CHAPTER 4

AUGMENTED REALITY-BASED DIDACTIC SYSTEM FOR LEARNING FACTORIES IN TECHNICAL EDUCATION

4.1 INTRODUCTION

Current Industrial Era is seeing a rapid transformation in education systems, as wells as the mindset of students toward the educational system (ES) has been changed. The collaboration between te learner and the platform of learning have to done to properly prepare the students for future. For the process of effectively engaging the learners, the educational platforms must incorporate the interests of the students.

To offer remote participation in the area of training or the area of workspace, a learning factory has been proposed in this work and developed specifically for training in the field of print technologies, training, and learning of professional skill. Using microlessons based on augmented reality, the systems of didactic for the recommended learning factory are created and integrated into the app of learning factory.

Survey parameters and performance indicators have been established to ensure that students and technology are complying with the platform. Survey parameters such as User Satisfaction, Learning Outcome Improvement, Ease of Use, Interactivity, Engagement, Usability, Content Quality, Immersion & Interactivity, and User Satisfaction are selected based on educational technology evaluation frameworks and human-computer interaction (HCI) standards. These parameters help assess the effectiveness, user experience, and educational value of AR applications. The evaluation of this platform showed some average compilance performance only initially and then they were improved by improving the micro lessons by getting feedback from the learners. The significance of this proposed Augmented Reality (AR) based system is evaluated by sample paired t-tests.

The attributes were significant at levels of 1% and 5%.The coventinoal systems of education was mostly face to face based system, but after the pandemic situation of covid-19 the online based education system have been introduced. These online system of education was done using study materials in mobile phones, communicating via webinars, doing online evaluation and in some essential cases virtual labs were also made possible.

Even though the pandemic has come to an end now the online or the digital based education has been a choice of preference for many as it offers some special features like anytime and anywhere availability without being restricted to some location.

With the help of National education policy, the researchers were able to know about the requirements for changes in pedagogy as per as per some factors, like the essentiality to help the students to improve their ability of learning using pictorial form of communication, having attention, learning based on games, and a transition from direct contact teachers to digital learning via the concept of immersive learning. Students should be offered hands-on provisions that comply with the state-of-the-art trends.

This will help the students to be engaged in the process of teaching and learning. These environments are well known as the systems of learning. The concept of learning factories is installed even in the environments of academies as they can complement the virtual world. This work has developed a platform for technologies of education that is rarely seen while trying to improve the systems of education. Architecture diagram of didactic system is presented in ***Figure 4.1***.

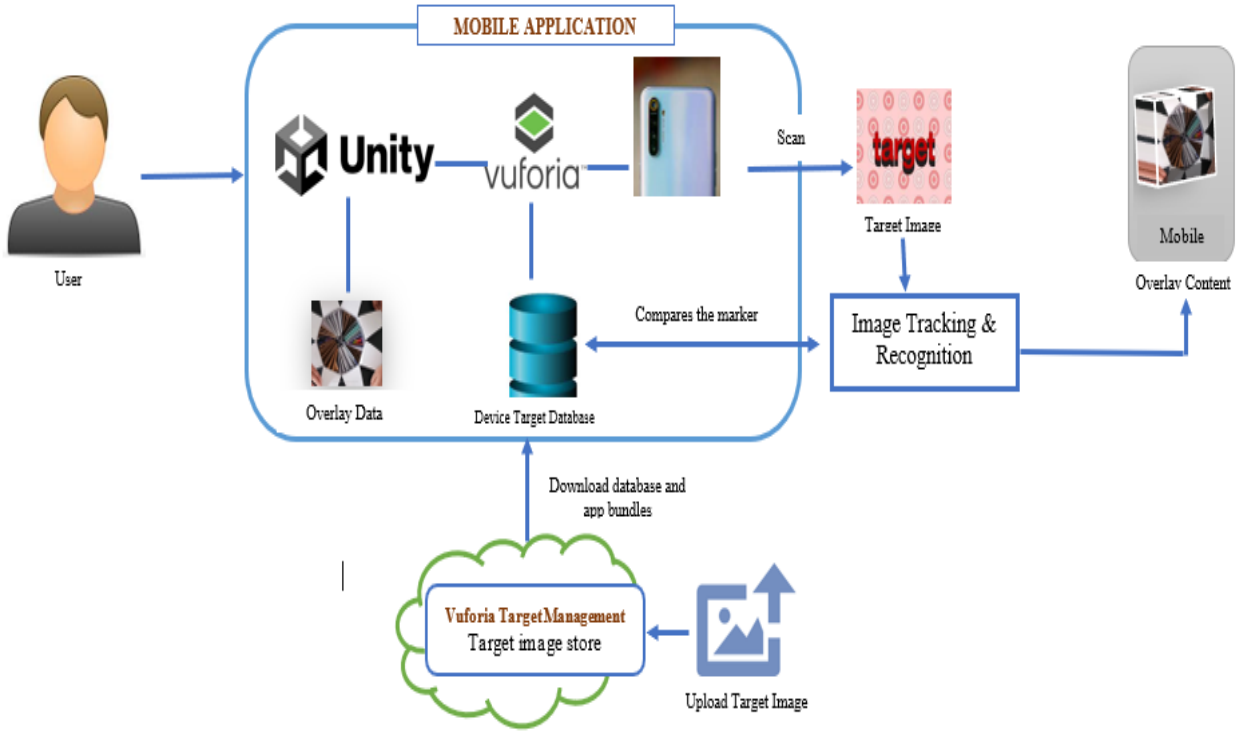

Figure 4.1 Architecture of Didactic System

The workflow of the augmented reality application developed using Unity 3D engine and Vuforia. Initially, the user scans the target image through the mobile AR application that is built on Unity 3D engine. The target images are uploaded in Vuforia and managed through Vuforia Target Manager.it is a cloud-based store for target images. The image database is then downloaded and integrated with the application in Unity. Vuforia SDK recognizes the image and tracks the image using device target database. As soon as the image is recognized, the Vuforia Image tracking and recognition module compares it with the images stored in the device target database. Once the target image is recognized, the application retrieves the superimposing data and renders the overlay on the mobile screen.

4.1.1 Overview of Learning Factory

The concept of learning factories started off as realistic teaching or learning environment and now these transitioned to a digitalized level that includes the real physical environment and the virtual environment. These learning factories are different from conventional systems of learning as these can offer problem-oriented learning as they include the learning through the real time environment of production. The learning factory improves the outcome of learning.

This also allows students to gain immense knowledge and consistent learning in a sustainable way. By indulging in these learning factories, the students will be able to gain knowledge about real world problems. This learning factory has its own versatility as it connects innovation with the systems of technical education, making the SMEs use such digital technologies.

The learning factory also helps to build the ability of self-learning through its phases of learning. Some existing models have suggested a model of learning factory for the program of production engineering that had 3 modules they are didactic, integrative, and engineering that have to a transformation of learning factory that fosters learning space to improve professional and social skills by developing a novel platform to building an understanding and to bridge the gap between the systems of higher education and reality of business.

Competency has become a much-needed quality to become a driver of acceptance of technologies and employability. Integrating the industries of education 4.0 will obtain a much significant agility, efficiency and profitability.

4.1.2 Overview of Augmented Reality

The environment of digital learning is mostly created using technologies like VR, AR and metaverse. Augmented reality is a technology that overlays the images generated by computers in front of the user that is view of the real world. Even some of the smart have these features of augmented reality.

The gaming applications, 3D visualization and applications like digital quiz uses these technologies of AR. These technologies of AR can be used in learning of manufacturing industries will helps to bridge the gaps in skills. It will increase the engagement of students in learning. This AR technology will bring print to life and enhances the systems of education and training.

4.2 DEVELOPMENT OF AR – BASED DIDACTIC SYSTEM

This work has introduced a didactic system that uses AR oriented micro lessons which is a digitalized form or subsystem of learning factories that is developed specially for technical education. The manufacturing factories will be of massive size and they digital versions via which the micro lessons will be mapped to the relevant topics in a syllabus of given course.

The proposed model of AR bases system for didactic is shown in ***Figure 4.2.***

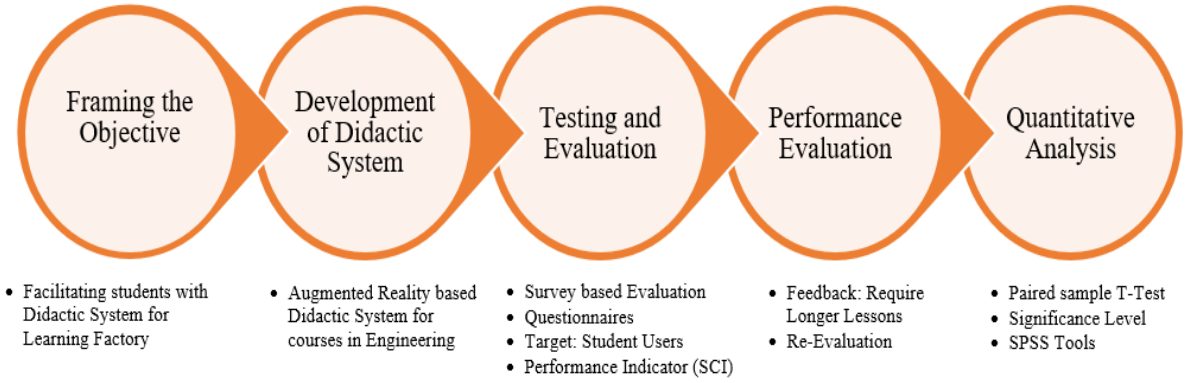

Figure 4.2 Methodology of proposed AR-based didactic system

The first steps of the model are to frame the objective of this work by stating the Facilitating students with Didactic System for Learning Factory. Next step is to develop an AR based didactic system and it is subjected to evaluation. The evaluation is done based on survey with relevant questions being taken from the students' users.

The performance is enhanced by getting feedback and revaluation is also done. Quantitative analysis is also made for the process of deterring the level of significance and acceptance of AR based on didactic systems for learning factories.

4.2.1 Design of AR based Didactic System

This section offers the necessity for building learning factories for education in technologies that is followed by comprehensive design of AR based didactic system for learning factories.

4.2.1.1 Need for the AR – based Didactic System for Education

There are many courses based on disciplines, they are science, management, engineering, entrepreneurship, mathematics and humanities. In the multi-disciplinary nature, it is herculean task to integrate experiential knowledge-based learning concepts. Firstly, a better understanding of machinery is needs like from the aspects of construction, working and control is significant to engineer a process of high-quality production.

Due to advancement in technologies and cost of equipment's, it is not possible to offer a high-class education in the situations of India. But still, the use of smart technologies and using learning factories does justice to these kinds of challenges. And so, the aim of this work is to set up a learning factory for technical education on campus of education by offering a real feel of factory via the digital technologies like Augmented reality especially for the purpose of self-learning.

4.2.1.2 The use of AR in Didactic System

Augmented Reality (AR) can be used in several situations for improving the experience of learning in classrooms, laboratories and libraries. AR technology is used to make the environment of learning a digitalized one. It acts as a tool of visualization in shops of house products and offers a better way of engaging and alluring the buyers. AR-based connections to experts from industries and academics are offered at each of the steps so that the students will be able to reach out to them over digital media and they can gain knowledge.

The highlights the different learning experiences and the targets used for the application. Charts, Laboratory equipment's, raw materials and samples serve as target images for micro-lessons and mock test that provide interactive learning experience. The

trending information such as applications, specifications and workflow, the target images can be artifacts, complimentary items, sample products from industry. To establish a real – world experience, industry mentors can be connected with collaborative industry logo and institute mentors with institute logo. For entrepreneurial learning, sample business plans can be integrated with incubator cell (***Table 4.1***).

Table 4.1. Sample scenarios provisioned with AR-based microlearning

S.No	Type of Learning	Target Images
1	• Micro lessons • Mock tests	• Charts in classroom • Equipment of lab, raw materials, • Samples
2	Trending Information (Applications, specifications & workflow)	Artifacts, Compliments, Samples Products from industry
3	Connect to an industry mentor	Collaborating Industry's logo
4	Connect to Institute mentor	Collaborating Institute's logo
5	Sample business plans	Equipment in Incubator cell
6	History and significance with a mock quiz	Items in museum

4.3 AUGMENTED REALITY BASED DIDACTIC SYSTEM FOR EDUCATION

The systems of didactic is aligned with the model of OBE that is mostly followed for the process of higher education in India. The model of OBE has 4 stages, in that the plan stage represents the teacher's role and the other 3 states are students' role. ***Figure 4.3*** depicts the process of outcome-based education system.

To offer a platform of self-learning, different stages offers different methods they are,

- DO stage, is where the micro lessons based on AR are given,
- in the stage of VALIDATE, self-paced AR oriented mock tests are conducted

- The ACT stages is where the AR connects is connected to the industry and the mentors are given for interactions such as webinars and internships.

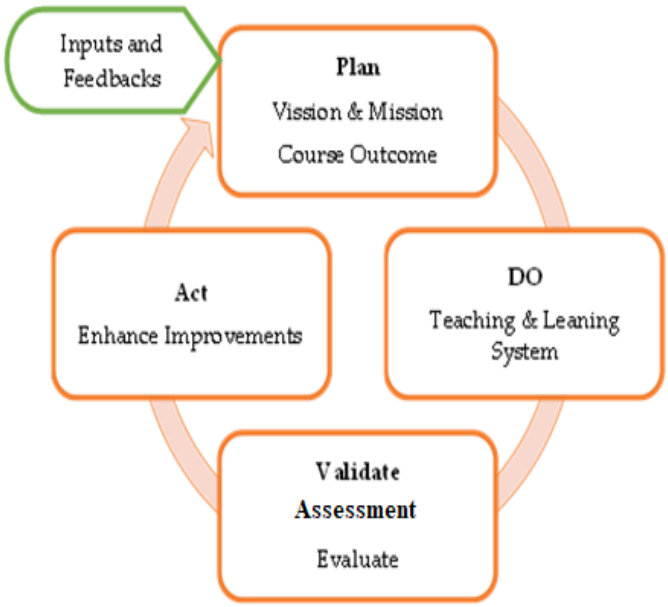

Figure 4.3 OBE based Education

The modules shown on left represents the typical classroom, labs and library. Centre of excellence and cells of incubation are necessary for improved learning, research and development of entrepreneurship.

The units specific to technical education are also indicated is illustrated in ***Figure 4.4***

I. In-house unit of production of print where the needs of the printing of the institutes are done

II. Product Artifacts – It is the place where the students will be able to see diverse range of materials for learning, products, models of products which will help in learning for the students

III. Product Museum – it's a place where historical items of products are shown, that helps in understanding the evolution behind the technologies.

IV. Product House (in shop) is the commercial place for the students and students' entrepreneurs

V. Finally, the in-house shop is a commercial outlet for student entrepreneurs.

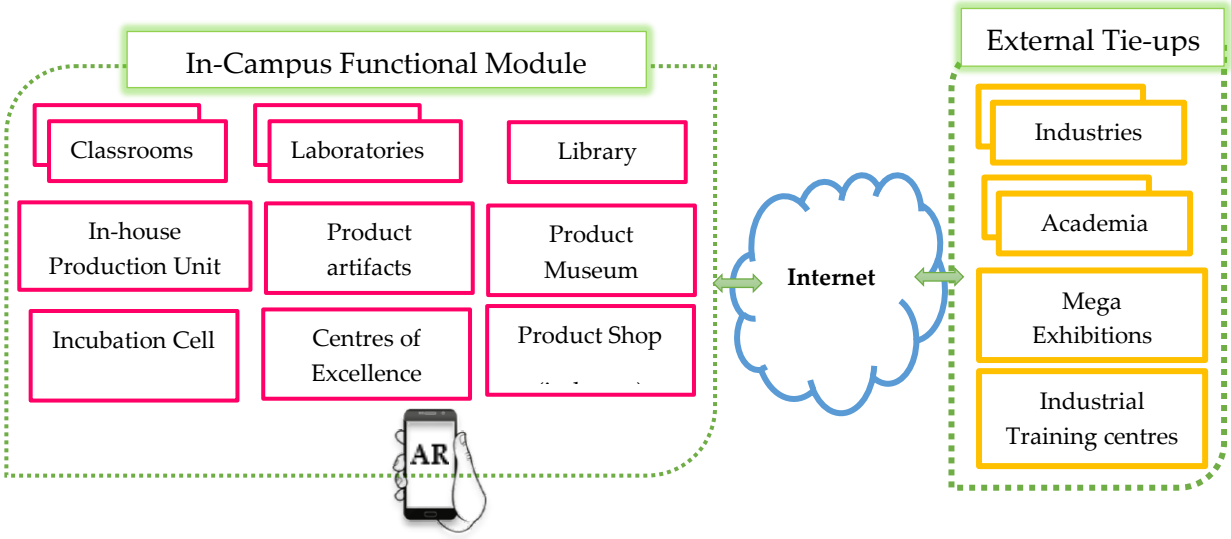

Figure. 4.4 AR-based Didactic System for Technical Education

On the right side, the external linkages are indicated -

I. Core Engineering and its related industries across the world in collaboration with institutes via an MoU or any related agreement. Such industries support the learners via mentoring, informal kind of one-on-one discussions, webinars, internships, project support etc.

II. These industries across the world are already related to learning factories. These institutes agree to support the learners in many of the academic based activities.

III. Mega exhibitions are organized by the industries and its allied sectors which extends their support for the communities of student by offering digital access to the expos that share the digital content that is relevant to the study topic.

IV. Centers of industrial training is where the skills will be provided, industrial clusters where massive infrastructure is set up for carrying out the production – such centers will help the student to understand the system of production and its related details

AR can server many purposes by improving the experience of learning in classrooms, experiments of self-learning in laboratories, a dynamic environment of digital learning in libraries and tools of visualization in environment of in house and gives information about the products of in-house through engaging and entertaining the users with the help of technologies of AR.

The users will be able to scan the targets with the help of smart devices, it will recognize markers, retrieves data and augments the insights of overlay over phone. This data could be realistic scenario from industries, content for academics, data on mega exhibitions and virtual or real hands-on experience of training. AR bases features of didactic are integrated into these 3 stages to help the students to explore the environment and self-learn at their own pace. It will connect to the experts from the industries and academia that are offered at each of the steps so that the students will be able to able to reach out in case of queries using the digital media and they can get knowledge.

4.4 IMPLEMENTATION, EVALUATION & ENHANCEMENT

This section explains the modules that are developed, with the sequence of working. A comprehensive description of 2 scenarios of use case for which the AR is developed and incorporated into the system of didactic of learning factory is also provided. This section explains how the testing of performance is done according to survey and the results are also presented.

The learning factory is developed with the system of AR based didactic as one of the subsystems. The learning factory is developed with an AR based system for didactic as one of the sub-systems. Nearly 20 AR based micro lessons are developed till now as given in ***Table 4.2.***

Table 4.2. Modules developed for AR-based didactic system

S. No.	AR-Enabled Location	The topic of Micro-Lesson / Quiz / Mock Test / Connect to Mentors	Types of Learning
1	Classrooms	• Adrino board • Space craft • Offset machines	• Modular learning
2	Laboratories	• Usage of Adrino board • Aircraft engine	• Experimental Learning
3	Library	• Electronics and Programming concepts • Coding microcontrollers • Engine Mechanics • Aerodynamics	• Cognitive learning
4	In-House Production unit	• Uses cases for novel design	• Kinaesthetic Learning

S. No.	AR-Enabled Location	The topic of Micro-Lesson / Quiz / Mock Test / Connect to Mentors	Types of Learning
5	Product Artifacts	• 3D Models • Environmental monitoring	• Kinaesthetic Learning
6	Product Museum	• Fixing skeleton of aircraft engine • Designing skeleton for adrino	• Museum Pedagogy
7	Incubation Cell	• Business plan for products on Screen	• Entrepreneurial Learning
8	Centre of Excellence	• Building smart home system • Aircraft maintenance training	• Holistic learning
9	Product Shop	• Marketing tool using Electronics • COVID-19 Awareness Tool using Electronics	• Behavioural learning

4.5 WORKING FRAMEWORK

As mentioned in table 4.1, the scenarios of sample contain the images that are printed like charts of PE, logos, labels, equipment's of real world and materials are identified as targets which enables the process of learning using AR. Such targets of AR are spread across all of the units of function. For each of the micro lessons, quizzes, mocks tests as represented in table 4.2 are developed and incorporated into the applications of learning. These students will be given access to the app called the learning factory.

If any student scans the target of AR with the help of this app called Learning Factory using their smart phones, this app will recognize the target of AR, retrieve data and will augment the insights of overlay over mobile phones.

A new user will be accessing the app of learning factory by going to AR based spot in that learning factory will scan that QR code using their smart mobile. This will take them to the website of that course, where one will be able to download the app and install it. Now then the installed app will scan the target of AR and will proceed. The working of AR based didactic system is shown in ***Figure 4.5***.

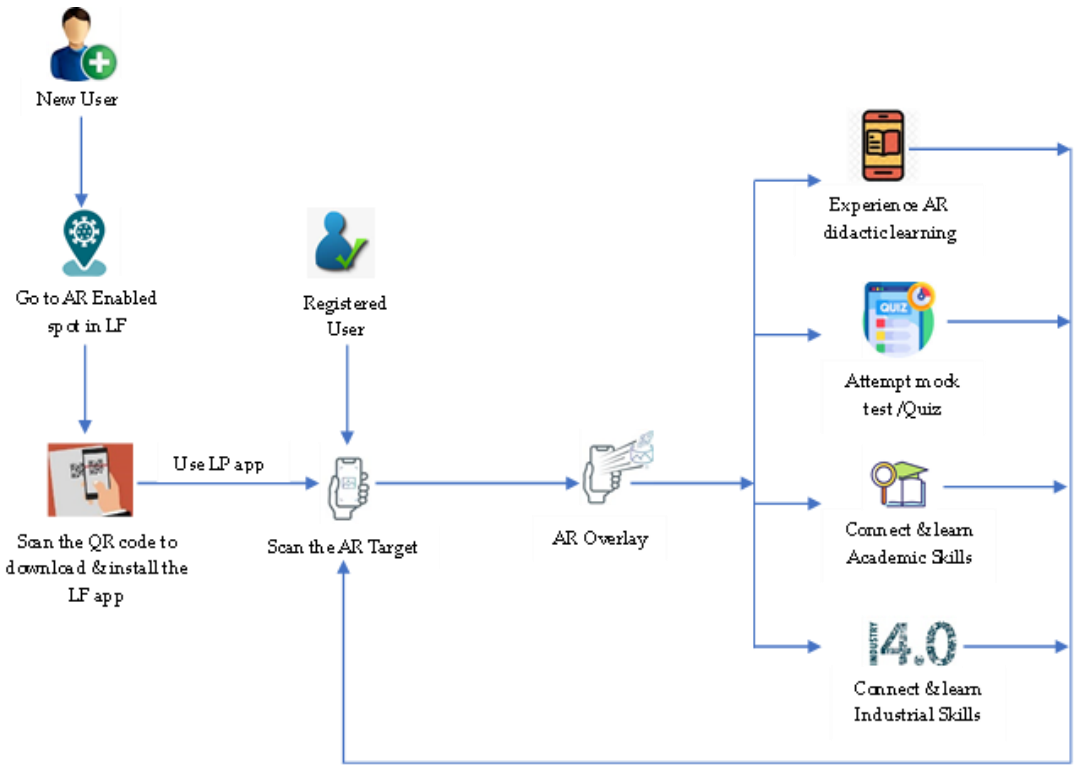

Figure 4.5 Flow diagram of an AR-based didactic system

4.5.1 Developed AR Based Didactic System

Two scenarios of use case are shown in ***Figure 4.6*** for that the AR enabled lessons of didactic are developed and they are described below

a. Offset Printing machine

b. View of AR-based micro lesson for the Machine

c. Combo package design

d. View of AR-based details of the package

Figure 4.6 Prototype for AR-based didactic system

One of them is a printing machine to give a comprehensive study of offset machine along with its parts, process, uses and other is patented design of packaging of combo to provide a detailed study about they are used, designed and their significance of box of combo packaging.

4.5.1.1 Offset Printing Machine:

In the labs of learning factories there will be a one colour print machine of mini offset. This machine is used for the purposes like teaching courses such as design of printing machine, technology of offset, quality of control and reproduction of colour. Understanding its construction, working, assembly, maintenance, printing and control of quality is necessary. Thus, there are several micro lessons that are related to the machine One of them is described in this lesson.

The applications are developed with the help of 3D engine and SDK called Vuforia. Initially, the images of target are uploaded to the Target manager of Vuforia and the license key is created in its portal of development. The display of interaction of user is designed in the Unity 3D Engine with version of v.2019 and the database of target is imported to Unity 3D Engine. The insights of overlay are stored in asset of Unity 3D Engine. This overlay is then assigned to the respective target images in Unity 3D. The interactions of user are programmed in C#, Visual Studio. Then this developed application is converted into the applications of android using the Android SDK.

4.6 SYSTEM TESTING AND EVALUATION OF PERFORMANCE

The proposed system is evaluated systematically with the parameters of performance. The evaluation begins by making 20 micro lessons available to 30 students and enables them to learn and do activities of self-assessment over 1 week. After that a survey with particular objectives and attributes are made at that weekend.

From the parameters of survey, the parameters of performance are derived for inference.

A. Survey Objective:

- To evaluate whether the students have accepted the introduced system for didactic learning.
- To assess whether the AR based micro-lessons is appropriate for didactic learning

B. Survey Form:

5 parameters are identified as per which the form of survey is drafted. They are Content Comprehensibility of content, Flexibility of learning, Experiential Learning,

Clarity of Audio/Visual, and Sustained Engagement. The appropriate form of inquiry is given in ***Table 4.3***

Table 4.3. Parameters of survey

Survey Parameters	Survey Form	Rate it on a scale of 5
Comprehensibility of Content	Understandable content of lesson in just one experience	3
Learning Flexibility	Flexible to learn at your own time and use your own style of learning	4
Experiential Learning	The content of overlay content gave a feel of virtual reality with good effects of visual.	3.21
Clarity of Audio/Visual	The audio and visuals were clear and did not disturb the process of learning	3
Engagement	The visuals of narration of lesson were entertaining and was able to get the attention	4

In this the ratings are considered as 1 denotes Strongly Disagree, 2 denotes Disagree, 3 represents Neutral, 4 indicates Agree and 5 represents - Strongly Agree.

4.7 PERFORMANCE PARAMETERS

A. Student Compliance Index (SCI):

It is framed and used to represent the acceptance of introduced system by the students for learning. It is estimated as sum of weights of 5 attributes that is given in ***Table 4.4***. The weights are assigned with the help of heuristics.

Table 4.4. Performance Indicators

Parameters of Survey	Symbol	Weightage for calculating Student Compliance Index (SCI)
Comprehensibility of Content	C	25
Flexibility of Learning	F	22
Experiential Learning	E	15
Clarity of Audio/Visual	A	19
Engagement	S	19

B. Methodology Used

a.Students self-learning in the Offset Machine Laboratory

b.Students exploring combo pack with AR micro-lesson

Figure 4.7 Students in Learning Factory

Students are offered with access to learning factory and its system of didactic based on AR which at present contains 20 micro lessons or tests as displayed in ***Figure 4.7.*** They can work on their available time; a survey is made at that week's end.

4.8 DATA DRIVEN ANALYSIS

The ratings of survey are gathered and their average is shown in ***Table 4.5.*** The SCI is estimated as

$$SCI = \sum(X_i * Y)_i (3.1)$$

In this X_i denotes the Average of parameters of survey, Y_i is the Weighted sum of Student Compliance Index

Table 4.5. Average Survey Rating before Enhancement

Survey Parameters	Symbol	Average Survey Rating	
		on a scale of 5	In Percentage
Comprehensibility of Content	C	3	60
Flexibility of Learning	F	4	80
Experiential Learning	E	3.23	64.6
Clarity of Audio/Visual	A	3	60
Engagement	S	4	80

Values of performance indicators (Weighted sum of survey parameters),SCI = 3.44

Acceptance of augmented Reality in Didactic System in Print Education before enhancement is shown in ***Figure 4.8***

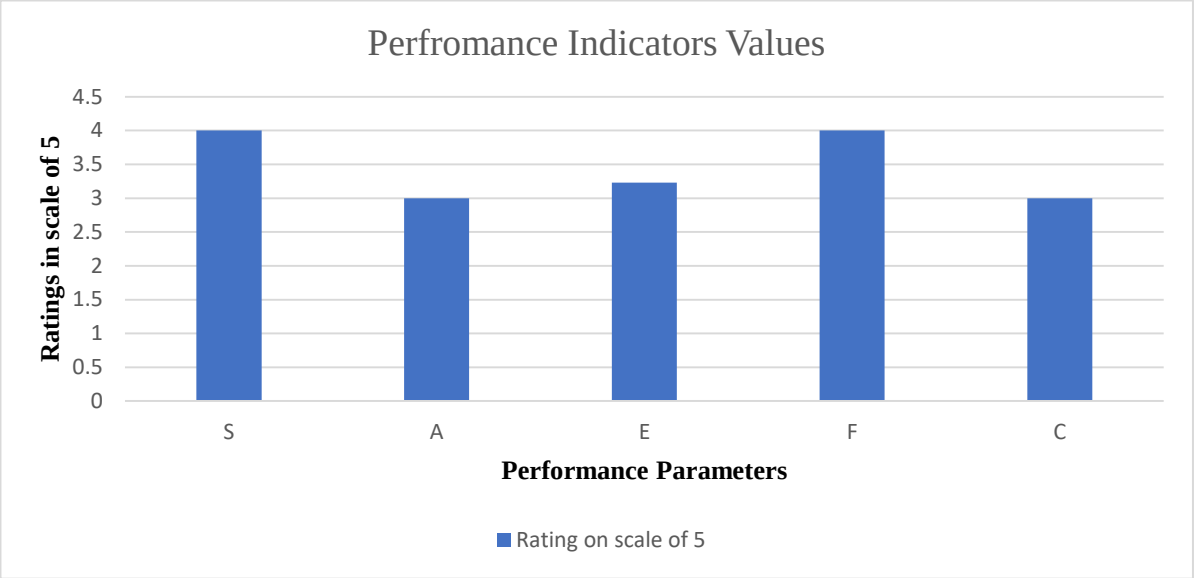

Figure 4.8 Performance Indicators before Enhancement

The significant additional remarks given in the survey are as given below.

The significant remarks that are mentioned in the survey are as follow

- Providing flexibility and ability to students to learn anywhere anytime
- The search time is reduced because with this the students willable to learn just by scanning their targets of interest so they don't have to spend time for searching the information they need actually.
- Students are found to be excited to use this innovative model of learning
- Since the content is augmented automatically merely by scanning the targets, the time to search for the required information is reduced.
- Students were excited with the innovative learning method
- They have found it to be an interactive feature as fun and helped with faster understanding

(i) Interpretation of results:

- ***Table 4.5*** depicts that the flexibility of Learning and Sustained Engagement have obtained 80% and more, but the Audio/Visual Clarity, Experiential Learning, and Content Comprehensibility are found to be with a lower rate.

- On detailed discussions, it is found that the students take to this platform as a classroom-based teaching and thus, and they expect the lessons to be longer, but these AR based lessons were micro-learning lessons and they were found to be lesser than 1.5 minutes.
- SCI Value is 3.44.

4.9 AR BASED DIDACTIC SYSTEM UPGRADATION

Though the results of the previously made evaluation was good and the proposed system was accepted by the students, one more trial was made, this time duration of the lessons were increased based on the feedback obtained from the students. The overlays of AR were created to be of three minutes, and the extra information such as formulas and links of reference were given.

The whole process was repeated and the results of the survey were taken after improving the proposed system and those results are given in ***Table 4.6***

Table 4.6. Average Survey Rating after Enhancement

Survey Parameters	Symbol	Average Survey Rating	
		on a scale of 5	In Percentage
Comprehensibility of Content	C	4.5	90
Flexibility of Learning	F	4.53	90.6
Experiential Learning	E	4.33	86.6
Audio/Visual Clarity	A	3.83	76.6
Sustained Engagement	S	4.33	86.6

Values of performance indicators (Weighted sum of survey parameters),SCI = 4.32

Acceptance of AR in didactic System for PT Education After Enhancement

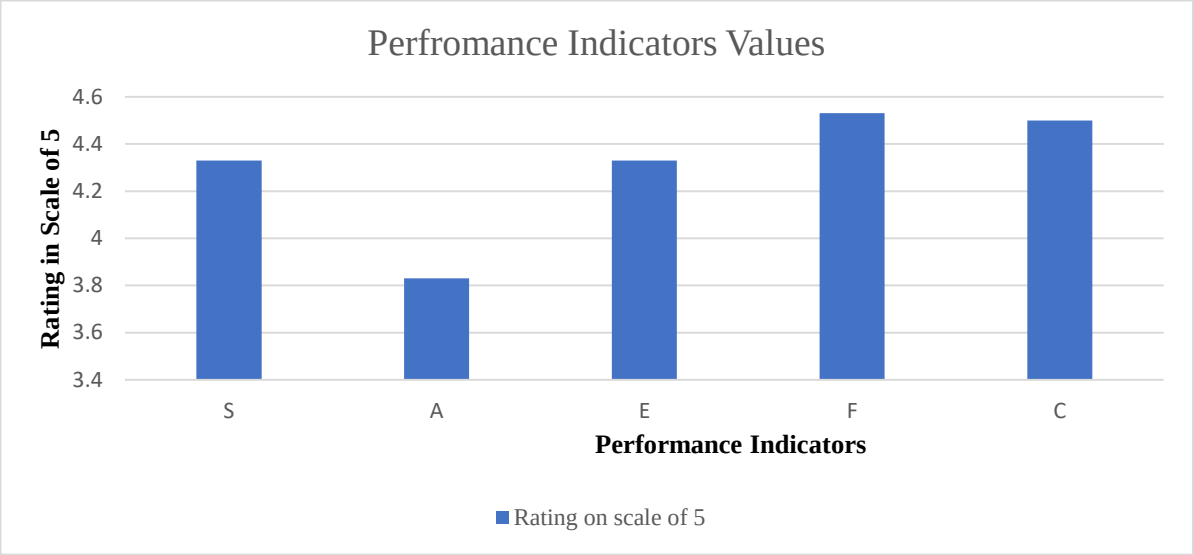

Figure 4.9 Performance Indicators after Enhancement

As you can in ***Table 4.5 and 4.6***, the results of evaluation were better. The comprehensibility of content was raised to a level of 90% from 60% after enhancement, Flexibility of learning was increased from the 64 to 86% approximately. The clarity of audio and video visuals were improved to a level of 76.6% from. The engagement was also improved to a level of 86.6% and then the SCI was improved to be 4.32 that is shown in ***Figure 4.9.***

The results of the system indicate that the system have obtained improved results after enhancement.

SCI comparison before and after enhancement based on Performance Indicators

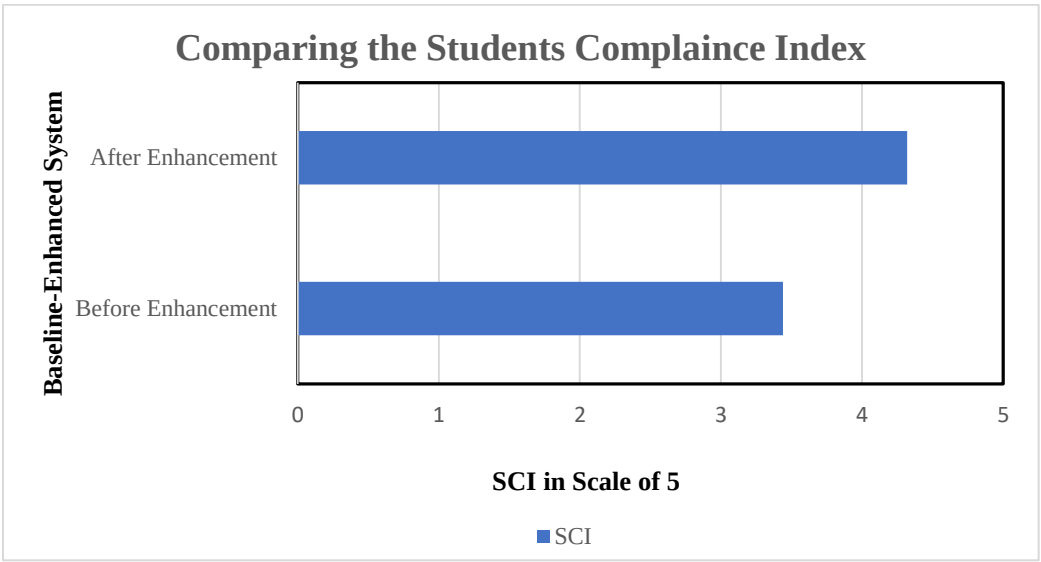

Figure. 4.10 Improvement in Performance Indicators

From the ***Figure 4.10,*** it is evident that the proposed model has obtained better results after enhancing the system by increasing the duration of micro lessons. Apart from this student should know the differences among these various methods of learning they are micro-learning, learning in classrooms and several other types. They should be aware about the advantages of each of these models and must learn to use them properly. So, from the results it is assumed that the students will accept the AR based system of didactic for learning.

A. Quantitative Analysis and Discussion of Data

This work focuses mainly on the primary data that are gathered from the survey that was done and collected by questionnaire-based collection of data

B. Hypothesis

There are 2 hypotheses that can be considered for this work, they are H0 and H1. The hypotheses are depicted in ***Figure 4.11.***

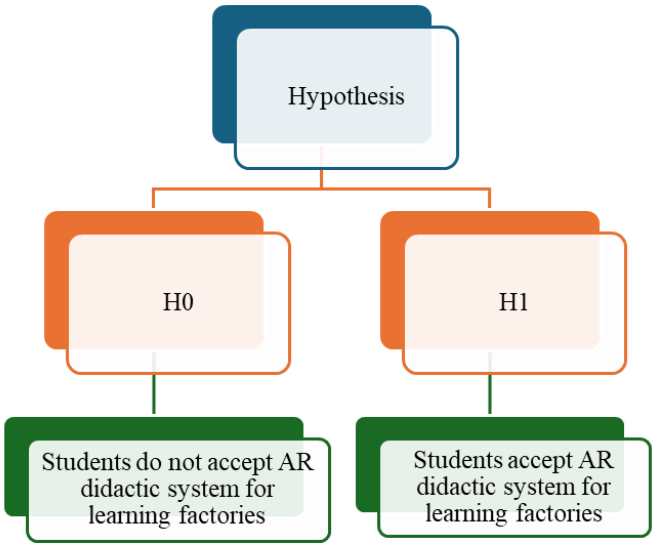

Figure 4.11 Hypothesis Projection

C. Research Design

This work was conducted for a limited, homogenous and well-known population of students who were graduate of B.E. course with the help of pre-experimental designs. And the impact of intervention was calculated with the help of single group pre-test design and post-test design.

D. Sampling

The studies based on experiments are conducted using 30 students with 20 micro lessons were made available for the study. The learning was up to 1 week and the survey was conducted before and after improving the learning app based on AR.

E. Data Collection

The collection of data was framed as per the access experience to learning factories and its AR system of didactic for learning. The AR oriented system for didactic learning has 20 micro lessons in total. The students who are the users were made to work on them at their own available time providing flexibility and a survey is conducted at the weekend.

F. Intervention

The intervention is the improvement of this AR based system for didactic. This improvement was made based on receiving feedback from user, the duration of micro lessons was improved and some extra information such as formulas and links of reference are also given. The whole process was repeated, and the results of the survey were taken after the improvement.

E. Data Analysis & Discussion of Data

The compliance of the suggested system from the perspective of students is measured as per the ordinal measurement scale on a rating of 5. Individual scores are used for calculating the results of pre-test and post-test of this adoption of technology of AR for the didactic system. The scores designed are shown in table ***Table 4.7.***

Table 4.7 Ordinal Measurement Scale

Rating on Scale of 5	Rating description
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

Paired sample t-test was conducted to determine the acceptance of this suggested AR based system for learning by the comparison of the scores before and after the process of intervention.

F. Demographic Characteristics of Respondents

For this some of the students were selected as respondents, they are students taking the course of Bachelor of Engineering from year II, III, and IV, among them nearly 21% of them are from year II, 25% are from year III and 54% of the respondents of these sample population are taken from the year IV as shown in ***Table 4.8.***

Table 4.8. Educational Level of Respondents (Source: Field Data 2022)

Year	Frequency	Percentage
II	6	21
III	9	25
IV	15	54
Total	**30**	**100**

The AR has a significant role in education. The below ***Figure 4.12*** shows the level of awareness of AR in the systems of Education. It is found that 83% of respondents are aware of this AR Usage in the process of active learning, whereas 17% of respondents are not aware of this concept of using AR in learning.

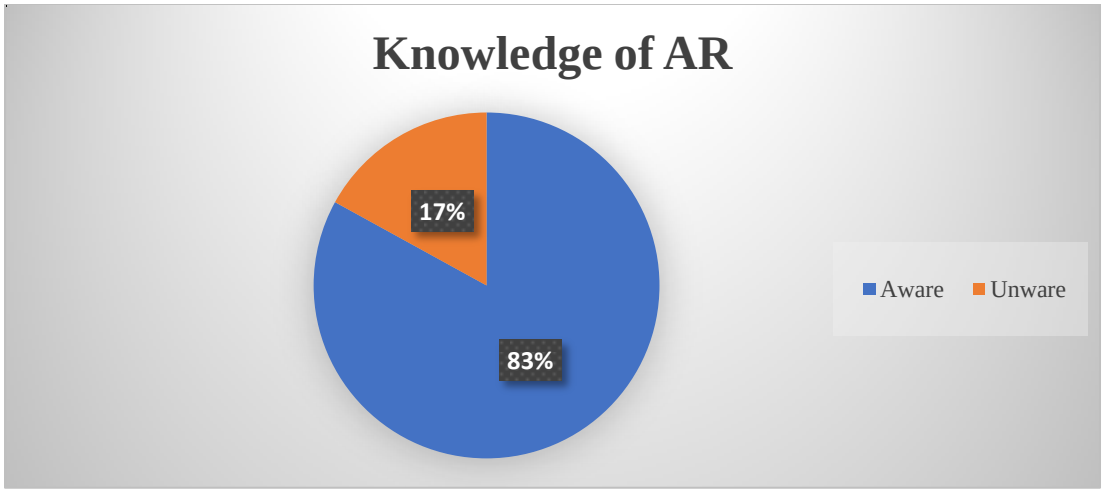

Figure 4.12 Awareness of AR in Didactic System (Source: Field Data 2022)

G. Accessibility of AR System

Next to this, classify the usage and accessibility of this didactic system of AR based on respondents of different type. One were the students from hostel and the other were day scholar students.

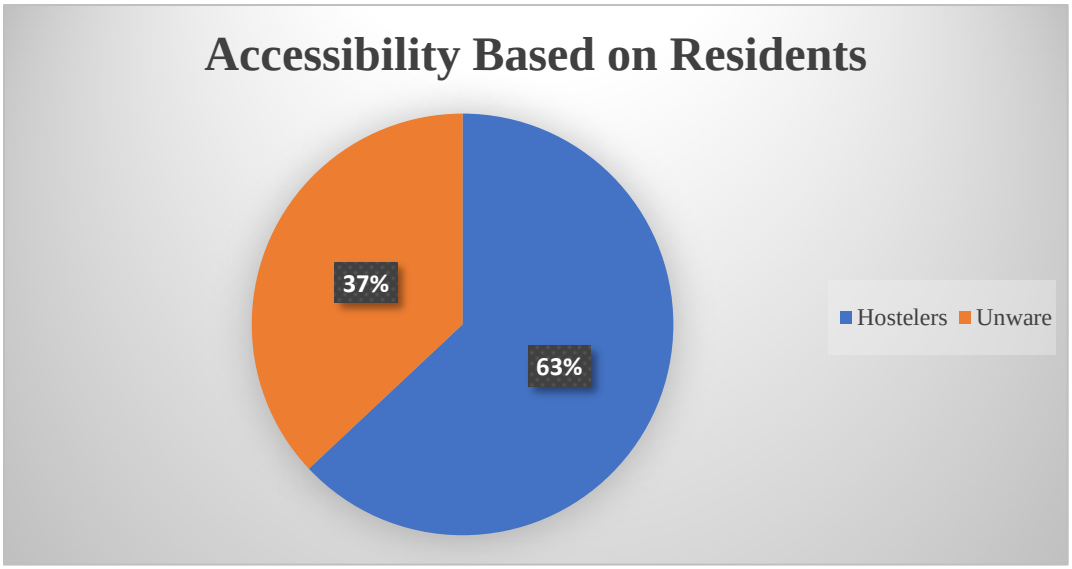

Figure 4.13 Accessibility of the AR Didactic System by Respondents based on Resident (Source: Field Data 2022)

The accessibility of AR system of didactic was used by the hostel students that were the respondents for up to 63%, and they are using it even after the period of college hours that is shown in ***Figure 4.13*** that gives them an opportubity to improve their knowledge and capability of self learning.

Now let us look into the results of the proposed AR based Didactic System in detail in the upcoming section

4.10 RESULTS & DISCUSSION

The data tha are collected are analysed with the samples that are statical paired the samples are denoted as t-test formula.

$$t = \frac{\bar{d}-0}{\hat{\sigma}/\sqrt{n}} (3.2)$$

In this the $\bar{d}$ represents the mean of differences of sample

$\hat{\sigma}$ indicates standard deviation of differences of sample

N represents the size of the sample

Sample mean of difference is computed by,

$$\bar{d} = \frac{\sum d_i}{n} \text{ , (3.3)}$$

In this the d_i represents the difference between the Y_i and X_i

Standard Deviation $\hat{\sigma}$ is estimated by,

$$\hat{\sigma} = \sqrt{\frac{\sum {d_i}^2 - (d)^2 * n}{n-1}} \text{ (3.4)}$$

Sample means and the standard deviation are first estimated as per the rating obtained before enhancing (X_i) and after enhancing (Y_i) of AR based system of didactic. Next to that the t-statistics is calculated with the help of the formula that is mentioned above. The t-statistics helps in determining the major difference between mean of 2 observations and their relationships. And finally, the probablity of observing test statistics unser null hypothesis was computed. The value of probablity is obtained by comparing t value to the t distributions with degree of freedom. P-Value will help to decide if to aceept or to reject the null hypothesis. ***Table 4.9*** shows the Analysis of periodic sample test.

Table 4.9. Results of period sample test using SPSS tool

Pairs	Mean	Std. Deviation	Std.Error Mean	95% Confidence Interval of Difference	
				Lower	Upper
Pair 1: Comprehensibility of content - Content_Dummy	-1.5000	.57235	.10450	-1.71372	-
Pair 2: Flexibility - Flexibility_dummy	-53333	.86037	.15708	-.85460	-
Pair 3: Experimental_Learning – Experimental_Dummy	-1.10000	.84486	.15425	-1.41548	-
Pair 4: Audio_video – Audio_Dummy	-83333	1.17688	.21487	-1.27279	-
Pair 5: Engagement –	-33333	.80230	.14648	-.63292	-

Pairs	Mean	Std. Deviation	Std.Error Mean	95% Confidence Interval of Difference	
Engagement_Dummy					

Significance				
Pairs	**T**	**Df**	**One-Sided p**	**Two-sided p**
Pair 1: Comprehensibility of content - Content_Dummy	-14.355	29	<.001	<.001
Pair 2: Flexibility - Flexibility_dummy	-3.395	29	.001	.002
Pair 3: Experimental_Learning – Experimental_Dummy	-7.131	29	.002	.002
Pair 4: Audio_video – Audio_Dummy	-3.878	29	<.001	<.001
Pair 5: Engagement – Engagement_Dummy	-2.276	29	.015	.030

Thus it is observed that the content satisfaction, flexibility of learning, learning based on Experiments, clarity of audio and video were dfound to be significant at level 1% and the engagement was significant at level of 5%. Therefore the null hypothesis is not significant. By the paired sample T test it is concluded that there was much acceptance of this proposed AR system for didactic for learning factories by students.

4.11 SUMMARY

In this work, we have developed a AR based didactic system for learning factories that is designed specifically for Education and Training in Technical Education. Few courses of the technologies are unqiue and multi-discipline and few programmes are quite rare and so there were some lacking when it comes to having expertise and materials of learning, and so this system was designed to offer students with improved study materials with environment. The system of didactic was developed based on the model of OBE that is Outcome-based Education. This work offers AR based micro lessons for both the

process of self learning and self evaluation or assessment by the users that are students can use, learn and get benefitted from this at their own pace when they at their campus.The proposed system is evaluated with the help of student users the metric called SCI – Student Compilance Index as evaluation metric. The feedback from the students were obtained, considering the scope for enhancement, the system was enhanced and reevaluated, offering better performance and an increased acceptance for this proposed AR based system for didactic concerning the availability of content was 90%, clarity of audio and video are found to be 76.6%, the flexibility of anytime learning was 90.6%, learning based on experiments were 86.6% and interaction of students was 86.6%. The level of significance of this AR based system of didactic was analysed with the help of paired sample T-tests, that resulted in significant acceptance of this proposed system model for learrning factories at a rate of 1% and 5% respectively by students.