In Figure 1, the outermost circle presents what a learner cannot do. The study emphasizes a set of student learners who undergo a middle term course learning outcome (CLO) item as identified in a course syllabus. The topic under discussion is Java predefined methods. As the study highlights the two levels in the ZPD, the middle inner circle is where the learner can do with guidance. This is the Level of Potential Development, where students underwent course learning activities in the form of laboratory exercises through learning scaffolds passing through teaching/learning activities (TLA) i.e., concept discussion, actual program demonstration in the presence of a faculty, thus termed as controlled learning activities. In the Actual Development Level, represented by the innermost circle, students underwent course learning activities in the form of laboratory exercises on their own capability and aptitude, passing through self-paced learning scaffolds, thus termed as experimental learning activity. This is where self-instruction is applied by the student. In his book, Dickinson (1987) has defined that "self-instruction is a neutral term referring generally to situations in which learners are working without the direct control of the teacher." Both experimental and controlled learning activities engaged by students were assessed by a rubric applied to laboratory activities in courses adhered by the IT department of the institution. This study aimed to present the learner performances in the ZPD levels in topical area of Computer Programming to students under the BSIT program. Specifically, the following objectives were addressed:

1.1 Identify efficacy in learners' performance in the level of potential development level to the actual development level if there is a significant difference in the mean scores of a pretest and a post test and the mean scores of controlled and experimental learning activities.
1.2 Mount learner experience based on a seven-item questionnaire on the student learning experience, scaffolding strategies in the experimental CLA, devices used by students, IDE used, and SDK version sourced.

2. Learning Scaffolds

Scaffolding which is straightforwardly identified in the ZPD is defined as the support mechanism that helps a learner effectively perform task assignments branded within the ZPD. This process is completed by a more skilled individual, i.e. a faculty, supporting the learning of a less proficient individual, thus the student. As Bikmaz, et al. (2018) have put it, in scaffolding instruction, another more knowledgeable individual provides scaffolds or supports to facilitate the learner's development. In an educational context, scaffolding is teaching techniques or tools that provide a supporting framework for student learning. (Yantraprakorn et al., 2013). To implement scaffolding successfully, teachers must first determine the differences between what each student can accomplish independently and what he or she can accomplish with guidance, i.e. the student's ZPD (Gaskin et al., 1997). An important aspect of scaffolding instruction is that the scaffolds are temporary. As the learner's abilities increase the scaffolding provided by the more knowledgeable other is progressively withdrawn. Finally, the learner can complete the task or master the concepts

independently (Chang, Sung, & Chen, 2002). The scaffolding strategies used in this paper were identified whilst the learner is in the pace of actual development and potential development. These is presented in the 2nd and 3rd tracking phases as presented in figure 2. In the controlled course learning activity, identified learning support and scaffolding strategies will be presented via the delivery methods of the faculty. In the experimental course learning activity, they were identified by the researcher from which the respondents of this study have chosen.

Figure 2. Tracking Phases of Learners

Therefore, the goal of the educator when using the scaffolding teaching strategy is for the student to become an independent and self-regulating learner and problem solver (Hartman, 2002). The researcher labeled the tracking phases as shown in Figure 2. "Teacher scaffolding and more specifically, support that is adapted to or contingent upon a student's understanding, is considered effective in promoting student learning" (van de Pol, Janneke & Elbers, Ed. 2013). A faculty followed the phases in the conduct of this study. A pretest was administered to associate a curb in the learner performance. In the ZPD, this is where the learners have zero or little knowledge of the Java predefined methods topic. Learning scaffolds addressed in this study, is where the faculty performs responsibilities in accordance with the course learning outcomes, implementing delivery or teaching/learning activity (TLA) to students. This is to address key performance indicators developed in the HEI's Course Assessment and Evaluation Plan. The teaching/learning activity (TLA) mentioned in this document includes Lecture and Interaction/Recitation, Direct Instruction, Guided Discussion, Program Demonstration, and Accomplishment of laboratory exercises as shown in Figure 3, an excerpt screenshot from the HEI's Course Assessment and Evaluation Plan for Computer Programming 2 course.

Course Learning Outcome		Key Performance Indicator (KPI)	Student Outcome	Delivery (TLA)	Assessment Method	Assessment Tool	Evaluation Target
CLO 1	Distinguish the various tools used for analyzing code fragment behavior in solving, developing, and applying algorithmic solutions to programming problems. Predict program outputs and repair its errors.	a. Enumerate and identify various tools for code analysis. b. Describe key requirements when solving programming problems. c. Present program outputs.	A	Lecture and Interaction/Recitation Direct Instruction Guided Discussion Program Demonstration Accomplishment of laboratory exercises	Quizzes Seat works, Laboratory Exercises	Results of Quizzes	60% of students got >=3.0 on a 5-point scale

Figure 3. Delivery Methods in Teaching and Learning

These delivery methods were implemented to the learners as materialized in the level of potential development. This 2nd phase exhibited in the level of potential development is where the set of learners were steered with scaffolding strategies and assessed by controlled learning activities. Passing through 3rd phase identified in the level of actual development, the students was examined venturing on experimental learning activities. This is where the learners solved the laboratory activities in their own aptitude. "Scaffolding is another instructional strategy which assists in strengthening confidence as students slowly build their knowledge and skills as the content progressively increases in difficulty" (Hammond & Gibbons, 2005). The researcher termed the

learning scaffolds as: lecture and interaction/ direct instruction and guided discussion, program demonstration, and accomplishment of guided laboratory exercises. From these scaffolds, inventive styles were engaged. In direct instruction and guided discussion, context flows of programming problems included simulation, formative assessment included approaches such as the think-pair-share and pair programming. In the program demonstration, the skilled individual has commissioned MS Excel spreadsheets in the comparison of program output to aid the learners in catching up the logic of the program cited. It has been noticing that after comparing the process flows from an Excel spreadsheet, some learners already knew how to attack the program solution. Learning scaffolds used by the respondents in the experimental CLA included internet sources, help from classmates, help from other experts. Some even didn't use any. The researcher's 4th phase demarcates the posttest in the discovery of the efficacy of the learning scaffolds used in the levels of the learner performance in the ZPD. The 5th phase determines the user experience as to their feel of these phases.

3. Learning Management Systems

Various LMS were enumerated in the study of Dasig & Pascua (2015). Facebook as an LMS used for putting up announcements, sharing resources, organizing weekly tutorials and conducting online discussions at a teacher education institute. Moodle supports social constructionist epistemologies of teaching and learning in distance education, Blackboard, WebCT, and Desire2Learn. Several open-source and free LMS systems, such as Schoology, Moodle, Segue, Interact, CourseWork, Atutor, KEWL and several others. In another study, (Dasig, 2014) used Schoology to deliver blended learning approach in an Embedded System class which learners were provided online groups, classroom where assignments, project requirements, assessments, and other class activities are delivered. In this study, the Canvas LMS was commissioned in the delivery of the pretest, posttest, controlled and experimental course learning activities. Figure 4 displays the dashboard of the Canvas LMS interface and Figure 5 shows the weekly modules.

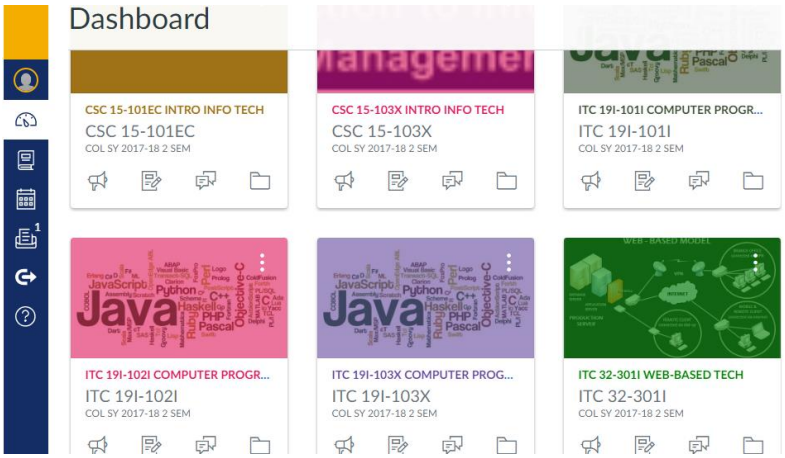

Figure 4. Canvas LMS Interface – Dashboard

Figure 5. Canvas LMS Interface – Weekly Module

The Canvas Dashboard shown in Figure 4 consists of two focal elements, the actual dashboard and the global navigation view. The former immediately displays the course view that provides access and updates in the courses. The latter provides quick links to all areas and can be accessed from any screen. The dashboard shows a screenshot view of six (6) courses from which the three (3) sections of Computer Programming course are captured. The sections mentioned are posted with its course code, ITC 19i, completed by the section code, ITC 19i-101i, ITC 19i-102i, and ITC 19i-103x. In figure 5, the global activity stream view displays of one of the Computer Programming courses. The figure indicates one of the weekly modules. A larger amount of this view contains the recent activities from the ITC 19i course including class announcements, discussions, assignment notifications, and quizzes. As the Canvas LMS is an easy-to-use and intuitive system, it is highly important to keep at pace in the classroom management skills of the faculty to its learners.

4. Research Design

The study employed descriptive-quantitative design to ascertain efficacy in learners' feat in the ZPD. The experimental method of research was employed in this study across the tracking phases the researcher had ascertained. In the pretest phase, the student participants were seasoned to yield on the topic of Java pre-defined methods as an item in the course syllabus of the Computer Programming course. The next phase is undertaking the controlled course learning activity (CLA) cumulative scoring using three (3) laboratory exercises, from which the participants had scaled coming from teaching/learning activity delivery methods with a more competent individual, exemplified by a faculty and pegged as the level of potential development in the ZPD. Further, the student participants took next phase where the participants were examined in the experimental course learning activity (CLA) cumulative scoring using three (3) laboratory exercises which they have solved on their own aptitude, thus stating this level as the actual development level.

Respondents consisted of three sections totaling 85 students taking Computer Programming course under the 1st year level of the BSIT program curriculum. These students belonged to the College of Computer Studies and Engineering division of a higher education institution (HEI) in Metro Manila. Sixty-five (65) student participants were purposively selected based on the following qualifiers: they have accomplished and completed the researcher-identified tracking phases as the pretest, controlled CLA, experimental CLA, and posttest, and user experience.

4.1 Instrumentation

The researcher used a 30-item pre-test and post-test scheme. Data collected as students procured the tracking phases in the line of using an LMS from which the HEI has instructed to utilize across its divisions. The participants were assigned three laboratory exercises for the controlled and experimental course learning activities (CLA). They were graded by means of a 10-point laboratory rubric guide developed by faculty committee teaching programming courses under the IT department supervised by the chairperson. A 7-item researcher-made survey questionnaire with 4-point Likert scale was floated online using Survey Monkey to determine learner experience in the actual development level phase instrumented in the learning scaffold strategies pegged by the researcher. The 4-point scale with no neutral option was used to extract specific responses from the students, from which the options were: strongly agree, agree, disagree, strongly disagree. The 7-item questionnaire designed for this study was subjected to a validation process for content validity, as preceded by a project headed by the Office of the Vice President for Information Systems in using BYOD contrivance in the HEI. Content validity is defined by McBurney (1994:123) as the notion that a test should sample the range of behavior represented by the theoretical concept being tested. In the validation process, this type was used. The 7-item questionnaire were formulated by six experts of the Bring Your Own Device project study of the HEI. These were the VP for Information Systems, IT director, coordinator of the Institute of Technology-Based Learning, and three faculty of the IT department under the College of CSE who were implementing the Canvas

LMS for their delivery methods in teaching and learning. The experts have formulated and tapped the questions in the intention of measuring the relevance of the objectives of the study. Following the formula in calculating the content validity ratio (CVR), the questionnaire's worth is based on the ratings of the experts.

Formula: $CVR = [(E - (N / 2)) / (N / 2)]$
where: E is number of experts who rated the questionnaire as essential, N is total number of experts

In the compliance of the experimental course learning activity (in the actual development level in the ZPD), where the students have conformed to submit their three (3) laboratory exercises, other elements observed by the researcher were: scaffold strategies, devices used outside the HEI assigned laboratory room, IDE used, and JDK version sourced. The 30-item pre-test and post-test subsequently followed by the scores of controlled and experimental course learning activities were administered to the group to determine the difference of performance as well as to mention the efficacy of the learning scaffolds. The researcher utilized percentage frequency distribution to display the data expressing relative frequency of the responses for the learner experience in the experimental CLA in the actual development level afterward the level of potential development in the ZPD. The statistical mean and t-test value for the learner efficacy in the results of the pretest and posttest, and the controlled and experimental course learning activities.

5. Results and Discussion

This section presents the results of the analysis conducted. Of the 65 respondents, 52 or 80% are male and 13 or 20% are female. Correspondingly, the succeeding parts will contain the: percentage frequency distribution of the Learner Scaffolding Strategy Experience, percentage frequency distribution of the 7-item questionnaire from the learner experience, statistical mean of pretest and posttest and; statistical mean of controlled and experimental course learning activity (CLA) to measure efficacy of the learning scaffolds

5.1 Learner Scaffolding Strategy Experience

5.1.1 *Learning Tasks in the Controlled Course Learning Activity (CLA)*

Following the tracking phases of the study, the HEI's Course Assessment and Evaluation Plan served as the basis of trail of monitoring learner paces. This plan adapts to the Outcomes-Based Education measure for each course offered in the HEI. A measurement tool reports its attainments. The teaching/learning activity (TLA) conforms with the Assessment Method, Assessment Tool, and Evaluation Target. The scaffolding strategies employed in this study for the Course Learning Activity disclosed in this study is the Accomplishment of Laboratory Exercises as the main substance utilized. Laboratory exercises included demarcates the topic on Java methods. Table 1 shows the result of the laboratory exercises for the controlled and experimental CLAs in the duration of this study.

Table 1 *Measurement of students under ZPD in the Laboratory Exercise Learning Task*

Assessment Method & Tool	Laboratory Exercises Results Controlled	Section A	Section B	Section C	Laboratory Exercises Results Experimental	Section A	Section B	Section C
Evaluation Target	60% of students get >=80%	*21/28 (75%)*	*13/20 (65%)*	*16/17 (94%)*	60% of students get >=80%	*28/28 (100%)*	*17/20 (85%)*	*16/17 (94%)*
Remark		*Attained*	*Attained*	*Attained*		*Attained*	*Attained*	*Attained*
Average of Scores		*90%*	*93%*	*94%*		*97%*	*96%*	*98%*

5.1.2 Learning Tasks in the Experimental Course Learning Activity (CLA)

On the other hand, results in the experimental learning activities underwent by the learner on the tracking phases signify the learning scaffolds tapped reflects that 47.92% utilized the internet for aid in solving the laboratory activities, only 3.08% needed aid from another competent individual. Students tapped in the study who underwent the tracking phases of the delivery methods in the level of potential development zone have reflected much improvement as seen in the actual development zone. Further, 17.24% or 10 of 65 students managed to ensure that their compliance is on their own propensity, gaining enough skill from the level of potential development in the ZPD where they were aided by a faculty through the teaching/learning activities. Table 2 presents the actual number of learners involved.

Table 2 *Strategies Used in the Experimental Laboratory Activity*

Strategies	Number of Students	%
Internet sources	28	47.92%
Help from classmates/friends	25	38.46%
Help from other experts	2	3.08%
Did not use scaffolding strategy	10	17.24%
TOTAL	65	

Table 3 *Percentage of Devices Used*

Devices		Responses	%
Smart Phone	Owned	5	8
Laptop	Owned	20	37
	Borrowed	4	
Tablet	Owned	1	5
	Borrowed	2	
Desktop	Owned	10	51
	Open Laboratories	21	
	Library	2	

Table 3 stages the list of devices the students have utilized in the compliance of the laboratory exercises outside the laboratory room. 51% have used desktop computers, and only 5% have operated on their tablets of which 1 owns, and 2 have borrowed. The Computer Programming course allows students to become well versed in Java. Different IDEs might be employed to hard code programs. Table 4 shows the type of IDE the students have used in the compliance of the laboratory exercises outside the laboratory room.

Table 4 *Percentage of Integrated Development Environment Used*

IDE	Responses	%
JCreator	47	72
Netbeans	9	14
Eclipse	3	5
Other IDE	6	9
N=65		

The largest representation of 72% or 47 of 65 students have used JCreator as their preferred IDE in coding their programs. Three (3 of 65) students or 5% were able to utilize the Eclipse IDE. In trailing the IDE usage, table 5 presents a list of the Java SE that the students have installed and used in conjunction with their favoured IDE.

Table 5 *Percentage of Java Development Kit Version*

JAVA Version	Responses	%
JDK Beta	1	2
JDK 1.1	2	3
J2SE 1.3	1	2
J2SE 1.4	1	2
Java SE 6	3	5
Java SE 7	4	6
Java SE 8	36	55
Java SE 9	7	11
Java SE 10 (18.3)	3	5
Unknown	7	11
N=65		

Substantiating the records on table 5, most of the students have favored Java SE 8 as the installed JDK version in their devices. Shadowing 2% of respondents, it sums up to three (3) JDK versions of JDK Beta, JDK version 1.3, and JDK version 1.4 respectively.

5.2 Learner Experience Questionnaire Responses

The seven-item researcher-based questionnaire as validated by a committee presents the following:
Q1 I find the instructional materials (such as lecture files, links, etc.) in Canvas easy to understand.
Q2 I find the course learning activities (laboratory exercises) doable.
Q3 I am able to effortlessly connect to Canvas when my class requirement commands me to do so.
Q4 I am comfortable doing the activities inside the laboratory room.
Q5 I am comfortable doing the activities outside the laboratory room within campus.
Q6 I am comfortable doing the activities outside the laboratory room and outside the campus.
Q7 For future courses, do you prefer bringing and using your own device to fulfill the activities required by the course?

Table 6 presents the percentage distribution of the seven questions commissioned and their responses as the effects of the learner experiences in the complying with the laboratory exercises outside the laboratory room assigned to them identified as the experimental course learning activity applied in this study.

Table 6 *Learner Experience Results*

	Strongly Agree	%	Agree	%	Disagree	%	Strongly Disagree	%	TOTAL	N
Q1	28	43	36	55	1	2	0	0	100	65
Q2	29	45	35	54	1	2	0	0		
Q3	20	31	42	65	3	5	0	0		
Q4	20	31	40	62	5	8	0	0		
Q5	13	20	38	58	13	20	1	2		
Q6	26	40	26	40	11	17	2	3		
Q7	16	25	38	58	8	12	3	5		

Topping this list is question 2 where 45% have strongly agreed they find the course learning activities were doable. Falling behind is question 5 which marks that 20% of the students have strongly agreed that they were comfortable doing the activities outside the laboratory room within campus. This suggests that the 20% had their opportunities of being inside the university utilizing its

resources such as the computers in open laboratories, desktop PC, loanable netbooks inside the library, or simply using own devices brought in the school premises. Then table 7 presents the computed weighted mean for each question as these have been interpreted using a 4-point Likert Scale to determine exact results. As reflected, the computed responses in all questions ranges from 3.4 to 3.0 which can be interpreted that the responses gathered from the learners concludes that they "agree." And the overall computed mean for all is 3.2 which yet can be interpreted as "agree" as evaluated by the respondents.

Table 7 *Learner Experience Results – Weighted Mean*

	SA	A	D	SD	Weighted Mean	Interpretation
Q1	28	36	1	0	3.4	A
Q2	29	35	1	0	3.4	A
Q3	20	42	3	0	3.3	A
Q4	20	40	5	0	3.2	A
Q5	13	38	13	1	3.0	A
Q6	26	26	11	2	3.2	A
Q7	16	38	8	3	3.0	A
Grand Mean					**3.2**	**Agree**

5.3 Efficacy of the Learning Scaffolds in the Learner Performance in the ZPD

The study resulted in the groundwork of the objective to identify efficacy in learners' performance if there is a significant difference in the mean scores of a pretest and a posttest; and the mean scores of experimental and controlled learning activities. The table 8 shows that the tracking phases employed by the researcher were operative. This implies a significant difference in the result data. The SD in the pretest was 5.262 while in the posttest was 5.857. The mean for the pretest is 14.54 while the mean for posttest is 19.14. The difference between the two is -4.600 which has a t-value -6.017 and significant difference in the score with 0.001 at α=0.05 and 64 degrees of freedom.

Table 8 *Pre-Test and Post-Test Scores*

Variables	Mean	SD	Difference bet. the Means	t	Sig
Pretest	14.54	5.262	-4.600	-6.017	0.000
Post test	19.14	5.857			

The experimental laboratory activity has gained remarkable improvements on the learner performance after the interventions on the controlled learning activity was given and the faculty has used the identified delivery on the teaching and learning activities (TLA). It entails a significant difference in the efficacy of the controlled and experimental laboratory activity performance as shown in table 9. The standard deviation in the Controlled CLA was 21.17 while in the Experimental CLA was 26.74. The difference between the two is 5.569 which has a t-value -6.261 and significant difference in the score with 0.000 at α=0.05 and 64 degrees of freedom.

Table 9 *Scores of the Controlled and Experimental Course Learning Activities*

Variables	Mean	SD	Difference bet. the Means	t	Sig
Controlled CLA	21.17	7.648	5.569	6.261	0.000
Experimental CLA	26.74	6.091			

6. Conclusion and Recommendation

In the ZPD, it is highly essential that the development of mental capacities of students, especially in the early years of tertiary must be assessed through collaboration with a more competent individual,

and not solely based on one's independent pace. In the course of this paper, students under the IT program in a university were tapped by the researcher to allow discovery beneficiaries that the utilization of scaffolding strategies were operative amidst the tracking phases from zero or little knowledge to the widening of the competency of a learner as results reflect significant differences in the mean scores of a pre-test and post-test, and in the mean scores of the controlled and experimental laboratory activities. The researcher utilized the Course Assessment and Evaluation delivery methods as the teaching/learning activities as scaffolding techniques for the controlled laboratory exercise in one tracking phase of this study. For the experimental laboratory exercise, students have identified that after undergoing the delivery methods from a faculty as their guide in the level of potential development zone, much improvement is seen in the actual development level where the group showed that only 3.08% needed aid from another competent individual. The respondents in this study leads to the degree of BSIT program of the College of Computer Studies and Engineering umbrella. Forthcoming researches may consider an attempt to investigate and contextualize on the applicable learning scaffolds to measure learner performances in the ZPD in other programs offered in the higher education institution (HEI). Consequently, it may be imperative that other groups in the program may act as participatory respondents to develop learner pace in the ZPD in other courses or areas of the IT track.

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