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Effectiveness of Active Learning Strategies for Engaging Learners and ImprovingPerformance in Data Structures Engineering Course

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Abstract: Engaging learners into learning tasks is one of the challenging aspects in andragogy. Various methods have been proposed and developed for efficiently engaging learners. Active and Collaborative Learning (ACL) is one such technique that incorporates interactive classrooms activities to reinforce concepts. Higher educational teachers seldom consider the psychological aspects of the present generation students. Traditional lecture-based approaches are found insufficient. The widely available scientific educational practices need to be considered and incorporated into their learning environments. These practices need to be adopted in teaching and in learning such complex courses. This work describes the use of ACL strategies that were implemented for data structures engineering course that incorporated psychological, sociological and philosophical aspects of learning. Through this approach and from the feedback obtained from learners, the program outcomes of 3a, 3c and 3i of ABET essential graduate attributes are successfully mapped.

Keywords: ICT, virtual learning; e-learning; learning management.

1 Introduction

The increase in student intake and the growing interest towards computing courses in SRM University have demanded uniformity in teaching learning processes across the different teachers handling the same course. The rapid advancements in engineering and technology demands usage of Active and Collaborative Learning (ACL). Learning derived from experience are influential and persistent in students. The role of an instructor in teaching-learning process is as follows; identifying learning requirements, creating specific student course learning outcomes and corresponding session learning outcomes, improving teaching and learning strategies, implementing the designed strategy, and also assessing & verifyingthe learning (S. Freeman & S.L Ready, 2014). Few learning strategies that engage learners such as; self-directed learning, role-play, peer learning, web-based learning and problem based learning are widely popular to engage learners (D. E. Meltzer& R. K. Thornton, 2010).

The use of ACL strategies for engaging learners in classrooms and its effect on learning have proven that active learning approaches are more effective towards developing student's higher order thinking abilities. (Christhu Raj & Rajeev 2017). To create a meaningful learning experience, ACL helps adapt scientific educational theories, thus enabling learners toremember, understand, apply, analyze, evaluate, create and customize their own individuallearning environments. Learning techniques (T. Richter, S. Rudlof, B. Adjibadji, H. Bernl C. Gruninger, C.-D. Munz, A. Stock, C. Rohde, & R. Helmig 2012) and Virtual-learning environments (Y. S. Son & Y. S. Lee 2013), can also be integrated along with the course instructor's inputs to form a blended learning experience to the current generation learners.

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The important courses in Computer Science Engineering curriculum are Problem Solving Techniques, Data Structures, Database Management Systems, Operating Systems and Algorithms (Y.S Son & Y. S Lee 2012). Problem Solving courses like C, C++, Java, Data-Structures are offered in consecutive semesters and they require high level of criticalthinking skills. Techniques for engaging students in Data-structures courses have been proposed over the years (Alice Y. Kolb, David A. Kolb, 2013). The use of andragogical apporaches in text-books are neither ignored nor in-sufficient to engagelearners in the learning rooms (Latha, Christhu Raj & Rajeev 2016). The drawbacks in adopting the same set of ACL strategies for different courses or for the same course with different text-books again resulted in least interest among learners.Fair-balance in various learning styles among learners and ACL techniques also needs to be considered for effective engagement. Therefore, there is a need to consider the psychological, sociological and philosophical aspects of learners. In this research study, ACL techniques were developed and implemented for the Data-structures course in order to engage learners efficiently and also to improve their problem-solving skills.

The course instructor adopts a three-fold methodology to engage learners such as; think-pair, build using technologies and discussion. This course is outlined for programmers with essential experience looking to understand the practical and conceptual foundations of the different data structures that are available. The course is aimed at studying algorithms that comes collectively with a set of suitable data structures that enable the algorithm to manage the data efficiently. Figure 1 shows the concepts in Data-structures that the students are studying for a semester course study.

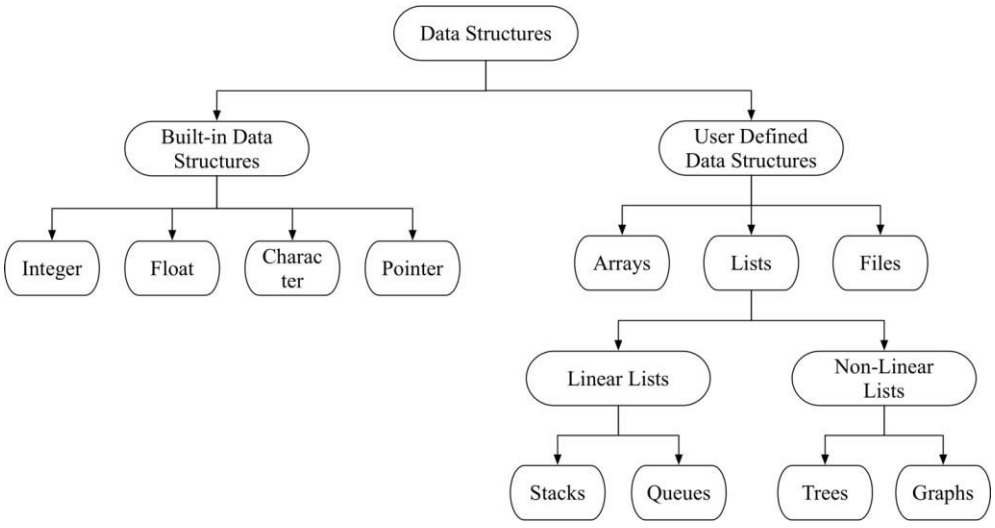

Figure 1. Introduction to Data Structures

In this research study, the following objectives are addressed: (a) creating a mindset in learners to appreciate and understand the relevance of this course and its importance to their lives and careers. (b) Helping learners to understand the context in which this course is

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learnt (c) creating interest towards learning and practicing using psychological methodologies (d) utilizing theories in education with an objective to improve learning. Towards achieving efficiency and effectiveness of the set forth objectives, different ACL techniques were used, in addition to the traditional class lectures and were periodically monitored using a well-constructed Learning Management System that was based on virtual learning environments

2 Analysis for the Study

In the analysis phase of this study, the following factors were considered for improving learning effectiveness, namely a) environmental b) emotional c) sociological d) physiological e) psychological. The learning aspects and its elements are presented in Table 1.

Table 1 Learning Aspects and its elements

Aspects	Parameters
Environment	Light, sound, seating design, learning room design
Emotional	Motivational support, persistence, self learning
Philosophical	Perceptual intake, rationale for studying
Sociological	Individual or group task, pair, varied
Psychological	Global, active, reflective, analytical, impulsive

Psychological assessments were conducted to identify the learning aspects in students. Thinking styles among learners were identified using Richard Felder and Solomon thinking style assessments. This assessment was administered for 65 learners and the results are summarized in Table 2.

Table 2 Summary of Learning Styles

Active	Reflective	Sensing	Intuitive	Verbal	Visual	Global	Sequential
41	24	39	26	03	62	49	16

The above table represents that learners have different learning styles. There is a need to fairly balance ACL techniques to suit these learning styles. The course rationale and learning outcomes for every learning session are informed inadvance to students. Students are divided into 12 groups and each group has on an average 5 students. These group will be shuffled after the completion of every learning module in the course. To balance the psychological and sociological aspects, various aspects of ACL techniques such as; Mindmap, puzzles, Keyword search, Multiple choice quesions, Quizzes, Role- play, Presentations, Videos, Animations and few more activities have been used in the class. The students are also given Project Based Learning (PBL) assignments such as; video making for concepts, animation creations, programming concepts and other group activities for outside class learning engagement. Table 3 maps ACL techniques to corresponding data structure topics.

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Table 3 ACL Techniques and it's maping with Topic

ACL Technique	Topic
Mind Map	Linear and non-linear Data structures
Quiz	All individual session
Role-Play	Stack, Queue, Expression, Searching, Sorting
Video-Presentation	Linked List, Hashing techniques, Trees
Puzzle (includes word search)	Stack, Lists, Graphs, Arrays
Match the following	Iterators, Tress, Hashing, stack, queue, expression, searching and sorting
Video Scribe	Student assignments

Using technology tools such as; video-scribe, prezi, and keynote, students were able to make their learning presentations by understanding the concept. This yields them confidence and motivation to learn the concepts. Also, students are actively engaged in the learning process by learning new technology tools.

3 Design of Course Materials

Various ACL strategies have been designed such as puzzles, keyword search, quizzes, fill in the blanks etc., areused to engage the students in the learning process. The students already have a pre-requisite course on 'C' programing language to implement and test the concepts and algorithms by writing computer programs. Figure 2 shows the learning materials used inside class learning.

Based on grouping theories, the learners were grouped into twelve teams with five members per team. Each team has chosen a unique topic; (i) Arrays (ii) Single Linked List (iii) Double Linked List (iv) Circular Linked List (v) Stack (vi) Infix to postfix conversion (vii) Queue (viii) Priority Queue (xi) Minimum Spanning Trees (x) Graphs (xi) Hashingtechniques. (xii). Recap of modules. The learners have taken the responsibility to choose appropriate ACL for learning the concept and implement their learning for other students. Every member of the team was assigned to ensure that all learners had respiective roles to perform and learn.

Learners were given time to prepare their individual learning of the topic assigned, and each team had been given specific slots to present their findings. Learners have created the mind map, concept map, animations, presentations and videos, which implicitly focus on concepts of learning. Mindmap, role-play, quizzes, videos, and animations were popular amongst the students. Figure 3 shows the mind map for Data structure concepts.

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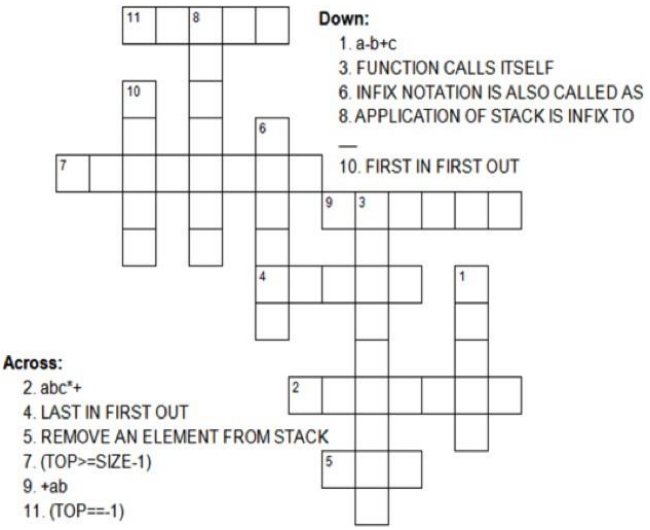
Word Search

stack	queue	top	push	pop
recursion	empty	overflow	infix	postfix
prefix	hanoi			

h o h u f y o z j j j v c g t g g y y v
u f m n p l e q e d e i q q l b y y j b
z m l o o x p s s a a q v e b l n v t e
d c h i s h o k j z c n s m x d c i z d
q a q s t u p l q z x j t s d m o v s d
l l d r f j p m l o a i a f j r m x g l
v j i u i u m k t b v a c c p s m k g l
q l y c x p t v a e c x k m e i q i d j
m d n e y p w y c k z n s p u o v h e n
z k p r f b r k z s l k j o e n u q m g
u k g c t k a n b e l m t t u a h v p h
p g y h y v w c k w z c w y q h b n t z
r a s z v t a w h e t d m s b b w s y q
e w x g h s n o v k g d r o m u x u m w
f t b k h w l l s h w c s f x q a b w c
i s c s c n k f n u q i z x i i v e t l
x k o n g t q r b x h s m s f k j f h a
y a z c y d l e u n h u h p n e y c n w
b o p e m j w v i l p u s h i x q f d h
k y w e k n t o y u e e h e c v s a w x

(a) Word Search



(b) Crossword Puzzle

Top++; stack[top] = value;	Stack is Full
top == -1	POP()
i=top; repeat till stack empty stack[i]; top--;	Delete()
Top==size-1	Peek()
stack[top]; top--;	Stack is empty
	Create()
	STACK()
	POP()
	PUSH()

(c) Match the following

```
node *stack_list::pop(node *top)
{
    node *tmp;
    if (top == NULL)
        cout<<"_____ "<<endl;
    else
    {
        tmp = top;
        cout<<"Element Popped: "<<tmp->info<<endl;
        top =_____;
        free(tmp);
    }
    Return_____;
     }
```

(d) Fill in the blanks

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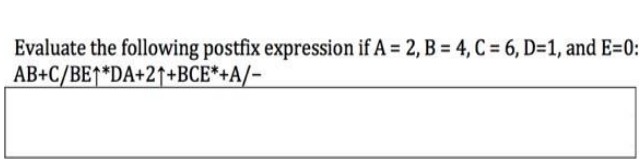
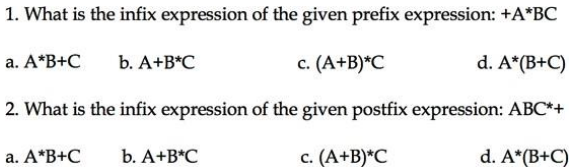


(e) Evaluate the problem



(f) Multiple Choice Questions

Figure 2. Active Learning Techniques for In-Class Learning Engagement

Figure 3. Mind map for Recollecting Concepts

3 Development Model Phase and Results Intrepretations

Among the strategies implemented, puzzles, mind map, role-play and quizzes are most popular among students. PBL like video and power point presentation making are other popular techniques. Learners had presented the concepts usingACL. The complete course was implemented using ACL, and a questionnaire was prepared to collect feedback from the learners. The motivation behind collecting feedback was to ensure the usefulness of the ACL in class learning. The parameters included in the feedback survey shows how the Visualization Techniques has helped in learning the module.

Table 4 shows the parameters of eight statements for learners. The scale determines the values; 1-Strongly Disagree (SD), 2-Disagree (D), 3-Neutral (N), 4-Agree (A), 5-Strongly agree (SA). Nearly 80% students agreed to continue the mapping techniques for other classrooms lectures also. Improvements in the performance of students during class interaction and assessments were observed. This further supports the use of visualization techniques for learning reinforcement, motivation and improvement. Furthermore, the facilitator was able to implement the higher order thinking style using Bloom's Taxonomy. The results show that visualization techniques have helped to improve learning and also to achieve the learning outcomes of the individual learning sessions. Feedback shows that active learning strategies are generally seen as useful learning techniques in classrooms.

Table 4 Learner's Feedback on ACL Techniques in Data Structures Course

Feedback	Response from Learners					Disagree (%)	Agree (%)	Neutral (%)
	SD	D	N	A	SA			
ACL helped me to creatively think	3	4	3	38	17	11	85	4
Simplifyied Complex Concepts	2	1	2	39	21	5	92	3
Ease of understanding	5	7	8	22	23	18	69	12
Big Picture of learning	3	6	7	27	22	14	75	11
Interesting and Engaging	4	6	9	21	25	15	71	14
Revision before Exams	3	4	1	28	29	11	88	2
Future Class Implementation	5	6	2	31	21	17	80	3
Linkage between concepts	4	5	6	26	24	14	77	9

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ACL helps students to learn the concepts with interest and the same was reflected in their examinations. Thestudents have undergone two internal continuous assessment tests and one model theory examination that covers the whole course content. The performance of the students has been enhanced, and the results of University End Semester Examination results proved the acceptance of ACL and the students understanding levels of each concept is reflected. Figure 4 shows the result analysis obtained in the end semester evaluation.

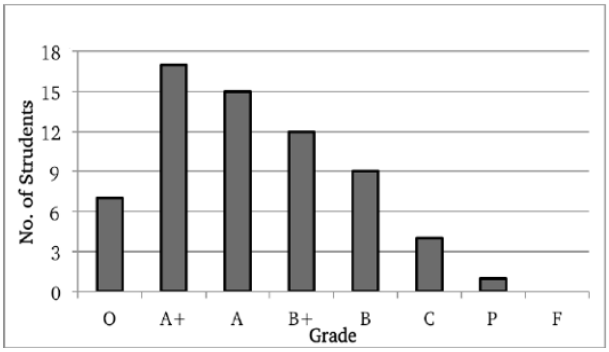

Figure 4 Result analysis of End Semester

Examination

The above figure shows that the learner's performance has increased drastically towards O and A+ grades and the weak students could also able to score well, and they have understood the concepts. The grades and grade points are explained in Table 5.

Table 5. Grade Point

Grade	O	A+	A	B+	B	C	P	F
Grade Point	10	9	8	7	6	5	4	0

From the reference Table 5 and Figure 4, it is observed that the learner's performance was improved to O and A+ grades. More than 50% students achieved O and A+ grades, and there were no failures in the subject. Weak student's performance also improved by using ACL techniques and by taking defined action plans for them.

3 Conclusion and Future Enhancements

This research study on the use of ACL for the course Data Structures helps any teaching researcher to introspect the present modalities followed, to adapt new and better practices in producing meaningful and purposeful learning in our current generation students. Student feedback about the entire course has been highly positive; most students expressed that they would like all their courses to be converted into such ACL supported courses. The learner's consolidated report shows that ACL was seen as the effective tool for learning and retention of concepts. ACL makes students to learn the concepts in depth and with interest. The core subject chosen is to develop confidence in learner's mind that the concepts are interesting and easy to study. Using ACL, the learners are engaged in the class as the strategies make them involve in activities. This better understanding of concepts and basics can encourage

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the engineering students to take up self or group research workand publish solutions for many-core related issues.

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