VHDL$_{\text{ISTE}}$: An Instructional Strategy to Cover the Additional Content beyond the Curriculum

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Abstract: In current scenario of engineering education, Students must have more practical knowledge and skills required to work in the technologies that are currently used in industries though they are not the part of the curriculum. The instruction based videos help students to develop their hands on the new skills that are essential for their adaptability to new technologies. Handout is the guided document which contains the instructions to follow during the laboratory session to complete the problem statement given in the assignment. Assessment of their knowledge acquirement and skills is done through grading of assignments given to them. So in this article, VHDL$_{\text{ISTE}}$ (Instructional Videos followed by Handout Learning – Implement, Submit, Test, and Evaluate) instructional strategy is designed and implemented for Tableau: A Visual Data Analytics Tool which is the part of the course Business Intelligence and Big Data Analytics of Final Year Computer Science and Engineering but is not covered in the syllabus.

This VHDL$_{\text{ISTE}}$ instructional strategy consists of six phases V- Instructional Videos, HDL- Handout Learning, I – Implement, S – Submit, T-Test, and E – Evaluate. In first phase V - Instructional Videos phase, students watch the instructional videos prepared by the instructor to get acquainted with the Tableau tool. In second phase HDL, students go through the lab handouts to read the instructions given for completing the lab assignment. In I – Implement phase, students implement the problem statement related to Tableau tool while test on covered topics is conducted in T-Test phase. In S – Submit, students submit the problem statement on institutional MOODLE. Instructor conducts the test on covered topic in T-Test phase. Instructor evaluates the problem statement as well as test submitted by students on institutional MOODLE in E – Evaluate phase.

In this article, one group post-test method is considered for checking the effectiveness of this VHDL$_{\text{ISTE}}$ activity. Main Learning objective (LOs) of this study is to teach the problem analysing and solving ability. These LOs are 1) Apply Filters on Dimensions and Measures for given dataset using Tableau (LO1) and 2) Apply K-means Clustering on given dataset in Tableau (LO2). The research question is - Whether the use of instructional strategy VHDL$_{\text{ISTE}}$ is useful for learning the content beyond the curriculum?

This activity is conducted for two Academic Years 2020-21, 2021-22 and 2022-23. The result of applying this strategy and perception of students are also explained. The result showed that this strategy improves the problem analysis as well as problem solving ability of students. Using t-test statistical analysis, it is found that there is significant difference in mean score between sample and overall population means for LO1 as well as LO2 for all these three years.

Keywords: Learning Objectives, Handouts, Instruction based Videos, t-Test

I.   INTRODUCTION

Engineering Education needs to move from an instructive to constructive approach. In current scenario, students can no longer survive by limiting their knowledge to textbooks. They need to explore and experience the knowledge that connects to the real-world; in which they can develop, and demonstrate authentic skills.

In this article, we recommend a pedagogy VHDL$_{\text{ISTE}}$ that uses a combination of Instructional videos and handout based learning for providing the knowledge of emerging technologies and practical exposure to tools required for experiential learning of the course.

This methodology contributes to:

a)   Enhance students' capability on practical oriented approaches to learning.

b)   To make students aware of real life problems for them to solve using technology learning.

c)   Enable learning of technology individually by each student

In the current study, the use of VHDL$_{\text{ISTE}}$ to cover the topic 'Tableau: A Visual Data Analytics Tool' which is beyond the curriculum of the course Big Data Analytics is considered for the final year Computer Science and Engineering students of Solapur University. The objectives of this study are to cover the content beyond the curriculum in effective manner using instructional videos

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and handouts as well as to improve the problem analysing and solving ability of students.

II. RELATED WORK

There are various research articles available which indicate the effectiveness of Handout based learning and experimental teaching technique. In the research article (Dol, 2017), the authors used Open Education Resource (OER): C-Programming Handout based learning during Lab Session using MOODLE while in the article (Indi, 2017), the authors designed the handouts for the various courses like C-Programming language, System Programming, Digital Technique, and Mobile Application Development course. Ahmed Ishtiak (2013) used experimental teaching technique to teach Mobile Application Development in which it is shown that the experimental approach is effective as compared to the traditional in teaching Mobile Application Development. The paper (Toplis, 2012) concluded that practical work engaged the students and influenced their own learning. Clara Davies (Davies, 2008) considered the practical challenges of designing laboratory learning within engineering curriculum. Leen-KiatSoh et.al. (2005) reported on an integrated approach to the designing and implementing laboratories with embedded instructional research design.

Also there are articles on effective educational videos. The teacher (Kostere4lioglu, 2016) identified effects of video clips from students' point of view and used for effectiveness and increased quality of teacher training programs educational psychology classes. In the study (Pekdağ, 2010), the use of videos in teaching-learning environments are effective in three aspects: providing cognitive benefits, psychological benefits and visualization of knowledge. Video also provides benefits to instructor as well as students to motivate stronger course performance which affect student motivations (Samad, 2023). In study (Woolfitt, 2015), the author examined the question, "What do we know about the effective use of video in higher education?" and covered this question in detail while in study (Sari, 2023), the author explored the results of the use of videos to help in increasing students' motivation in any stream. Use of video is enhanced when instructors consider three elements: how to manage cognitive load of the video; how to maximize student engagement with the video; and how to promote active learning from the video (Brame, 2016). When videos are incorporated into a lesson, it results in engagement and active learning (Budiati, 2023).

Video based learning is considered in research articles to
- Improve the quality of learning in elementary school (Sari, 2023),
- Improve students' cognitive ability (Budiati, 2023),

- Enhance students' motivation and engagement in journalism and communication courses (Galatsopoulou, 2022)
- Improve Learning outcome of computer system (Samad, 2023),
- Teach decision-making for surgery in medical education (Yee, 2022),
- Improve learning outcomes of students (Nurwulan, 2020),
- Teach the physical education (Lee, 2020),
- Study the effect of affective feedback in video based learning (Ha, 2022),
- Improve students' critical thinking ability such as analysis skill (Hsu, 2022),
- Foster learner's engagement (Taskin, 2019), and
- Improve clinical setting of students in medical sector (Hadi, 2019).

In research article (Gordillo, 2022), authors compared the game-based learning using educational video game with video-based learning and found that the game-based learning using educational video game is more effective that the game-based learning using educational video game. The research article (Movitaria, 2020) showed the effect of making video with the help of Microsoft PowerPoint.

From above literature survey, following point are noted –
- Handout based learning is considered for improving students' performance.
- Video based learning is used to show the effectiveness of using videos in teaching-learning process and to improve students' learning in the course.
- OER in the form of handout for Handout based Learning is considered in teaching-learning process.

Research gap - So there is no study which shows the effect of both videos and handouts in the teaching-learning process.

In the current study, the instructional strategy VHDL$_{ISTE}$ that make use of videos and Handouts based learning are considered for the topics which are not covered in curriculum of the university.

III. TABLEAU TOOL

Tableau is the most powerful, secure, and flexible end-to-end analytics platform for data (https://www.tableau.com/products/what-is-tableau). This tool is used for the courses like Business Intelligence and Big Data Analytics. A drag and drop facility of this tool helps learners to perform tasks easy. This tool is compatible with SQL Server, Excel, and cloud-based data repositories. The screenshot of this tool is shown in Figure 1.
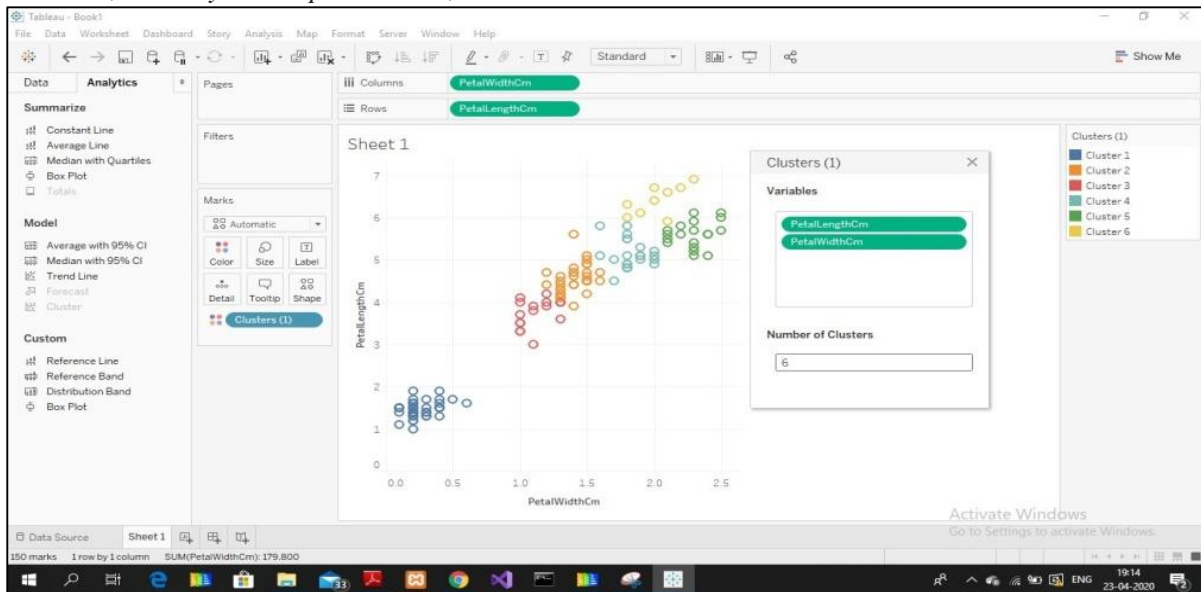
Fig. 1. Tableau Tool

IV. VHDL_{ISTE} METHODOLOGY

The instructional strategy VHDL_{ISTE} consist of following phases

- **V**- Instructional **V**ideos,
- **HDL**- **H**an**d**out **L**earning,
- **I** – Implement,
- **S** – Submit
- **T** - Test and
- **E** – Evaluate

A. *V- Instructional Videos*

Instruction based Videos consist of all videos related to the Tableau introduction, basic operations for data analysis in Tableau, data extraction in Tableau and Tableau Filters. Each video consists of

- Introduction: Introduction related to the topic is considered which motivates the students to go through the video.
- Learning Outcomes: It is a statement of what the students will be able to do after completion of a topic. Bloom's Taxonomy is used to express the learning outcome. It will have a common stem: "Student should be able to" which will be followed by a verb phrase and an object of the phrase. The verb phrase is from Cognitive domain - Remember, Understand, Apply, Analyze, Evaluate, and Create. The object of the phrase states the type of knowledge.
- **Topic description**: After learning outcome, the topic is explained with the help of example.
- **Think and Write (Reflection spot)**: The reflection spot is a point where video is paused and the learner is required to answer a question asked based on previously covered content. Reflection spot allows the learner to micro-practice or simply apply

the concept that they have learnt immediately. The question asked here is Multiple Choice Question, short answer, True/False Question, etc.

- Explanation of quiz asked in reflection spot: After reflection spot question, explanation about the correct answer is given along with reason.
- **Content following the reflection spot**: Here the same topic is continued and explained.
- **References used**: The references used for preparing this presentation are mentioned.

Following five videos were created as a part of this strategy as shown in Table 1.

TABLE I
INSTRUCTIONAL VIDEOS AND LEARNING OUTCOMES

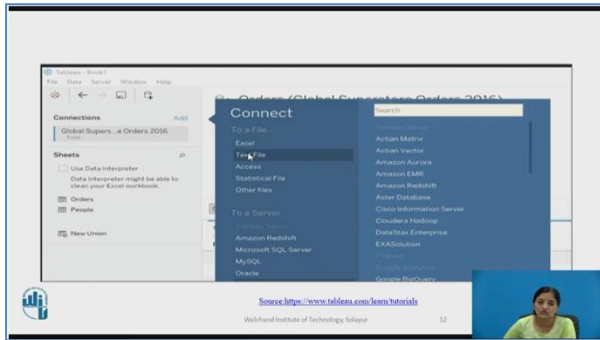| Sr. No.	Topic Name	Learning Outcomes
1	Introduction to Tableau: A data Visualization Tool	Students are able to 1) Identify the unique features of Tableau as a very good visualization tool of Business Intelligence 2) Demonstrate the Installation of Tableau 10.3 on Windows operating system
2	Basic operations for Data Analysis in Tableau	Students are able to Illustrate basic operations in Tableau: Connecting to data source, choose dimensions and measures and apply visualization technique
3	Tableau: Design Flow, Data types & Terminologies	Students are able to demonstrate: 1) The design flow of Tableau 2) Data types and data terminologies used in Tableau
4	Data Extraction & custom data view in Tableau	Students are able to: 1) Create an extract 2) Add new data to an extract 3) Apply field operations 4) Generate custom data view
5	Tableau Filters	Students are able to demonstrate 1) How filters help to generate the extract of data 2) The working of different types of

		filters

Fig. 2. Sample Video on YouTube

B. HDL - Handout Learning

A handout is the resource provided to the students during laboratory session for completing the task assigned to them. So it is guided document used by students for implementing the problem statements in the lab session.

Each handout used for the topic- Tableau: A data Visualization Tool of the course Business Intelligence contains

- Problem Statement
- Input
- Output
- Description or steps to be performed

Handout sample is given in Figure 3.

Fig.3.Handout Sample

C. I – Implement

In laboratory session of 2 Hours, students implement the problem statement with the help of instructions given in the handout. Sample problem statement completed by one of the student with the help of this handout is given below:

Problem Statement: Apply Filters on Dimensions and Measures for any dataset using Tableau.
Input: Sample– Superstore.csv
Output: Filtered dimensions and measures.
Description:
- Perform following steps for Dimension Filter:
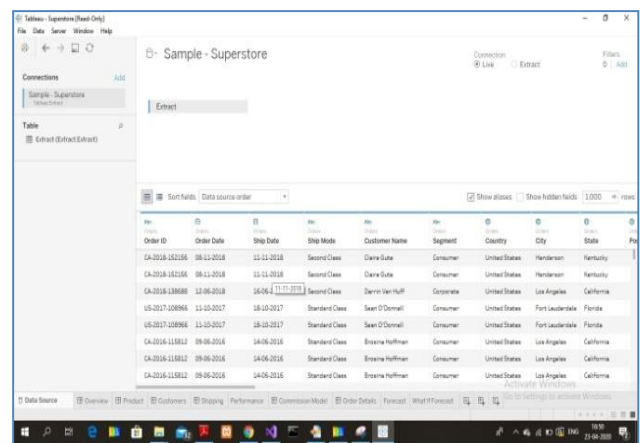 - Step 1: Go to the worksheet and open "Sample–Superstore.csv" as shown in Figure 4.

Fig.4. Step 1 for Dimension Filter

  - Step 2: Select dimension "Category" from dimension list. Drag the dimension into 'Filters' box as shown in Figure 5.
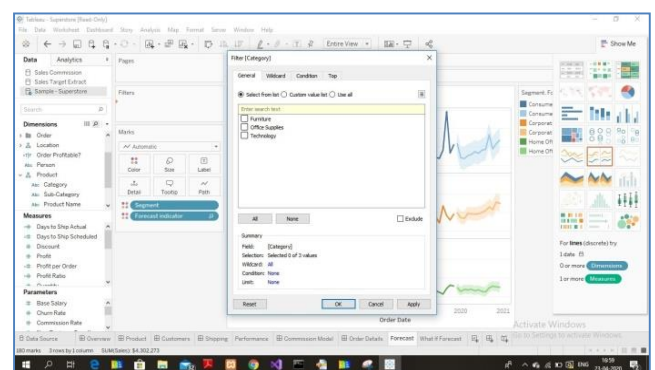

Fig.5. Step 2 for Dimension Filter

  - Step 3: It opens the 'Filter' Window as shown in Figure 6. Select the member from the list. After clicking on OK, the screen shown in Figure 7 will be displayed.
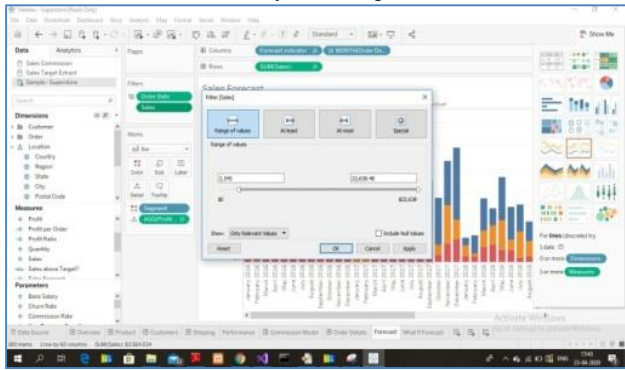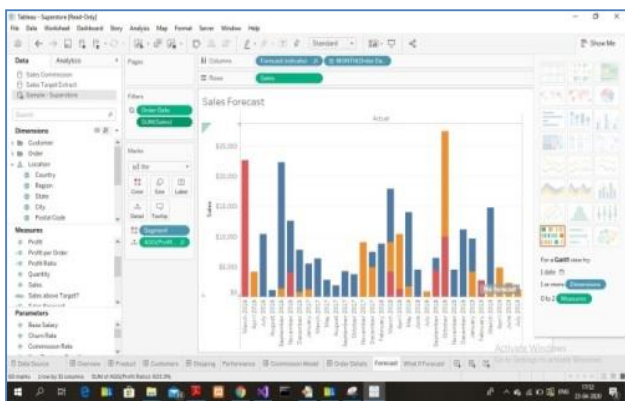
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Fig.6. Filter Window

Fig.7. Step 3 for Dimension Filter

D. S – Submit

Students submit the implemented problem statements on institutional MOODLE site for evaluation.

E. T - Test

Test of 30 marks is conducted on covered topics. In this test, questions covered are the Apply level of Bloom's Taxonomy - Cognitive domain

E. E – Evaluate

Instructor evaluated problem statements as assignments as well as test submitted by students on institutional MOODLE.

V. EXPERIMENTAL DETAILS

A. Experimental Setup

The experimental setup for this VHDL$_{ISTE}$ learning mode is shown in Table 2.

TABLE II
EXPERIMENTAL SETUP

Technique use	Instructional Strategy VHDL$_{ISTE}$
Course	Big Data Analytics
Sample	Final Year Computer Science and Engineering Students • A group of 70 students for Academic Year 2020-21 • A group of 70 students for Academic Year 2021-22

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	• A group of 69 students for Academic Year 2022-23
Instrument used	One Sample t-Test Survey Questionnaire and Feedback
Learning domain used	Bloom's Taxonomy Cognitive Level- Apply

B. Research Design

The research design for this activity is shown in Figure 8. Instructor prepares the instructional videos for the topics beyond the curriculum. Also instructor designs the handouts containing instructions for completing the assignment during the laboratory session. Students go through these videos and attempt the quiz asked in 'Think and Write'. During the lab session, students read the instruction given in the handout and discuss the problem statement. After discussion, with the help of the content covered in instructional videos and instructions given in the handouts, students implement problem statement and submit it on the Learning Management System institutional MOODLE (modular object-oriented dynamic learning environment). Instructor conducts the test of 30 marks after uploading assignments on MOODLE. Instructor evaluates these assignments submitted as well as test conducted by students.

Learning objectives (LOs) of this study is to teach the problem analysing and solving ability. These LOs are

- Apply Filters on Dimensions and Measures for given dataset using Tableau (LO1)
- Apply K-means Clustering on given dataset in Tableau (LO2)

Research question is

- Whether the use of instructional videos and handouts is useful for learning the content beyond the curriculum?

B. Assignment Problem Statements

Assignment questions cover the Cognitive Level - Apply level of Bloom's Taxonomy. The sample assignment statement is given below:

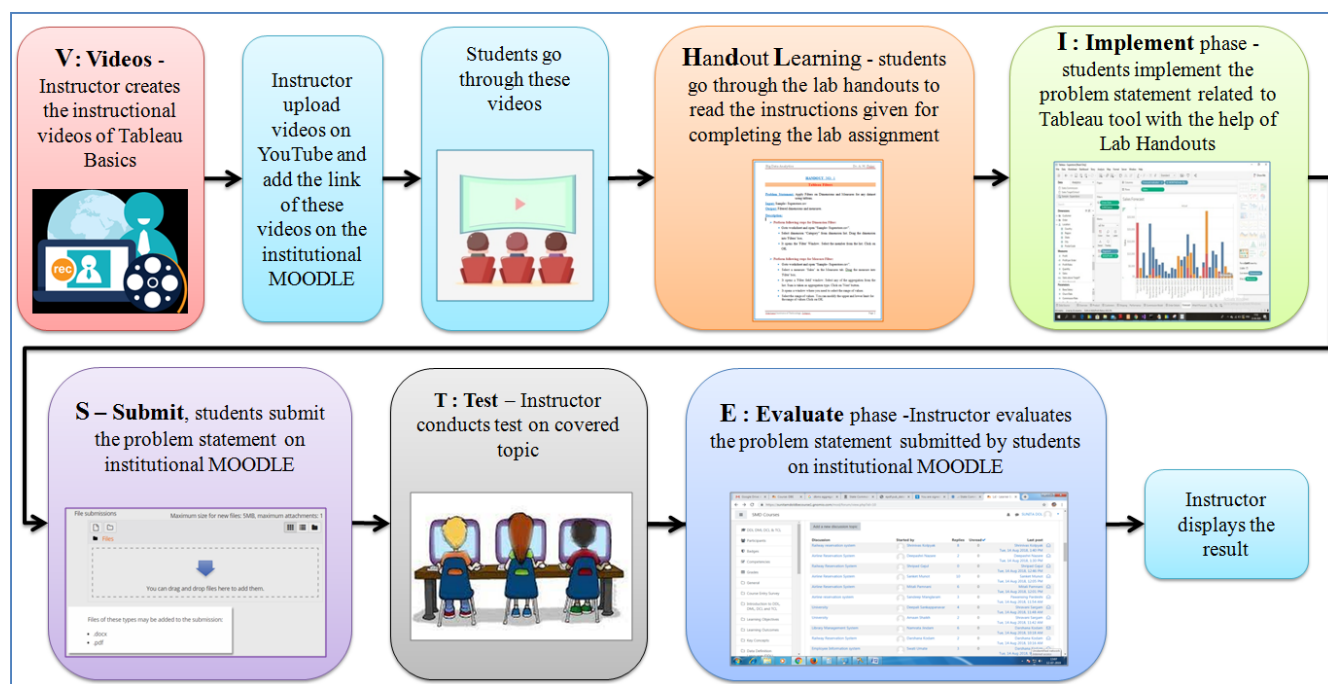| PROBLEM STATEMENT	DATASET PROVIDED	BLOOM'S TAXONOMY
APPLY FILTERS ON DIMENSION AND MEASURES FOR GIVEN DATASETS USING TABLEAU	• SUPERMARKET • DATA ANALYST JOB • STOCK MARKET • CREDIT CARD FRAUD DETECTION • CAMPUS RECRUITMENT • BREST CANCER	APPLY LEVEL

C. Feedback

To understand students' perception about this learning mode activity, feedback was conducted for Academic Year 2020-21 as per Likert's Scaling. A Likert's Scale is a type of rating scale used to measure opinions of students about activity. With this scale, students are asked to rate items on a level of agreement such as strongly agree, Agree, Neutral, and Disagree, Strongly disagree. From the feedback given in Table 3, it is found that 98% students liked this activity.

TABLE III
FEEDBACK

Sr. No.		Strongly agree	Agree	Neutral	Dis-agree	Strongly disagree
	Instructional Videos					
1	Whether the content of the videos were useful?	25%	69%	2%	4%	0%
2	Whether this video encouraged you to learn the topics beyond the curriculum?	43%	53%	2%	0%	2%
3	Whether the introduction at the beginning of videos stimulates your interest?	30%	63%	5%	2%	0%
4	The question/s asked in the reflection spot was useful to understand the topic covered	25%	61%	11%	3%	0%
5	The explanation about reflection spot question/s helped to understand the topic thoroughly.	30%	63%	7%	0%	0%
6	Overall rating of videos	24%	63%	5%	5%	3%
	Handouts					
7	Handouts provided were helpful for accomplishing the task.	56%	40%	0%	1%	3%
8	Guidelines provided in handouts helped you to complete the assignment.	47%	50%	1%	1%	1%
Sr. No.		Strongly agree	Agree	Neutral	Dis-agree	Strongly disagree
9	Overall rating of videos of Handouts	70%	27%	0%	3%	0%
	Both Instructional Videos and Handouts					
10	Instructional videos as well as Handouts were supportive to encourage for accomplishment of assignments	40%	58%	0%	2%	0%
11	Instructional videos as well as Handouts enriched our interest in implementation of Lab Assignments	42%	53%	5%	0%	0%
12	Instructional videos as well as Handouts helped you in effective implementation of the assignments on time	55%	42%	2%	0%	1%
13	Did you like this mode – Instructional videos and Handouts to learn the content beyond the curriculum?	Yes= 97% No= 3%				

Fig.8. Research Design

VI. RESULT ANALYSIS

A. Assignment Evaluation Analysis

To check the effectiveness of this learning mode, the rubric was set for evaluating the assignment and calculating the marks obtained by each student.

Here the sample of 70 students from final year Computer Science and Engineering for Academic Year 2020-21 is considered. The graph for LO1 is shown in the Figure 9.
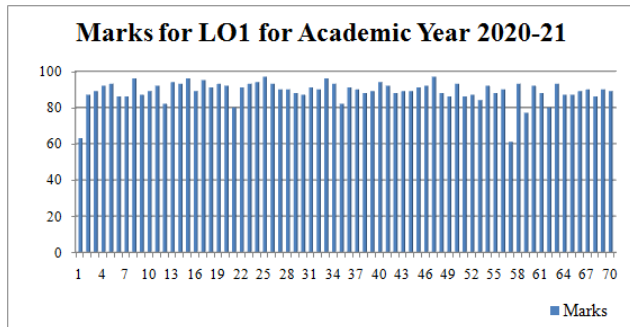

Fig.9. Graph of LO1 for Academic Year 2020-21

The graph for LO2 is shown in the Figure 10. From the graph, it can be seen that all of the students received the marks above 73%.
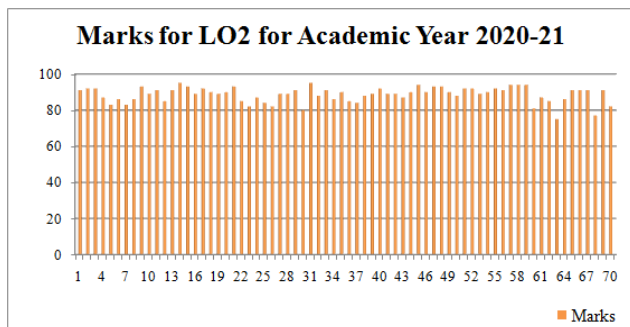

Fig.10. Graph of LO2 for Academic Year 2020-21

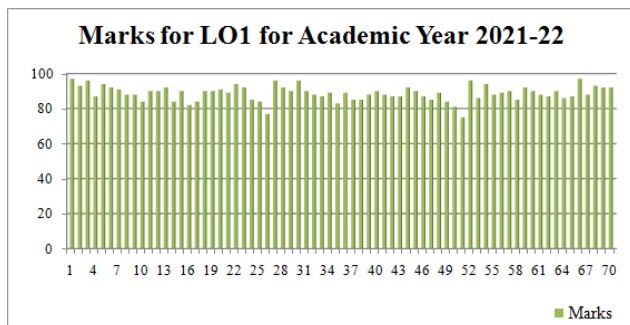The graph of LO1 and LO2 for Academic Year 2021-22 is shown in Figure 11 and 12 respectively.

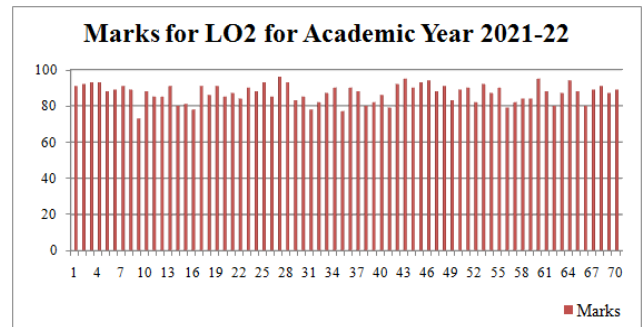Fig.11. Graph of LO1 for Academic Year 2021-22

Fig.12. Graph of LO2 for Academic Year 2021-22

The graph of LO1 and LO2 for Academic Year 2022-23 is shown in Figure 13 and 14 respectively.
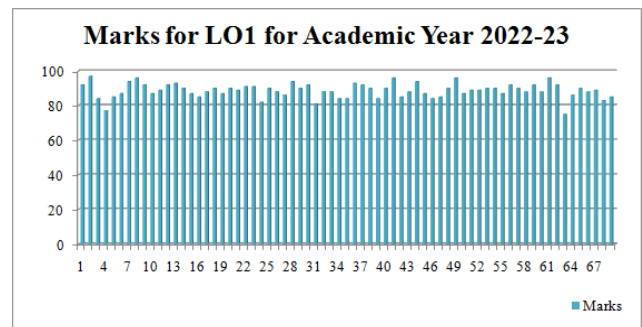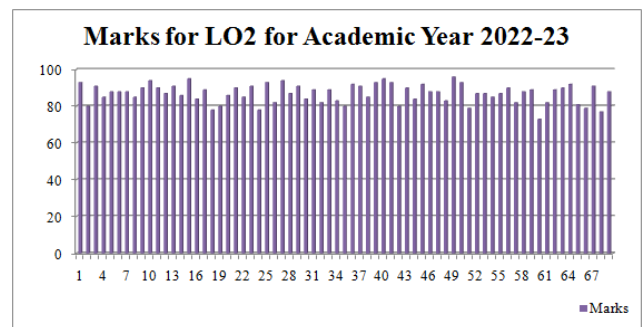

Fig.13. Graph of LO1 for Academic Year 2022-23

Fig.14. Graph of LO2 for Academic Year 2022-23

A single sample t-test compares the mean (M) of a single sample of scores to a known or hypothetical population mean (μ). In this method, input is the value of your known (or hypothetical) mean and your sample scores.

The t-value is a ratio of the difference between the mean of the two sample sets and the variation that exists within the sample sets (Gordillo, 2022). Higher values of the t-value indicate that there is statistically significant difference between the two sample sets.

Population mean is the average of the marks calculated based on the previous year result.

Assuming that the null hypothesis is correct, the p-value denotes the probability of obtaining test results at least as

extreme as the results actually observed (Hsu, 2022).If p-value is less than 0.05, it is concluded that there's a statistically significant difference two groups.

TABLE IV
STATISTICAL ANALYSIS USING SINGLE T-TEST

Academic Year	Number of Students	LOs	Population mean	t-value	p-value
2020-21	70	LO1	87.0	2.656	0.004
		LO2	87.5	2.268	0.013
2021-22	70	LO1	87.8	1.979	0.025
		LO2	86.5	2.557	0.005
2022-23	69	LO1	86.75	3.84630	0.000133
		LO2	85.02	3.300944	0.000769

Figure 15 shows the graphical representation of single sample t-test on marks scored by students in assignments submission on MOODLE for Academic Year 2020-21, 2021-22 and 2022-23 along with population mean, t-value and p-value for LO1 and LO2 for each academic year.
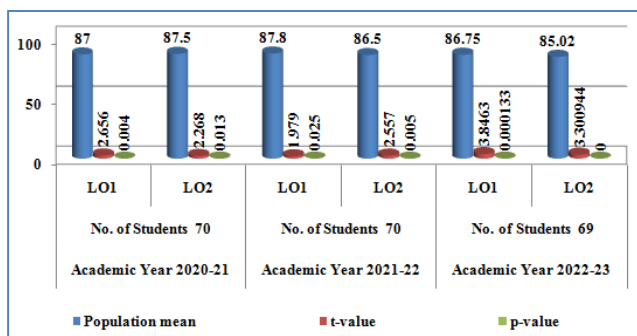

Fig.15. Single sample t-test analysis for Year 2020-21, 2021-22 and 2022-23

B. Tests Evaluation Analysis

In this subsection, we discuss the test marks evaluation analysis for Academic Year 2020-21, 2021-22 and 2022-23. Figure 16 represent test marks obtained by students in Academic Year 2020-21. From Figure 15, it is found that all students received the marks above 20.
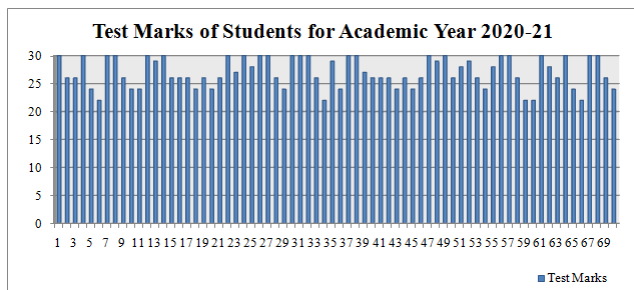

Fig.16. Test marks analysis for Academic Year 2020-21

Figure 17 represent test marks out of 30 marks obtained by students in Academic Year 2021-22while Figure 18 shows test marks obtained by students in Academic Year 2021-22.
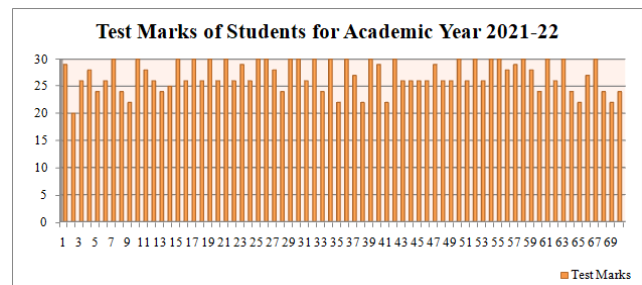

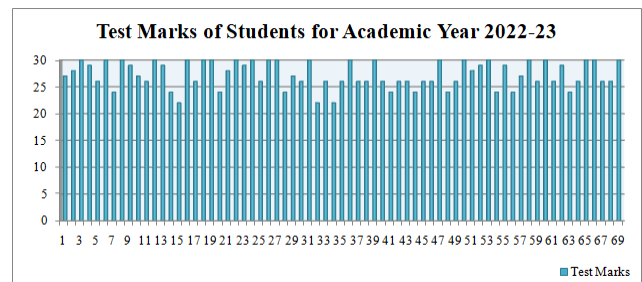Fig.17. Test marks analysis for Academic Year 2021-22

Fig.18. Test marks analysis for Academic Year 2022-23

Table 5 shows the result of single sample t-test on marks obtained by students in Test conducted for Academic Year 2020-21, 2021-22 and 2022-23 along with population mean, t-value and p-value for LO1 and LO2 for each academic year.

TABLE V
STATISTICAL ANALYSIS USING SINGLE T-TEST FOR TEST MARKS

Academic Year	No. of Students	LOs	Population mean	t-value	p-value
2020-21	70	LO1 and LO2	26	3.17	0.0011
2021-22	70	LO1 and LO2	26.1	3.13	0.0012
2022-23	69	LO1 and LO2	26.5	2.69	0.0044

From Table 4 and 5, hypothesis of this study is:
These tables show the significant improvement in students' marks of assignments submission and test conducted for LO1 as well as LO2 for Academic Year 2020-21, 2021-22 and 2022-23 as it is observed that p-value (probability) is less than 0.05.

VII.   CONCLUSION

In this study, we designed the instructional strategy VHDL$_{ISTE}$ to cover the content, 'Tableau: A Visual Data Analytics Tool which is beyond the curriculum of the course Big Data Analytics. This instructional strategy VHDL$_{ISTE}$ consists of six phases: V- Instructional Videos, HDL- Handout Learning, I – Implement, S – Submit, T - Test and E – Evaluate. Instruction based videos helped the students to understand the topic while handouts were used

by students to complete the problem statements during the laboratory session. From the statistical analysis of the result, it is found that there is significant difference in mean score between sample and overall population means for LO1 as well as LO2. The statistical analysis of the results also shows that the use of the instructional strategy VHDL$_{ISTE}$ is useful for learning the content beyond the curriculum. Therefore this method is useful for covering the contents not covered in the syllabus.

In future, this method may be used for other courses which require the hands-on knowledge for teaching particular topic such as NoSQL, HIVE, etc.

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