MASTER OF SCIENCE IN TECHNICAL EDUCATION
MECHANICAL ENGINEERING

Designing and Developing a Prototype of Digital Learning-Teaching Materials in Blended Learning Approach

BY

SHARIFUL ISLAM SHAKEEL
STUDENT ID. 191031104
M.Sc.T.E. (ME)

DEPARTMENT OF TECHNICAL AND VOCATIONAL EDUCATION (TVE)
ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
THE ORGANIZATION OF ISLAMIC COOPERATION (OIC)
BOARD BAZAR, GAZIPUR 1704, DHAKA-BANGLADESH

MAY 2022

Designing and Developing a Prototype of Digital Learning-Teaching Materials in Blended Learning Approach

Thesis Submitted in Partial Fulfillment of the Requirements of the Degree of Master of Science in Technical Education with Specialization in Mechanical Engineering.

SHARIFUL ISLAM SHAKEEL
STUDENT ID. 191031104
M.Sc.T.E. (ME)

DEPARTMENT OF TECHNICAL AND VOCATIONAL EDUCATION (TVE)
ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
THE ORGANIZATION OF ISLAMIC COOPERATION (OIC)
BOARD BAZAR, GAZIPUR 1704, DHAKA-BANGLADESH

RECOMMENDATION OF THE BOARD OF EXAMINERS

The thesis title " **Designing and Developing a Prototype of Digital Learning-Teaching Materials in Blended Learning Approach,**" submitted by Shariful Islam Shakeel, student ID. 191031104 of the academic year 2019-2020, has been found satisfactory and accepted as partial fulfilment of the requirement for the Master of Science in Technical Education (MTE) in May 2022.

Board of Examiners

----

1. Prof. Dr. Md. Faruque A. Haolader — Chairman (Supervisor)
Professor and Head
Department of Technical and Vocational Education (TVE)
Islamic University of Technology (IUT), Gazipur, Bangladesh.

----

2. Prof. Dr. Md. Faruque A. Haolader — Member (Ex-Officio)
Professor and Head
Department of Technical and Vocational Education (TVE)
Islamic University of Technology (IUT), Gazipur, Bangladesh.

----

3. Dr. Mahbub Hasan — Member (Internal)
Associate Professor
Department of Technical and Vocational Education (TVE)
Islamic University of Technology (IUT), Gazipur, Bangladesh.

----

4. Prof. Dr. Md. Shahadat Hossain Khan — Member (Internal)
Professor
Department of Technical and Vocational Education (TVE)
Islamic University of Technology (IUT), Gazipur, Bangladesh.

----

5. Prof. Dr. S M Hafizur Rahman — Member (External)
Professor
Institute of Education and Research (IER)
University of Dhaka, Bangladesh.

DEDICATION

DEDICATED TO MY PARENTS, WIFE AND THREE LOVELY DAUGHTERS.

ACKNOWLEDGEMENT

In the first place, I'd like to express my gratitude to Allah for bestowing upon me the ability to finish my Master's and thesis studies, even in the midst of difficult circumstances. I want to express my profound gratitude to the Organization of Islamic Cooperation (OIC) member states for providing me with a scholarship that enabled me to attend this eye-opening Master's degree at IUT. I am also indebted to the Ministry of Expatriates Welfare and Overseas Employment as well as the Bureau of Manpower, Employment and Training (BMET) for granting my study leave to attend this heavyweight program for TVE aspirants.

It is my genuine pleasure to express my deep sense of thanks and gratitude to my mentor and supervisor, Prof. Dr. Md. Faruque A. Haolader, Professor & Head of the Department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT). To get to this stage, I owe a debt of gratitude to his extensive research experience and knowledge. His unending patience, academic instruction, continual encouragement, frequent supervision, constructive criticism, good counsel, reading many substandard versions, and fixing them always have made it possible this far. I couldn't have asked for a better adviser and mentor for my Master's degree.

This study would not have been possible without the assistance and insightful recommendations provided by the IUT TVE department's faculty and personnel. Instructors and Principals of six Institutes of Marine Technology (IMT) are also to be commended for allowing me to conduct a Blended Learning Session at their respective institutions. As a student, I owe a debt of appreciation to my classmates and other students for their support and encouragement.

Finally, I would like to thank my entire family, especially my wife, for their unwavering support and unconditional love during my M.Sc. studies.

DECLARATION OF THE AUTHOR

This is to certify that the work presented in this thesis is the outcome of the investigation carried out by Shariful Islam Shakeel under the supervision of Prof. Dr. Md. Faruque A. Haolader, Department of Technical and Vocational Education (TVE), Islamic University of Technology (IUT), The Organization of the Islamic Cooperation (OIC), Dhaka, Bangladesh, is my original work.

It is hereby declared that this thesis is my original work. This thesis has neither been submitted by anyone else nor previously been accepted for the award of any degree in this university or elsewhere. I also testify that the sources used in this thesis were explicitly acknowledged with proper citations and references.

Prof. Dr. Md. Faruque A. Haolader
Supervisor
Professor and Head, Department of TVE, IUT

Shariful Islam Shakeel
Student ID. 191031104
M.Sc.T.E (ME), TVE

ABSTRACT

Following COVID-19, the global educational landscape shifted dramatically. Almost every university globally was forced to begin offering online courses; for some countries, this was a sea change that opened the door to digitalizing their education. But Bangladeshi TVET institutions have been stumbling to adapt to the new normal classroom situation as the government directed institutes to reduce their face-to-face class time and start online learning. Again, teachers also face great difficulties producing blended learning as there is no specific study conducted on course design for Bangladeshi TVET students. Also, the teachers are often required to make the blended learning classroom faster than usual in this sort of situation. Thus, this study proposes a customized prototype that uses the features of both Analysis, Design, Development, Implementation, and Evaluation (ADDIE) and Rapid Prototyping (RP) to help Bangladeshi TVET educators to make a reliable and robust prototype faster. The prototype was reviewed by experts and end-users and validated to ensure its fidelity. Eventually, the prototypes' construct validity was confirmed using Technology Acceptance Model (TAM), and usage of the prototype was evaluated through students' academic performance. It has also been observed that using the end-users at the beginning of the design and development process significantly reduced the lead time to prepare the prototype. Further, in the midst of the COVID-19 epidemic, Bangladeshi TVET institutions are frequently expected to provide blended learning in order to create competent, effective, and inventive learners. But it has become a daunting task for the TVET educators to produce an effective blended learning environment as very few studies have been conducted on the preparedness of Bangladeshi TVET students for blended learning. Thus, this study also investigated the learners' readiness toward blended learning, which should help course designers to offer a successfully blended learning environment. As a result, another purpose of this study was to determine the degree of students' preparedness for various learning components and the dominating factor and other variables that may impact their readiness for blended learning. In this study, the researcher envisioned six learning components and then solicited answers from 235 students. The study suggests that the readiness of Bangladeshi TVET students toward blended learning is at a moderate level. There is a significant positive correlation between blended learning readiness and attitude towards online learning, openness to new technology, and attitude towards the face-to-face classroom. In contrast, significant negative correlations are found between blended learning readiness and basic skills of using technology, learning flexibility, and study management. This study also reveals that in some factors, Bangladeshi students' readiness was high, whereas, in some segments, the course designer must incorporate a few things to implement a successfully blended learning environment. This study should help the TVET course designers and government body acknowledges the hindrances that need to be stamped out to introduce blended learning in Bangladeshi TVET institutes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

TVET	Technical and Vocational Education and Training
IMT	Institute of Marine Technology
BTEB	Bangladesh Technical Education Board
BMET	Bureau of Manpower, Employment, and Training
A2I	Access to Information
BL	Blended Learning
SPSS	Statistical Package for Social Science
SSC	Secondary School Certificate
HSC	Higher Secondary School Certificate
IUT	Islamic University of Technology
OIC	Organization of Islamic Cooperation
ICE	Internal Combustion Engine
ID	Instructional Design
ISD	Instructional System Design
LMS	Learning Management System
F2F	Face-to-Face
ADDIE	Analysis, Design, development, Implementation, Evaluation
RP	Rapid Prototyping

CHAPTER 1 INTRODUCTION

1.1 Background of the study

Students' learning outcomes depend on many factors, such as curriculum, curriculum materials (learning teaching materials), curriculum implementation strategies and methods, individual students learning styles (activities), and learning environment, among others. It is easily predictable that every learner has a way of understanding things. When we consider only the traditional face-to-face curriculum content delivery approach in a classroom where learning is entirely supported by chalk-duster/whiteboard-marker and printed materials, it may be convenient and pleasant for some learners, but for some, it may not be due to many reasons. However, it is also the prime time now to address the fundamental functionality of the teaching-learning approach, as it is another establishment that most students feel depressed when they cannot cope with the pace of the classroom (Winrow, 2019). Therefore, we observed a subtle paradigm shift from traditional face-to-face learning to online learning at the dawn of the twenty-first century, which includes applying digital learning materials (both synchronous and asynchronous. However, there are some significant drawbacks when fully online learning is considered, i.e., not useful for students who lack self-motivation and prefer immediate feedback. Social isolation (missing direct interaction among fellow students, between teachers and students, etc.), limit to specific courses- (not appropriate where hard skills are needed), etc., are some additional drawbacks. It is also evident that Blended Learning is more efficient than traditional face-to-face sessions (C. W. Tsai, 2010). Thus, we need a corrected learning-teaching approach that concurs with both online and traditional learning strategies- 'the Blended Learning' - an excellent way of fulfilling the learning objectives where multiple modalities of learning (web-based and traditional) are adequately instructed, organized, and introduced to achieve the optimum learning experiences at a minimal program cost. This approach also gives students the atmosphere of learning anytime and everywhere and prepares them to succeed and minimize all drawbacks of traditional presence learning strategies (Rahman & Sahibuddin, 2010). As ever-changing technology advances rapidly, blended learning modalities and tools are also changing every day. So, for designing courses in the Blended Learning approach, the designer has a very liberal field to make/choose his tools to deliver a session. Because of the ambiguity of the definitions of blended Learning (Alammary et al., 2014), course designers have the freedom to build their learning-teaching materials regarding courses (Sharpe et al., 2006). So, it is feasible to pick any course and design learning materials with available resorts to gain maximum student feedback. Some researchers developed a prototype of a teaching-learning environment (software) on a selected topic from the field of Information Technology, considering pedagogical and technical design principles and requirements for teaching/Learning software in the context of new information and communication technology (Haolader, F.A., Simmert H. & Ihbe, 2001). Also, some critical issues have been identified in designing a blended learning environment by examining basic design considerations and implementation issues (Gedik et al., 2013). But Blended Learning - a known approach in some developed countries, is still a new concept for Bangladeshi TVET students.

At present, there are 10452 affiliated institutes under BTEB, and more than 1 million students are enrolled in its various program. But unfortunately, very little or no work has been conducted on the Bangladeshi TVET students to acknowledge their understanding and preparedness for Blended Learning.

1.2 Problem Statement

Very little research has been carried out regarding the design and development of digital learning-teaching materials focusing on the upper secondary non-tertiary level TVET programs in Bangladesh. During the pandemic situation, the TVET course designer had to prepare a blended learning course within a short lead time. Thus, this study aimed to propose an acceptable and effective digital learning-teaching prototype that would help the TVET course designer in Bangladesh by reducing the lead time. Again, the students' perceptions of blended learning are not fully acknowledged in Bangladesh, as most traditional students are unacquainted with digital classroom materials. So, it is still unknown to us how well they are prepared to use the modern learning media/tools and how easy and convenient they are for them. So, it is high time to make a timely and straightforward prototype of digital learning-teaching materials to analyze the TVE students' readiness and perception regarding Blended Learning.

1.3 Research Objectives

This study aims to support blended learning by providing technically and pedagogically well-designed blended learning teaching materials that the learners can use at Diploma in Marine/ Shipbuilding Technology and Diploma in Engineering in Automobile and Mechanical Technology. Furthermore, this prototype will assess Bangladeshi TVET students - to find their readiness toward a blended learning approach. The specific objectives of this research are:

i. To design and develop a prototype of digital learning-teaching materials with an example of a technical course- the Internal Combustion Engine- in blended learning approach for a Diploma in Marine/ Shipbuilding/ Mechanical Technology.
ii. To pilot-test the prototype by the users for its functionality and design.
iii. To assess Bangladeshi TVET students' readiness to adopt/adapt to blended learning.

1.4 Research Questions

In this study, the researcher investigated rigorously to answer the following research questions. The researcher answered the below research question to fulfill the first objective.

RQ1: What suitable prototype can be used to create an effective BL environment for Bangladeshi TVET students?

This study considered the below two research questions to accomplish the second objective.

RQ2.1: To what extent do the TVET students of Bangladesh accept the proposed prototype for the BL environment?

RQ2.2: Do students attending BL courses using this proposed prototype have performed better compared to other courses?

Finally, the researcher answered the below research question to respond to the third objective.

RQ3: Are Bangladeshi TVET students ready for a blended learning environment?

1.5 Significance of the study

The tangible outcome of this study is an efficient and convenient prototype of digital learning-teaching materials to be designed for Bangladeshi TVET students. Assessing their preparedness and readiness toward blended learning is the most critical aspect of this study. If students and teachers are ready to learn in a blended approach, this prototype can be used in learning-teaching IC Engine courses at TVET institutions, and this study will encourage and direct TVET teachers to design and implement their courses in blended learning in their respective institutes. Thus, this study could be instrumental and pave the way for self-propelled study by empowering the Bangladeshi students in a dynamic environment.

1.6 Delimitations

Due to time constraints, among many Diploma in Engineering curriculum courses, it was not possible to go for many subjects and design BL sessions for all of them. It was also impossible to engage all students at those institutes to analyze prototypes in this limited time. Therefore, for research questions 1,2, and 3 - this study was delimited to only two TVET institutes, and only sixty-seven students were engaged in a BL course using this proposed prototype. It was also impossible to engage all students of those institutes and analyze prototypes and assess students' readiness in this limited time. So, for research question 4, only first-semester diploma engineering students of six TVET institutes were considered for this study. Therefore, developing a prototype and assessing the readiness of Bangladeshi TVET students, this study was delimited to:

1. The diploma in engineering 1st semester Marine/Shipbuilding Technology course "Internal Combustion (IC) Engine Principle" - was considered to develop the Blended Learning prototype.
2. Only Six institutes under the Bureau of Manpower, Employment and Training (BMET) offering the said "Internal Combustion (IC) Engine Principle" course has been selected as a population to assess the readiness of TVET students, and two institutes of marine technology were used to test the acceptance and usage of the proposed prototype.

1.7 Assumptions

The researcher assumed that the respondents would honestly provide reliable information required for the study.

1.8 Definition of terms

Blended Learning (BL): It is an excellent way of fulfilling the learning objectives where multiple modalities of learning (web-based and traditional) are adequately instructed, organized, and introduced to achieve the optimum learning experiences at a minimal program cost.

Online Learning (OL): Teaching and Learning are facilitated through technology in which most of the instructions happen to be stimulated via a Learning Management System (LMS).

CHAPTER 2 REVIEW OF THE RELATED LITERATURE

2.1 Introduction

With the advent of exponential growth of technologies, media, and the internet – the spectrum of learning has changed. The conservative approach towards online education has significantly changed, and more and more recognized international universities and institutes are offering online courses more frequently. But countries like Bangladesh are lagging in this segment. After the severity of Covid-19, the government of Bangladesh had to close all educational institutes and then directed the institutes to start online learning. However, we observed that many institutes could not offer online education throughout this phase because the concept is quite new for countries like Bangladesh. Again, it was way more difficult for technical subjects to be delivered in fully online learning mode, as some topics required hands-on activities and practice to master. Thus, mixing face-to-face and online classrooms is necessary to overcome this problem. So, Blended Learning (BL) is the only approach for the TVET institutes to minimize social distance and enhance students' performance (C. W. Tsai, 2010).
Additionally, multiple studies have indicated that students do not gain creative learning, out-of-the-box thinking, or advanced reasoning skills in a face-to-face classroom setting (Lee et al., 2017). Moreover, it is also essential to introduce global learning phenomena to Bangladeshi students to make themselves up to date with all the teaching-learning features that the advanced world is proposing. Therefore, in this study, the researcher will try to find the proper blend for Bangladeshi TVET students. Though the conceptual framework in blended learning is exciting for some, it is still a daunting task for many to anticipate. As there is no guideline on how to design blended learning for the TVET students, this study will focus on designing and developing a correct blend and trying to implement the design for current TVET students of Bangladesh. It is also important to reduce the design time, as many instructors in Bangladesh are in dire need to offer the blended learning sessions faster for the sake of students' achievement in this pandemic situation. In this literature, the researcher will consider the ADDIE model to design the digital teaching-learning materials prototype while considering its' limitation to produce the prototype faster - this study will try to customize the ADDIE model with some of the features of Rapid Prototyping (RP) as well as observing how the customized version work in a natural environment. Furthermore, this study will attempt to investigate the preparedness of Bangladeshi TVET students for the blended learning environment.

2.2 The Concept of Blended Learning

Blended learning is a collection of delivery media intended to work in tandem to facilitate learning and application-learned behavior. Blended learning programs may incorporate various learning resources, including real-time virtual/collaboration software, self-paced Web-based courses, and management of knowledge systems. Blended learning combines several modes of instruction, i.e., Various event-based live events, face-to-face classrooms, e-education, and self-paced education (Singh, 2003). This literature articulate that BL can be formulated in various ways depending on the designers' intention. A designer can make a course from scratch or add extra online activities to a traditional setup classroom (Alammary et al., 2014). Blended learning can be any of the following approaches (Driscoll, 2002; Oliver & Trigwell, 2005):

1. The merging of traditional and online education.
2. A pedagogical approach that is integrated with or without instructional technology.
3. An integration of instructional technology with instructor-led face-to-face training.
4. Alignment of instructional technology with actual job tasks.

Blended learning is the coexistence of face-to-face and online learning, where 30-79 percent of the content is delivered online (Allen et al., 2007). To make an effective blended learning course, the instructor needs to go through all course curricula to recognize the best fit for any particular course. The effectiveness of Blended learning depends on its' design approach, how the course outcome is defined and structurally organized, and how every aspect of the learning objectives is aligned. Therefore, Blended course designs involve the instructor and students collaborating in a variety of delivery modes, typically face-to-face and technology-mediated, to achieve learning outcomes that are pedagogically supported by assignments, activities, and assessments that are appropriate for each mode and that meaningfully connect course environments for the learner (McGee & Reis, 2012). At its most basic level, blended learning mixes offline and online modes of instruction, with online typically referring to "through the Internet or Intranet" and offline typically referring to a more traditional classroom environment (Singh, 2003). Blended learning is the approach that mixes the best features of self-paced, instructor-led, distance, and face-to-face classroom delivery to provide flexible, cost-effective training that is accessible to the largest possible audience geographically and in terms of learning styles and levels (Marsh & Drexler, 2001).

Blended learning is pedagogically supported by assignments, activities, and assessments appropriate for each mode and meaningfully connect course environments for the learner (McGee & Reis, 2012). At its most basic level, blended learning mixes offline and online modes of instruction, with online typically referring to "through the Internet or Intranet" and offline typically referring to a more traditional classroom environment (Singh, 2003). Blended learning is the approach that mixes the best features of self-paced, instructor-led, distance, and face-to-face classroom delivery to provide flexible, cost-effective training that is accessible to the largest possible audience geographically and in terms of learning styles and levels (Marsh & Drexler, 2001).

2.3 Designing Approach of Blended Learning

There are five key ingredients, i.e., live events, online content, collaboration, assessment, and reference, that need to consider in designing Blended Learning sessions (Carman, 2005). It is the instructor's authority to develop blended learning sessions as per the requirement of students. Here the instructors need to integrate the various modes of teaching-learning elements, e.g., lectures, discussions, and different activities, both synchronous and asynchronous. Blended learning can be designed considering the following three approaches (Alammary et al., 2014).

1. Low-impact blend: It is an approach where instructors add online activities to their traditional courses without eliminating any existing activities. It is an approach of inexperienced teachers designing their first blended course.
2. Medium-impact blend: It is an approach where the teacher redesigned some of the traditional face-to-face activities into online activities. If any course segment seems to be reasonably fit for online learning, it is offered online.

3. High-impact blend: It is an approach where the course designer designs a course from scratch. In this method, the designer investigates each learning outcome of the course rather than viewing the entire course. We can term it a total redesign or radical change of a whole course. Comparative discussion among low, medium and high impact blends (Alammary et al., 2014) will help us better understand the underlying factors.

Table 1 Comparative Analysis of Different Types of Blends

Topics	Low impact blend	Medium impact blend	High impact blend
Strengths	An easy and quick approach	Allows incremental changes while designing components for the course.	Allow teachers to get the maximum benefit of BL.
	Low risk to fail	Allow teachers to experiment with different approaches to learning and using various technologies.	Designing the BL allows better integration of online and face-to-face components
	Minimal experience required	Require less experience	
Weaknesses	Extra activities are often seen as a burden by students	There is no defined standard to guide how much and what part of the course can be replaced.	Require a high level of technological knowledge
	Often not recognized by administrators	It takes a long time to design and develop a medium-impact blend course.	It takes a long time to design and develop a high-impact blend course.
		Prior experience in teaching traditional classrooms is beneficial.	It has a higher risk of failure.

Based on instructor shifts following categories of the blend (McGee & Reis, 2012) can also be implemented:

1. Enabling blends: It is an approach through which the learner acquires some additional flexibility from the instructor through a different method to provide some new learning experiences.

2. Enhancing blends: It is a method that incorporates some incremental changes to the pedagogy but does not intend for a total shift in learning experiences.

3. Transforming blends: This type of blend offers radical changes in the pedagogical approach. In this method, learners are not only the information receiver; they construct knowledge through dynamic interaction.

After deciding on the correct blend for a course, it is the primary job of the instructor to go for a Prototype. It is a widely approved approach to designing a training program, course, or learning session. This is a systematic approach to determining students' needs as per the needs designing and developing the teaching-learning material, and finally evaluating the effectiveness of the training or course. In this study, the researcher will investigate the ADDIE model and Rapid Prototyping to develop a prototype of digital teaching-learning materials.

2.4 Few Approaches of Prototype Design to Deliver Blended Learning Session

This research aims to investigate methods for expediting the learning and implementation of prototypes. A proper Prototype is a necessary but time-consuming component of any training process; thus, establishing techniques for doing it well and efficiently is important, and the advantages are obvious. Several strategies for developing a prototype of digital teaching-learning materials for blended learning will be discussed in further detail below:

2.4.1 ADDIE Model

Florida State University developed this ADDIE model in 1975, later which became a famous Instructional Systems Development (ISD). The model consists of several steps under its five phases (Analysis, Design, Development, Implementation, and evaluation). The ADDIE model is an iterative instructional design method in which the instructional designer may return to any previous step based on the formative evaluation findings. The final result of one phase serves as the starting material for the subsequent stage (Aldoobie, 2015). It is necessary to understand the below phases carefully to design any training or course.

Analysis Phase: This is the most critical stage of the model's development. This phase requires the definition of the problem, identifying the cause of the problem, and determining feasible solutions (Kulvietiene & Sileikiene, 2006). This phase's result will serve as the input for the design phase.

Design Phase: The next step in the ADDIE model is the design phase. This step is primarily concerned with implementing the directive. Indeed, the Prototype designer considers how to develop genuinely effective teaching in facilitating people's learning and interaction with the resources one generates and provides in this stage. Additionally, throughout the design phase, the Prototype designer concentrates on developing assessments for their subject, choosing a course format, and developing their instructional approach (Aldoobie, 2015).

Development Phase: The development phase is when all the project's components are arranged and constructed following the design plan. In other words, the development stage is where all the disparate elements come together to form a fully functional prototype ready for execution. Before a completed product can be created, the many components envisioned in the design must "come to life (Onguko et al., 2013)."

Implementation: The implementation phase is concerned with putting a plan into action, and it entails three primary steps: training, preparing learners, and structuring the learning environment.

Evaluation: It is the final step of the ADDIE model. It is crucial to check every prototype step to ensure each stage is aligned with intended goals and needs. Evaluation could be of two types:
(a) Formative Evaluation: It is a continuous process. It can be done by one-to-one evaluation, small evaluation group, and trial on the field.

(b) Summative Evaluation: This type of evaluation is done to evaluate the actual value of the Prototype.

After completing each step, it goes back to the evaluation steps to check the model's reality. Therefore, in the ADDIE model designer has to ask many questions in different segments of the phases to understand the underlying factors.

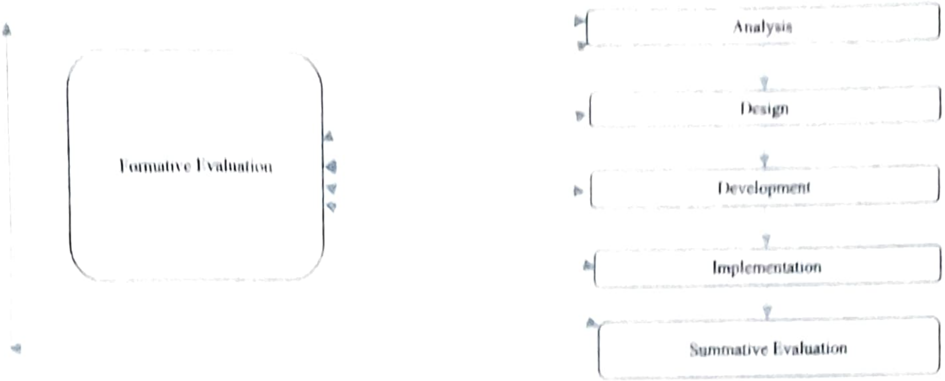

Figure 1 ADDIE Model

2.4.2 Prototyping Method

A prototype is a physical representation of an abstract concept. Prototyping is critical for developing iterative loops of new knowledge via social networking and team-based communication in both scenarios (Suson et al., 2020). The greater degree of cognitive attachment to prototyping establishes a clear link between implicit integrated awareness and its implications for objective learning. The prototyping process is defined as "any representation of a design concept, regardless of medium," while a designer is defined as "someone who builds a prototype to design (Yu et al., 2018)." Prototypes can assist in minimizing design faults that may occur early or late in the process. Prototypes are frequently generated quickly and inexpensively, and they serve as good models for designers, supporting them in discovering design problems and learning from mistakes (Deininger et al., 2017). The following is a list of the most often occurring and recognized functions (or purposes) ascribed to the prototype (Carfagni et al., 2020):
(a) Exploration: Assisting in discovering new design concepts or ideas.
(b) Active learning: Assisting in acquiring new information about the design space and/or pertinent phenomena.
(c) Refinement: Assisting in the progressive improvement of the design.
(d) Communication: Facilitating exchanging design information with various stakeholders.

The prototype approach is a very successful strategy for developing specific core competencies. To accomplish training objectives and needs in a comprehensive education system, adhering to the prototype approach is only a notion; thus, it is difficult to realize its function directly unless extensive programming is conducted using deep professional analysis(Shao et al., 2010). Therefore, the prototype approach increased the responsibilities of instructors, requiring them to devote more time to study to improve the quality of their knowledge and be capable of resolving the majority of students' difficulties. Additionally, Linear prototyping processes (Yu et al., 2018) and activities are viable for achieving specified milestones where defined targets must be met to advance the process. The process can be summarized as follows:

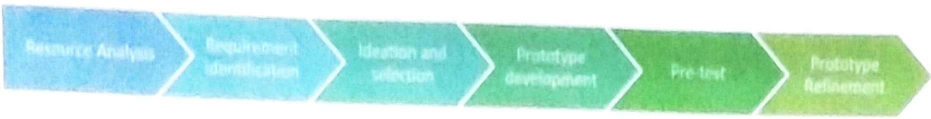

Figure 2 Prototype Process and Activities

(a) Resource analysis – The primary goal of resource analysis is to identify and evaluate cost-effective alternatives or the least expensive methods of achieving desired objectives.
(b) Requirement identification – Users define their basic requirements based on their own experience with the process. A prototype model is created by first analyzing the requirements. The system's requirements are explained in depth at this phase. The procedure involves interviewing system users to ascertain their expectations of the system.
(c) Ideation and selection – At this stage, the designer investigates the issues, concepts, and possibilities within the area of emphasis. It offers the designer a simplified insight into the system.
(d) Prototype development – This step involves the creation of an actual prototype using the knowledge acquired during fast design. It is a scaled-down version of the needed system.
(e) Pre-test – After developing the final system from the final prototype, it is thoroughly tested and sent to production. Routine maintenance is performed to minimize downtime and prevent catastrophic breakdowns.
(f) Prototype refinement - If the user is dissatisfied with the present prototype, you must modify it based on their feedback and ideas.

This phase will continue until all of the user's criteria are satisfied. Once the user is pleased with the prototype generated, a final system is constructed based on the final prototype accepted by the user.

2.4.3 Rapid Prototyping

Nowadays, technology plays a vital role in delivering an online learning session. That has created a strong demand for educators and learning designers to produce a quicker and more dynamic online learning experience for its users. But very few instructional design approaches propose a quick way to transform face-to-face learning sessions into online sessions effectively. Designers are typically faced with requests to provide high-quality products while minimizing design and development time. One possible solution to this conundrum is to employ rapid prototyping (RP) approaches(Jones & Richey, 2000). Rapid prototyping requires a design environment that enables the fast creation and modification of instructional objects. Thus rapid prototyping is considered a viable model for a quick transition from f2f to online learning.

The objective of rapid prototyping is to actualize the conceptual framework of the final product without paying the costs associated with the whole product development cycle (Tripp & Bichelmeyer, 1990), although these prototypes differ according to project requirements. The rapid prototyping model involves developing the working model early to trigger the prompt completion of the project. Tripp and Bichelmeyer devised a model in 1990 that illustrates the relationship between prototype utilization and the traditional design process.

Figure 3 Tripp and Bichelmeyer rapid prototyping ISD model

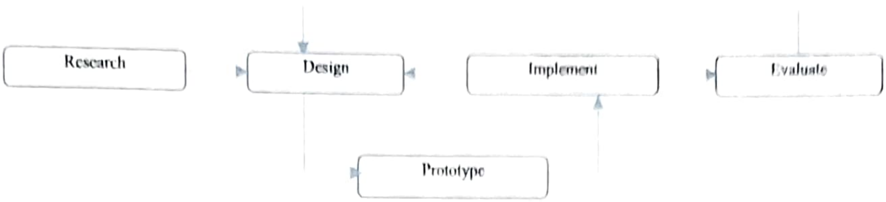

Figure 4 Rapid Prototyping

Rapid prototyping is now the most often used alternative to the ADDIE model and traditional instructional design. Its non-linear structure enables greater instructional flexibility than other prototypes'. It can identify issues early in the development process since consumers can provide rapid input. It decreases development time and costs by utilizing functional models early in the process of a project helps to avoid time-consuming adjustments later (Jones & Richey, 2000). Additionally, the benefits of fast prototyping include the ability for users to experiment with the system, identify potential problems, and contribute to selecting a suitable interface (Miller, 2008). Rapid Prototyping (RP) benefits users, reduces development costs, eliminates communication difficulties, reduces operational expenses, reduces calendar time, and results in the optimal solution for the assigned purpose.

2.5 Conception and designing a prototype using the ADDIE Model and Rapid Prototyping (RP)

The current and seemingly long-lasting pandemic has created a strong demand for educators and learning designers to produce a quicker and more dynamic online learning experience for its users. But very few instructional approaches propose a quick way to transform face-to-face learning into an online learning environment effectively. Specifically, the ADDIE approach has a few downsides to creating such a learning environment. An inherent problem with the ADDIE methodology is that each step is a resource-intensive procedure, requires a longer time for content design and development, and is sometimes expensive (Dong, 2021). Attempting to adhere to all phases of ADDIE during a pandemic is difficult for a course creator who wants a fast approach to designing a course. In contrast, faster implementation, reduced time and resource expenditures, and more frequent evaluations benefit the rapid prototyping technique over ADDIE (Jones & Richey, 2000). The benefits of fast prototyping include the ability for users to experiment with the system, identify potential problems, and contribute to selecting a suitable interface (Miller, 2008) through regular assessments and evidence-based design adjustments (Meier & Miller, 2018).

In the middle of a pandemic, a course designer quickly needs a trustworthy and robust model. Thus, combining ADDIE with Rapid Prototyping may be used to develop a personalized prototype that can be communicated, implemented, measured, and repeated. This integration shows how Designersers are always refining techniques and methods of working (*Instructional Design and Rapid Prototyping*, n.d.). In this study, some features of the ADDIE Model and Rapid Prototype (RP) have been included to reduce the lead time of designing and making a robust prototype.

The Design and Development phase of ADDIE will be customized by incorporating a few aspects of Rapid Prototype (RP). We will customize this model by introducing reviewers for Design/Prototype and Develop phase, which will be iterative, and the end-users will have access to the design, and their review will generate pace for the prototype and Development phase. In RP, it is called Concurrent design and development; a large portion of the front-end analytical work occurs concurrently with the production of the initial rough draft materials (Dong, 2021). It will also help the end-user and other reviewers see the outcome early in the cycle and effectively use time. Course level blending (McGrath, 2013) is one of the most common ways to blend. A course-level blend entails a combination of distinct F2F and online activities used as part of a course. In this study, a Diploma Engineering course of 1st semester Marine Technology students will be considered, and the researcher will attempt to find the proper blend for a TVET course like this. Its' the prime task of this study to find out a speedy and robust blended learning design for the TVET students of Bangladesh. And finally, the researcher will investigate how this customized model performs in a Blended learning environment. In this model, the course blend will enact like following:

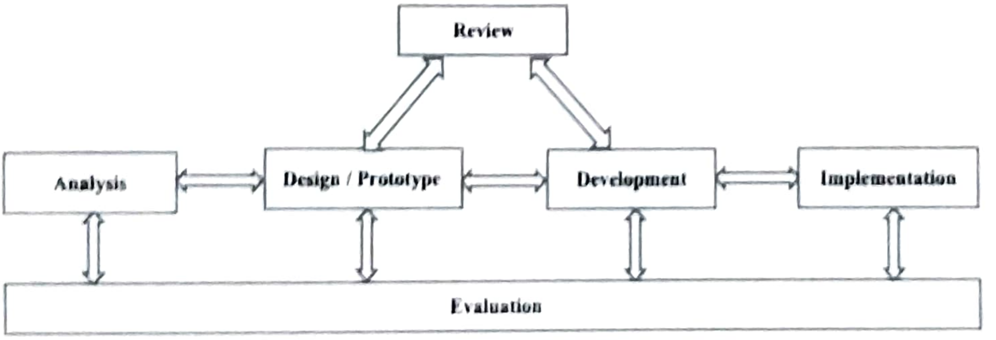

Figure 5 Proposed (customized) model for Designing Blended Learning Course based on ADDIE and RP models.

Analysis Phase: This is the first phase of this customized prototype. To carry out the analysis phase, we need to consider four things. We need to analyze the Goal, Content, Instructional strategy, and Learner. It examines what students must do in real-world situations following the completion of a course and investigates the learning objectives. The designer must be aware of the course objectives and how these can be met. What types of virtual and social settings are necessary to assist students in achieving the learning objectives need to be sorted out in this phase. There is widespread agreement that the most effective techniques for course design begin with a precise definition of course objectives before developing course activities, assignments, and evaluations

(McGee & Reis, 2012). Course goals are especially crucial for blended courses since they may guide material development, mode of delivery (in-class or online), and pedagogy. Eventually, Learner analysis investigates the students' prior knowledge and abilities to attend the course. Daft and Lengel argue that media capable of transmitting "rich" information (e.g., face-to-face meetings) are better suited to equivocal tasks (where available data can be interpreted in multiple ways). In contrast, media capable of transmitting "sparse" data (e.g., computer-mediated communication) are better suited to uncertain tasks" where there is a lack of knowledge" (Dennis & Valacich, 1999). The communication component that allows human interactions for more sophisticated or disputed learning activities is better suited for online learning.
Similarly, the Constructive part helps learners actively engage in the most complicated learning activities ideally suited for Online Learning. In contrast, the Information component that makes factual learning content available to learners is best suited for face-to-face Learning (Kerres & Witt, 2003). This is the most crucial phase of this customized ADDIE-RP model. Every task needs to be analyzed scrupulously to ensure the design parameter. After dissecting it, a formative evaluation is required by other designers to ensure all components are well endowed.

Design and development phase: There are three tasks to design a robust blended learning environment, e.g., learning activity design, assessment design, and prototype design. In this phase, the learning activities and instructional strategies should be defined. It is also essential to determine the criteria to assess and evaluate students' performance. Main class activities, assessments, assignments, lectures, and discussion forums must be prepared for designing learning activities. In this phase, a team consisting of designers and students reviews the tasks. This is a concurrent process where the designer is allowed to work parallel with many design segments while the end-user (fellow designers and students) reviews the prototype forwarded to them. For example, the designer will prepare five online classes for the blended learning session in this prototype. After completing the design of one online course, the designer will forward it to the end-user. The end-user will see the prototype even before it is finished. It will allow them to put forward new suggestions to the designer that will eventually reduce the lead time of the design phase than have the correction at the final stage of the model.

The development phase depends on two activities—this phase incorporates some essential tasks, e.g., material development and developing tutorials and activities. The designer must consider giving overall direction to the classroom and aligning the learning objectives with the learning outcomes. This phase is known as the rehearsal phase, where the designer checks all the materials the designer developed. In this stage, the designer must deal with the steps to deliver instruction to the user. The design team studied various platforms that don't require any subscription, as most TVET institutes will not afford it. This design is concerned with an individualistic design approach, and it was decided that "Google Classroom" could be the least expensive and comparatively most student-friendly platform for implementing the prototype. But there are some pitfalls of Google Classroom. It is not possible to prepare a group discussion forum in google classroom, so we have used a Facebook discussion group. Uploading the content in Google classroom was not difficult for the designer. Specifically, the rectified class material could be uploaded at ease after reviewing. In this customized model "Design and Development" phase will use the features of Rapid Prototyping (RP). That means end-users will have the opportunity to review the prototype even before it is completed. After developing any prototype segment, it will be forwarded to the reviewer to infer their views and opinions/suggestions.

Implementation Phase: This is the crucial phase where the plan is converted to action. This phase has three significant tasks, e.g., training the tutor, making ready the pupil, and structuring the learning environment. In this stage, the designer must investigate how to implement the teacher's training. Because sometimes, the course teacher may not be the person who designed the course. In this phase, the course designer must incorporate training sessions to use all the tools integrated into the prototype. As well as, the teacher needs to make sure the learners are well trained to use the prototype and the learning environment is organized. Strong integration of components is required, e.g., weekly themes or course content directing the conversation, teacher comments on progress or performance, and practice in the face-to-face meeting to ensure the quality of Learning (Poon, 2013). Students will be more motivated to engage, be better prepared for deadlines and compulsory meetings, and take the initiative and responsibility for their learning (McGee & Reis, 2012).

Evaluation phase: It is the final step of the model. It is critical to analyze each stage to meet our objectives by employing prototypes and appropriate resources for the learner's requirements. There are two types of evaluation, e.g., formative and summative. Formative evaluation is an ongoing process in which we develop instructional materials for each level of the customized ADDIE-RP Prototype. There are three fundamental phases of formative assessment: one-on-one, small group evaluation, and field testing. When we review, we aim to select a few end users who ensure the fidelity and reliability of the model.

2.6 Technology Acceptance Model (TAM)

Technology Acceptance Model (TAM) (Davis, 1985) has been widely utilized in studies on users' acceptance of new technologies. The primary goal of the TAM model is to give insight into users' views about new technology adoption. The original TAM model has four key dimensions: perceived usefulness, ease of use, behavioral intention to use, and actual use (Davis, 1989).

Perceived usefulness (PU) is defined as "the extent to which an individual feels that utilizing a certain technology would improve his or her work performance " (Alshurideh et al., 2019). Perceived usefulness (PU) in e-learning is defined as the degree to which users think that e-learning may assist them in achieving teaching and learning objectives (Lin et al., 2010). Several empirical investigations have shown that PU is the most important factor in deciding whether or not to use a particular technology (Tan et al., 2012; Tarhini et al., 2017). Students will adopt an e-learning system only if they believe that its use will improve their learning performance.

Perceived ease of use (PEOU) of a system refers to how an individual believes that utilizing a certain technology will be simple (Davis, 1989). Perceived Ease of Use (PEOU), as defined by Lin et al. (2010) in e-learning, is the degree to which users perceive that utilizing an e-learning system will be effortless. PEOU refers to the extent to which a student believes that using an e-learning system would not necessitate much effort and would be simple to use. Previous studies have shown that the perceived ease of use has a major impact on the perceived usefulness of a product (Binyamin et al., 2019; Zogheib et al., 2015).

Previous e-learning research has also established a substantial positive link between perceived usefulness (PU) and behavioral intention to utilize the e-learning system (Mahmodi, 2017). PU has been shown to substantially affect behavioral intentions toward e-learning adoption in previous research(Ritter, 2017; Teo, 2012; Wong, 2015; Zogheib et al., 2015).

Behavioral intention (BI) is "a cognitive process of persons' readiness to undertake specified activity and is a direct precursor of usage behavior. Behavior intention (BI) refers to the intention of learners to utilize e-learning systems, which includes a long-term commitment from the present to the future(Liao & Lu, 2008). Research shows that PEOU is positively associated with behavioral intention to use (BI) directly and indirectly (Sandjojo & Wahyuningrum, 2016).

Research also has demonstrated that the behavioral intention of an e-learning system directly and considerably determines the actual usage (Mou et al., 2016). Therefore, students' behavioral intention to use the proposed prototype in their learning impacts their actual use of it in the blended learning context.

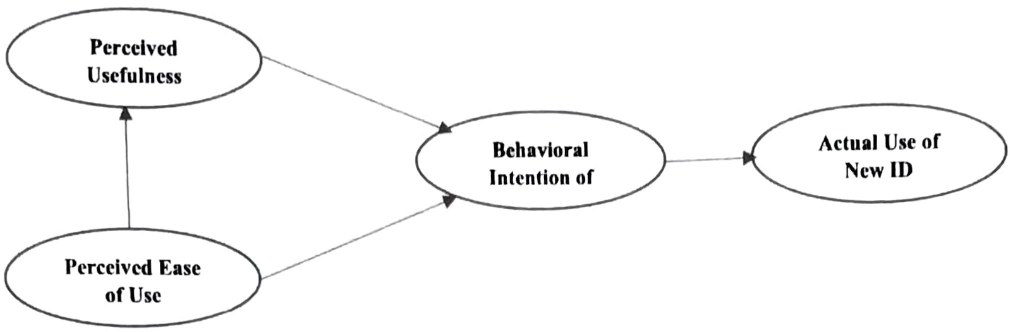

Figure 6 Technology Acceptance Model (TAM) (Davis, 1985)

2.7 Content Validity Index (CVI)

The content validation index (CVI) has been used to validate the content of the proposed prototype. Content Validity Index (CVI) is the most often used quantitative measure for determining the validity of any given course material (Rodrigues et al., 2017). Content validity is a critical early step in enhancing the construct validity of an instrument (Yusoff, 2019). Research shows that good content validity implies that the material is developed according to current evidence and best practices (Yusoff, 2019). The researcher studies the extant literature to develop the CVI scale (Lee et al., 2017; Polit et al., 2007; Waltz et al., 2016). Content validation determines whether the items included in the course design accurately represent all the learning domains. As a result, content validity works as the primary indicator of how well content is developed (Waltz et al., 2016).

The data coming from the content validity index (CVI) scale has been analyzed to measure how well the experts agree on the content's suitability for the blended learning context. In the CVI scale, TVET experts analyzed the appropriateness of the content on four dimensions: content reliability, comprehensibility, user-friendliness, and the generality of the prototype (Banyen et al., 2016; Hoffman, 2013; Lee et al., 2017). A 4-point rating scale on a continuum from not clear (1) to very clear (4) has been utilized to collect the expert's opinion on 14 different items about the contents (appendix A). The CVI is defined as the percentage of things given both raters a score of quite/very clear. Regarding content validity in instrument creation, CVI is the most generally reported technique(Zamanzadeh et al., 2015). It may be calculated using the Item CVI (I-CVI) and the Scale-level-CVI (S-CVI). The I-CVI is calculated as the number of experts who gave each item a rating of "very clear" divided by the total number of experts who gave that item that grade. If two experts independently score the clarity of each element on an instrument to a certain objective on a 4-point scale. The CVI is equal to the percentage of items granted a 3 or 4 by both judges. The interrater agreement will be flawless, and the CVI will have a value of 1.00 if both raters give all items 3 or 4 ratings. The CVI will be 0.50 if half of the items are jointly classed as 1 or 2, while the other half is jointly classified as 3 or 4, indicating inadequate content validity (Martuza, 1977). In a similar vein, the S-CVI is determined based on the number of elements in a tool that have received a rating of "very clear." It is possible to calculate S-CVI using two methods: the first is based on the Universal Agreement (UA) among experts (S-CVI/UA), and the second is based on the Average CVI (S-CVI/Ave) (Zamanzadeh et al., 2015).

2.8 Assessing Readiness of Students Towards Blended Learning

With the advancement of technology, i.e., telecommunication, web application, and smartphones- the traditional teaching-learning approach has changed significantly. In Bangladesh, 102million people have an internet connection on their mobile phones (*Digital Inclusion in Bangladesh*, 2021). People who want to accomplish a task must have the mental, physical, and cognitive preparedness required for their responsibilities. Students and teachers who serve as the focus of instruction in the learning-teaching activities should always be well-prepared for the events they will engage in during the course (Winarso, 2016). Readiness is a mindset of students who are prepared to engage in activities with full awareness to achieve outcomes in the form of changes in their comprehension of the subject matter and their abilities to apply that information, understanding, skills, and habits, values, and attitudes. To be ready to learn, pupils must possess certain capacities relevant to a certain educational goal. When students' preparedness to manage supports their learning, learning goals can be reached. Preparation can help students cope better in stressful situations. It's easier for them to comprehend issues and devise remedies. A correlation was found between student preparation and results. Those pupils who were more ready to learn had better results, whereas those who were not ready had trouble or felt discouraged throughout learning (Sriwichai, 2020; Winarso, 2016). Studying how students react to online learning after it has been implemented in the classroom is an important part of the growing research on blended learning innovation. Additionally, this type of study also involves research that evaluates the perceived effects of adopting an invention before the innovation is implemented (Ngampornchai & Adams, 2016). Students' preferences for online learning as opposed to face-to-face classroom instruction; their competence and confidence in the use of the internet and computer-mediated communication; and their ability to engage in self-directed learning are all factors that can be used to determine a student's readiness for online learning(M. L. Hung et al., 2010). To help concretely represent the notions of preparedness (McVay, 2000) designed a 13-item questionnaire to assess online learning readiness. The instrument's predictors include student behavior and attitudes. Hung (2010) proposed that the online learning readiness measure contains online self-efficacy, learner control, desire for learning, self-directed learning, and self-efficacy in online communication. Dray (2011) developed a survey design that focuses on two subscales, e.g., (learner characteristics and ICT engagement) to assess the readiness for online learning. According to Tang (2013), six characteristics of learning may be studied to determine a student's preparation for blended learning. These six facets of learning are attitude towards technology, online interaction, flexibility, attitude towards online learning, study management, and Face to Face classroom learning. In this study, by reviewing the extant literature, we propose six items that could be an indicator to assess student's readiness toward Blended Learning, e.g., learning flexibility, openness to (new) technology, attitude towards online learning, basic skills of using technology, study management and attitude towards Face-to-Face classroom. These six items will be analyzed in this study to assess the readiness of Bangladeshi TVET students toward Blended Learning. Learning to be adaptable is the first step in assessing learning readiness. Students increasingly have to juggle school, employment, and family commitments. Therefore learning flexibility is becoming increasingly important (Vaughan, 2007). The advantages of blended learning include saving students valuable time and allowing them to study whenever and wherever they choose (McGee & Reis, 2012). Students view blended learning as enabling them to study at their speed and in their own time and encourages them to develop greater self-reliance in their learning (Poon, 2012). Technology delivers knowledge interactively to learners using text, video, simulation, and animation as examples of new alternatives for providing information (Kerres & Witt, 2003). It is now possible to use communication technology in educational settings. These technologies allow for subtle changes in synchrony. Blended learning is much more than just combining classroom instruction and online learning. This allows for a greater variety of learning scenario designs. IT supports blended learning, and digital tools assist in creating online communities that span borders and time zones. For blended learning to be successful, learners must have easy access to digital tools (Harris et al., 2009). The third factor is the attitude towards online learning. An advantage of online learning is that students have more time to think about their answers before submitting them. Blended learning brings timid students out of their shells, as evidenced by the fact that most students converse more online than they do in a face-to-face setting (N Abdul Rahman et al., 2020). Students who favor online education indicate that they have more time to consider and respond to asynchronous dialogues, according to previous research (Tang, 2013). The fourth part of assessing is the attitude toward Face-to-Face classroom instruction. There may be differences in the theoretical foundations and educational goals of online instructors, just as there are with traditional onsite classrooms. However, it is found that "the more closely instructors' theoretical foundations and educational goals match the available technologies, the more easily educational goals can be achieved (Cargile Cook & Grant-Davie, 2005)." When it comes to students withdrawing from online courses, it is found that those who crave face-to-face engagement with their peers and lecturers are more inclined to do so (Howard, 2009). Many students believe that face-to-face interactions are better suited to activities that require students to investigate and engage in problem-solving, and they cite research that suggests online forums often fail to foster dynamic discussion and match the sensation of a real conversation (Stodel et al., 2006). The fifth part of assessing readiness is the basic skills of using technology. A study by Mijatovic (2012) found that different forms of interactions might lead to varying degrees of learning results. The most important factor in acquiring factual information is engagement with educational content. However, more engaging online communication is required if better levels of learning outcomes are to be reached, as well. Discussion and interaction, according to Harris (2009), are crucial components of learning and should be integrated into a blended learning setting. Asynchronous Web-based discussion forums can be used for open communication or critical debate (Garrison & Kanuka, 2004). However, If the students lack basic skills in using technology, it would hamper the overall learning environment. The sixth element of assessing learning preparedness is called "study management." An independent learning process in which students organize, manage, and coordinate their own learning activities and collaborate with their teachers (C. W. Tsai, 2010). As a result, students who are taking classes online will have an easier time keeping track of their time and staying motivated. Blended learning empowers students to take charge of their own education, which necessitates self-discipline and self-inspiration. With the help of online and face-to-face classes, students in blended learning programs may learn at the pace that best suits their schedules (Cahyono et al., 2019).

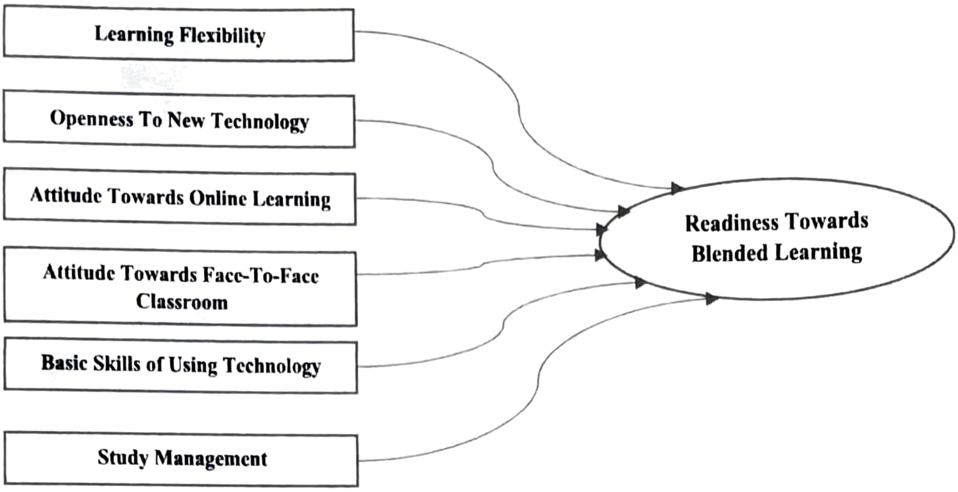

Figure 7 Dimensions of Assessing Readiness Towards Blended Learning

CHAPTER 3 METHODOLOGY

3.1 Introduction

This chapter describes the process that was followed to complete the investigation. It contains information on the study's design, its geographic scope, and the study population. It outlines the data collecting technique, the segments that were utilized for data collection, and the type of data analysis employed.

3.2 Design of the Study

This study was mixed-method research that utilized qualitative and quantitative data. The research model, data, and information required to carry out this research are described below:

Design and Development of the customized ADDIE-RP model
In order to design and develop a prototype, a qualitative study was conducted. The researcher explored related literature (Boulet, 2007; Dong, 2021; Kulvietiene & Sileikiene, 2006; Lee et al., 2017; Lee & Jang, 2014; Li, 2017; McLaughlin et al., 2014; Molenda, 2003) to propose customized ADDIE-RP model. Moreover, the author figured out a general guideline to create a prototype for the blended learning environment.

Validation of the proposed prototype
In this study, the content validation of the prototype was checked by using several TVET experts. A content validity index (CVI) has been developed to evaluate the validity of the proposed prototype. Content Validity Index (CVI) is the most often used quantitative measure for determining items' validity (Rodrigues et al., 2017).

Testing the acceptance of the proposed prototype
This study used the theoretical framework of the Technology Acceptance Model (TAM) to validate the construct of this prototype. The technology acceptance model (TAM) has been used to evaluate whether the end-user accepts the prototype. After studying the extant literature, the author concluded the following four hypotheses.

- H1: Perceived ease of use (PEU) positively influences perceived usefulness (PU).
- H2. Perceived usefulness (PU) positively influences the Behavioral intention (BI) to use the proposed prototype.
- H3. Perceived ease of use (PEU) positively influences the Behavioral intention (BI) to use the proposed prototype.
- H4: Behavioral intention of use (BI) has a positive influence on the actual use (AU) of the proposed prototype

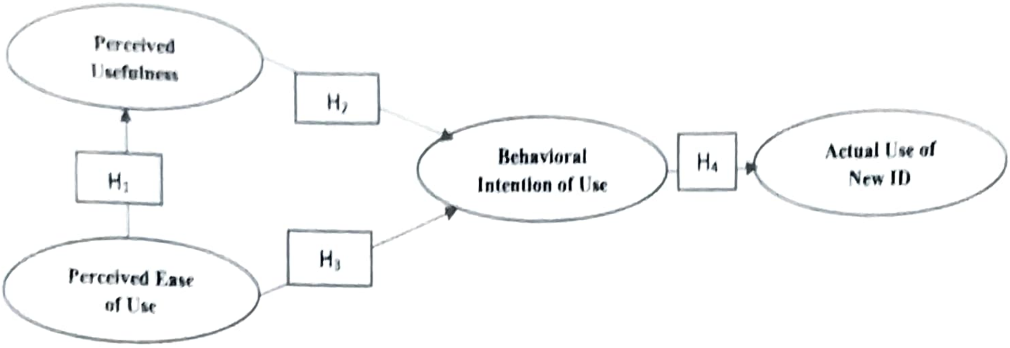

Figure 8 Construction Validation of Proposed prototype Using Technology Acceptance Model (TAM)

Prototype Effectiveness

Eventually, the semester final exam result of the students will be checked statistically to acknowledge whether this prototype improved their performance or not when applied in a blended learning environment. The researcher will explore one hypothesis to ascertain whether the customized prototype of blended Learning improved the performance of Bangladeshi TVET students. This assumption will assist the researcher in determining the statistical significance of the data collected from the population. SPSS will be used to analyze the data, while paired sample t-tests will be performed.

H_a: Students attending blended learning courses using this proposed prototype perform better in semester final exams compared to other courses.

Research Model for assessing the readiness of Bangladeshi TVET students towards blended learning

After reviewing the cognate literature and having a discussion on the readiness aspect towards a Blended Learning environment (Birbal et al., 2018; Collopy & Arnold, 2009; Garrison & Kanuka, 2004; J. F. Hair et al., 2020; Harris et al., 2009; Howard, 2009; Tang, 2013; C. W. Tsai, 2010; Vaughan, 2007; Winarso, 2016) we have come up with the following six hypotheses that can help us to determine the readiness of Bangladeshi TVET students towards Blended Learning.

H_1. Students' attitudes toward learning flexibility influence students' positively to be engaged in blended learning.

H_2. Students' openness to (new) technology influences students positively to be engaged in blended learning.

H_3. Students' attitudes toward online learning influence students' positively to be engaged in blended learning.

H_4. Students' attitude toward face-to-face classrooms influences students negatively to be engaged in blended learning.

H_5. Students' basic skills toward using technology influence students positively to be engaged in blended learning.

H_6. Students' attitude toward study management influences students positively to be engaged in blended learning.

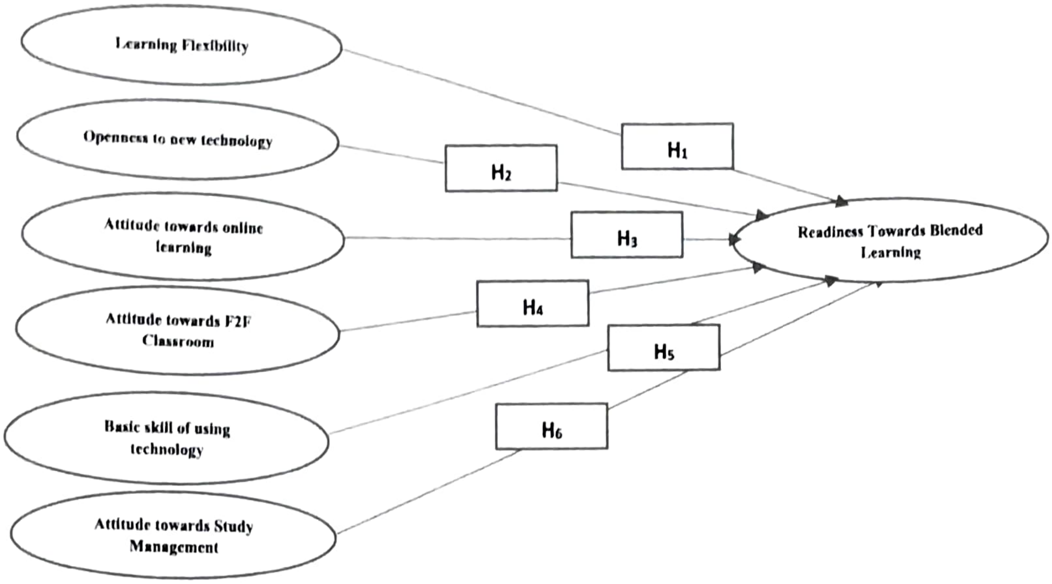

Figure 9 Research Model to Assess the Readiness of TVET Students Towards Blended Learning

Table 2 Underpinning Items of Readiness Dimensions

Dimension	Items Number	Items
Attitude towards Learning Flexibility (LF)	3	
LF1		I would like to access the class materials in my own time
LF2		I would like to access the class materials at my own pace
LF3		I would like to access the class materials in my own space
Openness To (New) Technology (NT)	5	
NT1		I prefer technology while learning
NT2		Access to all digital learning materials helps me understand my lesson Precisely
NT3		I would like to be in charge of my learning
NT4		I would like to keep myself updated with new educational technology
NT5		I believe technology improves my quality of learning
Attitude Towards Online Learning (OL)	5	
OL1		I believe online tasks help me build my learning capacities
OL2		I am comfortable with self-directed online learning
OL3		I do not feel isolated in an online classroom
OL4		I believe online learning helps me to prepare well for my future endeavors.
OL5		I prefer an online platform to communicate with other teachers and Students
OL6		
Attitude Towards Face-To-Face Classroom (CL)	5	
CL1		I prefer to learn in the face-to-face classroom environment
CL2		I learn better in a teacher-directed face to face classroom
CL3		I believe face to face learning develops my interpersonal and team-building skills
CL4		I prefer immediate feedback from the teacher
CL5		

		I prefer learning through collaboration with other people in Face-To-Face Classroom
Basic skills of Using Technology (BST)	4	
BST1		I have basic skills in using technology
BST2		I can understand the online instruction for assignments/quizzes/tutorials
BST3		I can manage unwanted situations and download the learning materials
BST4		I prefer browsing the website and various new applications
Attitude Towards Study Management (SM)	3	
SM1		I believe a change in the teaching-learning environment has a positive influence on my learning ability
SM2		Online discussion and collaboration help me to learn efficiently
SM3		I believe online learning helps organize my time better
Readiness Towards Blended Learning (BL)	4	
BL1		I am more comfortable with blended learning than face to face learning
BL2		I want to attend courses that offer blended learning
BL3		I believe a blended learning environment improved my learning capacity
BL4		I am open to new ideas and concepts

3.3 Participants

For research questions, 1,2, and 3 - this study Prototype has been implemented in two TVET institutions in Bangladesh, i.e., Faridpur and Munshiganj institutes of marine technology. In total sixty-seven, students participated in the course Internal Combustion (IC) Engine Principle using the proposed prototype in the BL context. After that, this proposed prototype was used in six institutes of marine technology, e.g., Faridpur, Munshiganj, Narayanganj, Chandpur, Sirajganj, and Bagerhat, to assess the readiness of students toward a blended learning environment.

This study comprises three groups of participants whose reviews and opinions were asked at different levels to validate the prototype in the BL context. The author and a group of two supervisors were engaged in preparing the prototype to reduce the lead time and ensure the fidelity of the design. Two instructors from the Institute of Marine Technology (having two years of online teaching experience) and two end-users (course students) were used throughout the design and development phase. They have been provided with an opinion journal book to infer opinions after the completion of each class. Their reviews have been considered highly important for further rectification of the items. For content validation of the BL prototype, six experts were asked to infer their opinion on the design. Among the six experts - three professors, two associate professors, and one assistant professor at the Islamic University of Technology, Technical and Vocational Education Department were engaged in this evaluation. Their specialization was mechanical, electrical, and computer science and technology, though their focus was educational technology. They all have more than three years of experience taking online classes. Furthermore, all sixty-seven 1st semester students from two Institutes of Marine Technology were provided with a set of questionnaires to test the acceptance and usability of the proposed prototype after completion of the semester using this platform of blended learning.

Table 3 Participants of Prototype Review and Internal Validation

Participant	Role	Position	Expertise domain	Years of Online teaching/learning experience
Model Review				
A	Reviewer	Instructor	Mechanical Engineering	2 Years
B	Reviewer	Instructor	Mechanical Engineering	2 Years
C	Reviewer	Student/end-user	-	1 Year
D	Reviewer	Student/end-user	-	1 Year
Content Validation				
A	Reviewer	Professor	Educational Technology	8 Years
B	Reviewer	Professor	Educational Technology	8 Years
C	Reviewer	Professor	Educational Technology	8 Years
D	Reviewer	Associate Professor	Educational Technology	5 Years
E	Reviewer	Associate Professor	Educational Technology	5 Years
F	Reviewer	Assistant Professor	Educational Technology	3 Years
Prototype acceptance and usage				
67 participants	End-user	Student	-	-

This study comprises three groups. Six experts' reviews will be sought to validate the BL prototype (Table 3). One of them is a professor specializing in Educational Technology, and the rest five are senior instructors/instructors from different TVET institutes. Their specialization was mechanical engineering. All the experts had a handful of experience in conducting Blended Learning courses. Another team of two students and two instructors were engaged in this study to sort out the items of different readiness constructs (Table 3).

Table 4 Demographic information of the respondents for assessing readiness toward BL

Demographic Information	Respondents (N=235)/Students	Number	Percentage
Gender	Male	209	89%
	Female	26	11%
Device	Smartphone	212	90.2%
	Computer	10	4.26%
	Laptop	10	4.26%
	Tablet	2	.85%
	No Device	1	.43%
Internet Access	Yes	180	77%
	No	55	23%
Capable to Navigate through webpages	Yes	220	93.6%
	No	15	6.4%
Capable of downloading and uploading files	Yes	223	94.9%
	No	10	5.1%

Finally, six TVET institutes' 1st-semester marine technology students (N =235) will undergo the Blended Learning course. Table 4 shows that 90 percent of the 235 respondents had cellphones, which is a significant number. Female respondents accounted for just 11 percent of all responses, indicating that the proportion of women admitted to polytechnic institutes is still below the national average. Twenty-three percent of the respondents did not have access to the internet, and six percent had difficulty navigating through web pages. There was 5 percent of those who answered the survey were unable to download or upload files. It turned out that three pupils didn't have any kind of email address at all.

3.4 Instrument development and data collection

Reflective Journal

Two instructors and two end-users were engaged throughout the design and development phase. A Reflective journal book was devised to record the review generated by the reviewer. After completing each class, reviewers were provided with a form (see Appendix B). A reflective journal (Chitpin, 2006) was devised in order to record the review generated by the reviewers. Journaling encourages observation, conjecture, doubt, questioning, self-awareness, root cause, problem-solving, expressing, and idea development (Holt, 1994). It's a potent technique that can help to develop a better and more organized activity. Prescriptive strategies or guided processes in which students or reviewers are instructed to keep a reflective journal are common in educational research on journal-keeping. Journals appear to be beneficial in allowing students to reflect on their own teaching and learning (Cooper & Stevens, 2006). Thorpe (2004) divided her students into three groups: non-reflectors, reflectors, and critical reflectors, showing the wide range of responses students performs for journal-keeping requirements. Journaling in the workplace can assist individuals in putting their experiences into words, keeping track of their activities, and keeping track of their obligations. Later examination of these entries may lead to a more thorough knowledge of the evolution.

Content Validity Index (CVI) instrument development

Validation of how effectively material represents the content domain is vital for all measures, but it is particularly important for cognitive assessment instruments. This study aims to determine if the items selected for inclusion in the tool accurately represent the content domain covered by the instrument and the relevance of that content domain to the suggested interpretation of scores given when the measure is used. As a result, the content validity of an instrument is essentially decided by the manner in which it is designed (Waltz et al., 2016). Content validity (S-CVI) is a vital early step in improving the construct validity of a survey instrument or questionnaire. In order to demonstrate that their scale and the items on it are valid in terms of content, developers of new scales are increasingly expected to present evidence. The researcher will conduct a review of existing literature as part of their investigation (Lee et al., 2017; Polit et al., 2007; Waltz et al., 2016) to develop the CVI scale. CVI is a metric that assesses the degree to which experts agree on a subject's content. According to the findings of our study, TVET specialists were presented with the objectives and items and asked to rate the clarity of each item in relation to the objective(s) on a 4-point rating scale: (1) not clear, (2) somewhat clear, (3) quite clear, and (4) very clear. In the case of two experts independently scoring the clarity of each element on an instrument to a certain objective on a 4-point scale, the CVI is defined as the percentage of things that receive a score of quite/very clear by both raters. The percentage of items given a 3 or 4 by both judges determines the CVI. If both raters give all items 3 or 4 ratings, the interrater agreement will be immaculate, and the CVI will have a value of 1.00. If half of the items are jointly rated as 1 or 2, while the other half is jointly classified as 3 or 4, the CVI will be 0.50, suggesting a lack of content validity (Martuza, 1977).

Technology Acceptance Model (TAM) instrument development
We had reviewed extant literature (Al-Maroof & Al-Emran, 2018; Amin et al., 2016; Drueke et al., 2021; Mailizar et al., 2021; Ritter, 2017; Salloum et al., 2019; Sandjojo & Wahyuningrum, 2016; Siregar et al., 2017; Y. R. Tsai, 2015) to design the survey questionnaire for sixty-seven students who had attended the BL course using this customized prototype. After completion of the course, the researcher was handed over a printed questionnaire set. The data were then used to validate the construct of the proposed customized prototype.

Survey Instrument
A survey was utilized to gather data for this study, which is a quantitative one. Using a survey was deemed acceptable since it enabled researchers to analyze each of the readiness factors of blended learning components independently and their links to each other (McMillan & Schumacher, 2006). Researchers utilized a survey to find out how students felt about various aspects of blended learning. A total of 240 students from six different TVET Institutes were engaged in the Blended Learning course. Data has been collected from 235 students out of 240 students, with a return rate of over 98%. To assess the readiness of Bangladeshi TVET students, we articulated 29 items in this survey instrument. Initially, it was a 35 items instrument, but as many of them were highly similar in meaning, it was deleted afterward. Extant literature (Birbal et al., 2018; Cigdem & Ozturk, 2016; Dray et al., 2011; M. L. Hung et al., 2010; Smith et al., 2003; Tang, 2013; Venugopal, 2020) has been reviewed, and two students and two instructors were engaged in the item development process to ensure no critical items remain untouched. Attitude towards learning flexibility had three items, openness to new technology had five items, attitude towards online learning (4), basic skills of using technology (4), attitude towards study management (3), attitude towards face-to-face classroom (5), and readiness towards blended learning had four items. A survey questionnaire using a four-point Likert scale was developed to record the response of the TVET students. Where 4 indicates "strongly agree" and 1 indicates "strongly disagree." Furthermore, Exploratory Factor Analysis (EFA) will be used to explore the underpinning items of each construct to determine the readiness scale for a Blended Learning environment. For statistical analysis, SPSS software will be used.

3.5 Data Analysis

The content validity index (CVI) is a metric that measures how well experts agree. In our study, TVET experts were given the objectives and items and asked to score the clarity of each item to the objective(s) on a 4-point rating scale: (1) not clear, (2) somewhat clear, (3) quite clear, and (4) very clear. The CVI is defined as the percentage of things given a quite/very clear score by both raters if two experts independently score the clarity of each element on an instrument to a certain objective on a 4-point scale. The CVI is equal to the percentage of items granted a 3 or 4 by both judges. The interrater agreement will be flawless, and the CVI will have a value of 1.00 if both raters give all items 3 or 4 ratings. The CVI will be 0.50 if half of the items are jointly classed as 1 or 2, while the other half is jointly classified as 3 or 4, indicating inadequate content validity (Martuza, 1977).
Structural Equation Modelling (SEM) evaluated the relationship between exogenous and endogenous components. Additionally, this study helped re-examine the idea and underlying

variables that contribute to students' adoption of a new Prototype. The researcher used Technology Acceptance Model (TAM) to illustrate students' adoption of a new prototype. Smart Partial Least Square (Smart-PLS) was used to validate the construct of each dimension. CFA is developed from structural equation modeling (SEM) and is theory-driven, assisting in determining whether or not the number of factors and their loadings with measured variables adheres to pre-established theory expectations (M.-L. L. Hung et al., 2010). Therefore, in this study, confirmatory factor analysis (CFA) was utilized to test the hypotheses instead of using EFA. Finally, to evaluate this customized Prototype's effectiveness, we compared the students' performance, e.g., Grade Point (GP) in the blended learning context, with their overall Grade Point Average (GPA). In that semester, students had to study six different courses. After the semester final exam, their IC Engine Principle course Grade Point Average (GPA) was compared with their CGPA. We proposed a hypothesis that – "students attending the BL session using this proposed prototype will perform better in semester final exam." We will run a non-parametric one-sample t-test in the SPSS to test our hypothesis. Exploratory Factor Analysis (EFA) will be used to determine the readiness scale's underlying factors. Principal axis factoring with varimax rotation was used in the SPSS.

The relationship between exogenous and endogenous components was investigated using Structural Equation Modelling (SEM). Additionally, this research contributed to a re-examination of the concept of blended learning and the underlying characteristics that influence students' readiness for it. The constructs of each dimension were validated using the Smart Partial Least Square (Smart-PLS) algorithm. The construction of CFA is derived from structural equation modeling (SEM), and it is theory-driven. It is used to help determine if a given number of factors and the loadings of those factors on measured variables conform to pre-established theory expectations (M.-L. L. Hung et al., 2010). The hypotheses in this study were tested using Confirmatory Factor Analysis (CFA), which was performed on the data.

CHAPTER 4 DATA ANALYSIS AND RESULTS

4.1 Design of the proposed prototype for Blended Learning

The customized ADDIE-RP Model was used to prepare the Blended Learning (RP) environment for a diploma in engineering course titled *Internal Combustion Engine Principle*, which was selected from the first semester of the Diploma in Marine Technology program (BTEB, 2016). Forty-five percent (45%) of the content was intended to deliver online, and 55% through the face-to-face classroom. After a thorough qualitative study of extant literature (Kulvietiene & Sileikiene, 2006; Lee et al., 2017; Lee & Jang, 2014), a generalized framework for designing blended learning was conceived.

Table 5 Framework for designing the BL prototype based on ADDIE and RP models (ref. Fig. 5)

Phases	**Tasks**	**Design Input**	**Design Output**	
			Online (45% course)	**Face-to-face (55% course)**
Analysis	Goal Analysis	What are the learning objectives? What are the expected learning outcomes?	To be able to develop knowledge, skills, and attitude in the area of the internal combustion engine with special emphasis on: Working principles of IC engines, Engine terms, types of engine, valve and valve mechanism, Systems of IC engine, and Concept of Modern IC engine (BTEB, 2016).	To be able to develop knowledge, skills, and attitude in the area of the internal combustion engine with special emphasis on: Working principles of IC engines, Engine terms, types of engine, valve and valve mechanism, Systems of IC engine, and Concept of Modern IC engine (BTEB, 2016).
	Content Analysis		**Online class:** (a)Learning objectives focus on more factual and conceptual knowledge, (b) less challenging content, unequivocal and unidirectional learning contents Test/Activities Forum/ Online Chat room Early assessment of prior knowledge **F2F class:** (a)Learning objectives focus on more procedural and meta-cognitive knowledge, (b) More challenging content, equivocal and multidirectional	
	Instructional Strategy Analysis	What types of virtual and social settings are necessary to assist students in achieving these objectives?		
	Learner Analysis	What attitudes, abilities, and prior knowledge are required of students?	learning contents analysis Early assessment of prior knowledge	
	Analysis of Assessment Techniques	What abilities should the learner gain after the completion of instruction? How can we know if pupils have met these objectives?	Test/Activities Discussion	
Design	Learning Activity Design	What should be the learning activities?	Main Class activities,	Task/activity design

	Assessment Design	How do we assess the students' performance? What should be the evaluating criteria?	Quiz design Assessment plan, assignment	
	Instructional Strategy Design	What strategies to follow for creating the instructional design?	Lectures, Discussions, Reading activities	Lecture note plan Online group discussion forum
Development	Material Development Developing tutorials/activities	How do you give overall direction to the classroom? How do align learning objectives with learning outcomes?	Worksheet development, Quiz development The online video clip, Images, PowerPoint presentation, Computer-assisted instructions, Prototype development	Lecture note development Quiz/activity development Workbook development
Implementation	Training the instructor Preparing the learner Organizing the learning environment	How do we train the students and teachers? How do we coordinate the learner's space?	Materials Extra materials Comments	Activities Monitoring Group discussion Feedback
Evaluation	Feedback	How to survey the data? How to interpret test results?	Recommendations, Revised prototype	Survey Recommendations

In this study, a real prototype has been conceived using the customized ADDIE-RP model (see Table 5) to design a blended learning session. There are many online teaching-learning platforms, e.g., Moodle, Google Classroom, Canvas LMS, Blackboard Learn, Talent LMS, etc. For the online part of the course delivery, Google classroom has been used (see Fig. 9, 10). Google classroom has been chosen because it is freely available for anyone with a Google account. It is also considered to be a very simple student-friendly platform for delivering and managing online Learning (Cristiano & Triana, 2019). But there are some pitfalls of Google Classroom. It is not possible to prepare a group discussion forum in google classroom, so we had to use a separate online discussion group.

For designing and developing the online class session, the researcher used a reflective journal throughout the design and development phase. After the development of each class lesson, reviewers were provided with a reflection journal to give their feedback (Appendix B). Reviewers were sought to be engaged as critical reflectors and asked to go through each of the items carefully and mention whether the item was reliable, consistent, and appropriate for the learning. They were also advised to note down the critical observation in their journals. Their suggestions were then analyzed qualitatively to rectify the items and improve the fidelity of each lesson. The journal played a critical role in developing the online classroom. The reviewers offered several recommendations for making the online classroom more engaging and participatory. One of the reviewers wrote,

"The rubrics of the assignment are necessary in online classroom 1 in order to ensure clarity."

Another reviewer opined,

"It will be helpful for the students if the class materials are organized properly in the course stream. It will help the students to follow the classroom properly."

In general, the course designer got positive responses about the online classes. In online class 1, the class test section needed complete reorientation as per reviewers' suggestions. For online classes 2,3,4, and 5, the reviewers had a few comments (e.g., structuring the sequence of the content, alignment of course materials, making pdf file of ppt slide, restructuring the "Google classroom stream" page), which were taken care of accordingly. Incremental changes had been done from the beginning of each lesson as per reviewers' reviews, which ensured the prototype's fidelity and didn't require any significant change further.

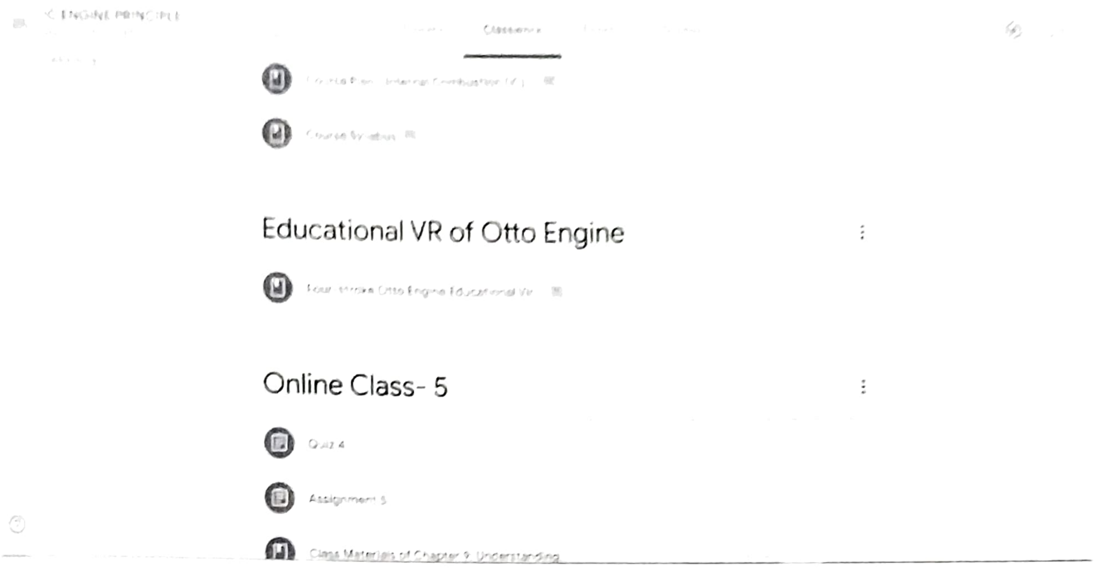

Figure 10 Google classroom for online learning featuring classwork

Figure 11 Google classroom stream for online learning

4.2 Prototype Validation, Acceptance, and Effectiveness

Effective prototypes have three key phases –development, validation, and usage (Lee et al., 2017). The details of the prototype design and development have been described below with the supporting theoretical and background information (see sections 4.2.1, 4.2.3, 4.2.3). The following sections are going to be discussed the methodology of prototype validation, acceptance, and its usability, i.e., model effectiveness.

4.2.1 Prototype Validation

In this study, evidence and best practices were used to quantify the content validity index. Here, CVI was introduced to validate the contents of this customized prototype. By dividing the entire number of experts who participated by the total number of experts who agreed on each given topic, we get the consensus percentage.

Table 6 Content Validity Index (CVI) of the learning-teaching prototype

Constructs	Items Number	I-CVI	S-CVI/UA	Cronbachs' Alpha
Contents reliability of the prototype	5	0.800	0.667	.769
Comprehensibility of the prototype	5	0.833	0.667	.618
User-friendliness of the prototype	5	0.867	0.833	.804
The generality of the prototype	5	0.800	0.667	.625
CVI		**0.830**		
S-CVI/UA			**0.709**	

A CVI of 0.80 or greater is considered excellent content validity (Polit et al., 2007). This prototype I-CVI is 0.830, and S-CVI/UA is.709 (see Table 6), confirming an excellent level of reliability. According to the results of the content studies, the content validity was exceptionally high. SPSS was used to determine the Cronbach alpha coefficient, a measure of an item's trustworthiness. Items' reliability was greater than 0.60, which was found to be dependable and acceptable (Taber, 2018; van Griethuijsen et al., 2015).

4.2.2 Prototype Acceptance

16-week "Internal Combustion Engine Principle" course was prepared for TVET using this prototype. Sixty-seven students were engaged in the blended learning sessions. After the end of the course, they were provided with a set of questionnaires. These questionnaires were delivered to the end-user to ascertain the prototype's external validity. Latent constructs are typically represented by items because of their inability to be seen. One latent construct must be represented by each item according to the uni-dimensionality principle. This means that things have a significant impact on a single latent construct but have little or no impact on the other constructs (Gefen & Straub, 2005). We used confirmatory factor analysis (CFA) to evaluate the proposed model. This paper conducted a CFA with structural equation modeling (SEM) using smart PLS(Chin & Newsted, 1998; Ramayah et al., 2018). PLS-SEM produces more accurate estimates when the sample size is limited and is recommended when predicting is the best choice(Gefen et al., 2000; J. F. Hair et al., 2020). Alternatively, because it considers variances and the significance of relationships, the PLS approach is perfect for making predictions. PLS analysis employs two distinct types of models: measurement models and structural models. PLS performs a CFA on both models. The measurement model, also known as the outer model, depicts the latent constructs and their items, whereas the structural model, also known as the inner model, defines the relationships between exogenous and endogenous latent constructs. Gefen et al. (2000) and Hair et al. (2017) presented various recommendations regarding the validation of the measurement and structural models. To determine the measurement model's convergent validity, usually referred to as an outer model, it is recommended to utilize the outer loadings of the survey items and the average variance retrieved (AVE). Discriminant validity was determined using cross-loading and the Fornell-Larcker criteria. Additionally, Henseler et al. (2015) proposed that the Heterotrait-Monotrait connection be analyzed in order to develop a more stringent discriminant validity. The route coefficients and coefficient of determination (R^2) in the structural model were investigated. Additionally, the bootstrapping technique is advised for determining the significance of route coefficients based on t-values.(Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2017). The bootstrapping, PLS algorithm, and blindfolding method were used to assess both direct and indirect impacts of the hypotheses.

Table 7 Reliability, AVE, CR of confirmatory factor analysis

Measures	Items	Composite Reliability	Average Extracted	Variance	Cronbach's alpha
Actual Use of Prototype (AU)	2	0.878	0.782		0.722
Behavioral Intention of Use (BI)	3	0.837	0.632		0.711
Perceived Ease of Use (PEU)	3	0.845	0.646		0.730
Perceived Usefulness (PU)	3	0.909	0.769		0.856

We evaluated the scale measurement model by examining the composite reliability and the convergent and discriminant validities. According to research, a construct with a reliability score of 0.7 can be considered adequate (C. Fornell & D. Larcker, 1981). There is strong evidence of convergent validity from factor loadings from the CFA, which shows that all items load sufficiently should be high on the relevant constructs, and the Average extracted variance (AVE) should be more than 0.50 (C. Fornell & D. Larcker, 1981). Table 7 indicates that all constructs satisfactorily passed the test as composite reliability was higher than .70, AVE higher than .50, and Cronbach's alpha was higher than .70 for each construct. Therefore, the model's constructions were all sufficiently reliable and valid(Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2017). One item, "I can use all the features of this prototype alone," from the Actual use of the new prototype was dropped as the factor loading was below 0.40 (Hulland, 1999). The composite reliability improved significantly after deleting this item from the construct.

Table 8 Latent variable correlations among constructs using the Fornell-Larcker criterion

Construct	AU	BI	PEU	PU
Actual Use of Prototype (AU)	0.885			
Behavioral Intention of Use (BI)	-0.242	0.795		
Perceived Ease of Use (PEU)	-0.113	0.447	0.804	
Perceived Usefulness (PU)	0.141	0.303	0.144	0.877

As shown in Table 8, each indicator's cross-loading is greater than the cross-loading of the underlying construct, confirming the validity of the measurement model utilized in this work (J. Hair et al., 2017).

The variable factor structure is shown in matrix form in Table 9. This shows great convergent and discriminant validity; all items had high loadings (>0.700) on their respective constructs, and no item had higher loadings on other constructs than it was designed to measure. The constructs' combined psychometric characteristics were deemed excellent (Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2017).

Table 9 Factor structure matrix

Scale Items	AU	BI	PEU	PU
Actual Use of new Prototype				
AU2	**0.897**	-0.225	-0.045	0.018
AU3	**0.872**	-0.203	-0.16	0.244
Behavioral Intention of Use (BI)				
BI1	-0.145	**0.823**	0.393	0.367
BI2	-0.176	**0.803**	0.355	0.216
BI3	-0.275	**0.758**	0.309	0.107
Perceived Ease of Use (PEU)				
PEU1	-0.08	0.447	**0.853**	0.103
PEU2	-0.089	0.31	**0.746**	0.146
PEU3	-0.109	0.286	**0.809**	0.101
Perceived Usefulness (PU)				
PU1	0.132	0.306	0.126	**0.911**
PU2	0.197	0.185	0.002	**0.818**
PU3	0.083	0.275	0.193	**0.899**

Discriminant validity is demonstrated in Table 10, which shows that all model construct values fall below a threshold of 0.85 (Henseler et al., 2015).

Table 10 Results of Heterotrait-Monotrait (HTMT) Ratio for discriminant validity

Construct	AU	BI	PEU	PU
Actual Use of Prototype (AU)				
Behavioral Intention of Use (BI)	0.347			
Perceived Ease of Use (PEU)	0.181	0.594		
Perceived Usefulness (PU)	0.231	0.353	0.163	

Table 11 Multicollinearity Assessment of the model

Items	VIF
AU2	1.470
AU3	1.470
BI1	1.366
BI2	1.453
BI3	1.366
PEU1	1.489
PEU2	1.332
PEU3	1.631
PU1	2.340
PU2	2.070
PU3	2.054

Collinearity between formative indicators is troublesome because it affects weight estimates and statistical significance. Indeed, collinearity raises standard errors, making it harder to show that the estimated weights are significantly different from zero. This is problematic when employing PLS-SEM in research with small sample numbers since sampling error increases standard errors. High collinearity can also cause inaccurate weight estimation and sign reversal. The Variance Inflation Factor (VIF) is used to analyze collinearity in PLS-SEM. Table 11 demonstrates that the variance inflation factor (VIF) is all below 5.0, indicating that the model is not multicollinear (Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2017).

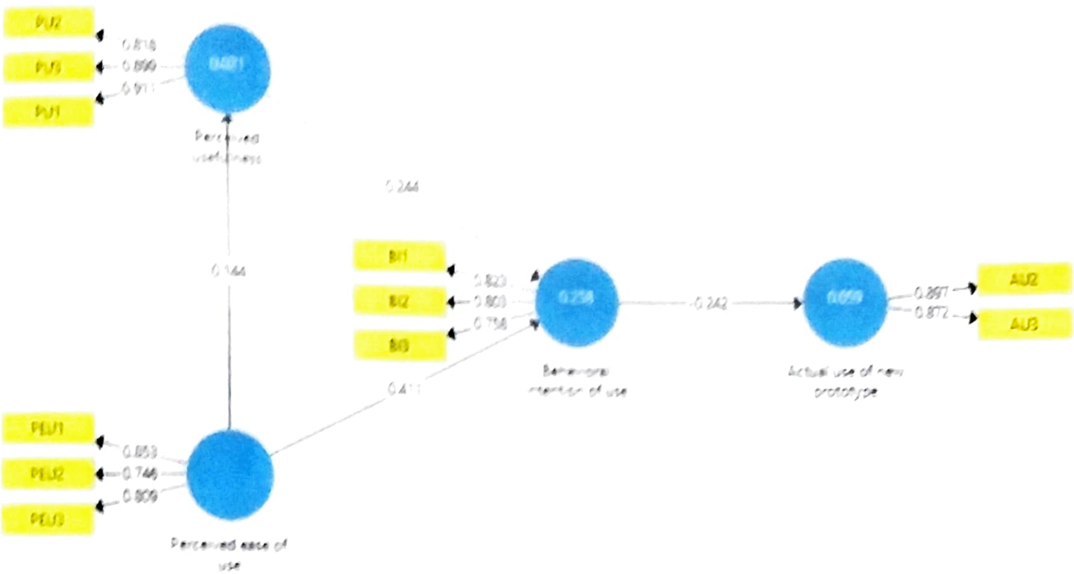

Figure 12 Results of the structural model using TAM

Table 12 Results of Structural Model

Constructs	Predictive explanatory power (R^2)	Cross validated redundancy (Q^2)
Actual Use of Prototype (AU)	0.059	0.033
Behavioral Intention of Use (BI)	0.258	0.133
Perceived Usefulness (PU)	0.021	0.005

The predictive explanatory power (R^2 value) indicates the degree to which the independent variables adequately explain the dependent variables(see Table 12). Cohen (1988) recommended that predictive explanatory power can be classified as substantial, moderate, or weak when R^2 values are 0.26, 0.13, or 0.02, respectively. Our model shows a substantial explanatory power (R^2) for behavioral intention to use (BI) and weak explanatory power for both actual use of the prototype and perceived usefulness (R^2 = .059, 0.021). This means that the structural model meets all model fit criteria. Additionally, we performed cross-validation redundancy (Q^2) to assess the model's predictive relevance for the latent dependent variables. It is frequently used to determine the predictive relevance of a model and may be determined using the blindfolding process included in the majority of PLS software products. If $Q^2 > 0$, the model is considered predictively relevant

(Geisser, 1975; Stone, 1976). According to the results in Table 12, the structural model is acceptable since the exogenous constructions have predictive relevance for the model's endogenous components.

Table 13 Results of Hypotheses testing using path analysis

Hypothesis	Relationship	Std. beta (β)	Std. dev.	t-value	P-value	decision	f^2
H_1	PEU->PU	0.144	0.156	0.919	0.359	Not supported	0.021
H_2	PU->BI	0.244	0.110	2.229	0.026	Supported	0.079
H_3	PEU->BI	0.411	0.102	4.025	0.000	Supported	0.223
H_4	BI->AU	-0.242	0.109	2.231	0.026	Supported	0.062

Sullivan and Feinn (2012) stressed that a p-value indicates the presence of a statistically significant impact but does not provide information about its magnitude. As a result, he advises that when presenting and evaluating results, both the impact size (f2) and statistical significance (p-value) should be included. Cohen (1988) defined f^2 values of 0.02, 0.1, and 0.35 as indicating small, medium, and large impact sizes, respectively.
Table 13 explores the hypotheses test results. It reveals that hypothesis H_2 perceived usefulness had a positive influence on behavioral intention to use the proposed prototype ($\beta = 0.244$, $t = 2.229$, $p < 0.05$), and H_3 perceived ease of use had a positive influence on behavioral intention to use the proposed prototype ($\beta = 0.411$, $t = 4.025$, $p < 0.05$). Similarly, hypothesis H_4 revealed the behavioral intention of use had a positive influence on actual usage of the proposed prototype ($\beta = -0.242$, $t = 2.231$, $p < 0.05$). But hypothesis H_1 suggests that perceived ease of use didn't have a positive influence on perceived usefulness ($\beta = 0.144$, $t = 0.919$, $p > 0.05$). Additionally, all the constructs had small to medium effect sizes.

4.2.3 Prototype Effectiveness

After the semester final exam, the students' CGPA was compared with the GPA of the IC Engine Principle course, which was conducted using this prototype. The hypothesis testing was done using SPPS.

Table 14 Summary of Prototype Effectiveness

		Mean	Std. Dev.	Paired Differences					t	df	Sig. (2-tailed)
				Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference				
							Lower	Upper			
Pair 1	Overall GPA	3.087	.78382	-.14045	.47702	.05828	-.2568	-.02409	-2.410	66	.019
	GP using proposed model	3.228	.60417								

After running the data in SPSS for the paired-samples t-test, we received the following information. This showed a significant improvement in GP (M= 3.228, SD = .60417) after the proposed model has been successfully implemented than the overall GPA ($M = 3.087$, $SD = .78382$), $t(66) = -2.410$, $p = .019$ (two-tailed) of that semester. The mean increase after implementing this ID was 0.141 with a 95% confidence interval ranging from -2.568 to -.02409. This result doesn't always provide information about the magnitude of the intervention's effect. One way to do this is by calculating the effect size. The eta square statistic (0.081) indicated a moderate effect size (Cohen, 1988). It indicates that we can reject our null hypothesis and stick to our alternative hypothesis (Table 14). It ensures that "the students who attended the blended learning session (developed with customized ADDIE-RP model) for the IC Engine Principle course performed better than the other courses."

4.3 Students' Readiness Towards Blended Learning in Bangladesh

In this study, both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were conducted to investigate individual items across variables. This study used structural equation modeling (SEM) based on partial least squares (PLS) (Gefen et al., 2000).

4.3.1 Exploratory Factor Analysis (EFA)

EFA is a handful to recognize the number of items in each construct. The study aims to investigate individual items across variables, selecting those that have a high correlation with a given component (Gefen & Straub, 2005). Items that have a high correlation with one component but not with others are put together to create a scale, and any item that has a cross-load on many factors or a weak load on any factor is subject to elimination (DUNN et al., 1994). In exploratory factor analysis, principal axis factoring (PAF) is one of the most often used estimate approaches. Weak factors are better recovered with PAF, as is well known(de Winter & Dodou, 2012). It was chosen to conduct an exploratory factor analysis using the Principal Axis Factoring approach and a Varimax rotation because the questionnaire data will be employed in a subsequent study (Samuels, 2016). The KMO sample adequacy score was 0.728, above the recommended threshold of .60 (Hair, Black, Babib, & Anderson, 2009), and the Bartlett's test was significant ($p = 0.000$), indicating that the correlations between questions were statistically significant for the question analysis (Hair, J. F. J., Anderson, R. E., Tatham, R. L., & Black, 1995). In this study, Item analyses were initially done to exclude any items with an inter-item correlation of less than 0.4(Samuels, 2016). In this analysis phase, we had to eliminate five items out of the twenty-nine, as they were either loaded with other constructs or had a load factor of less than 0.4. One item was deleted from the basic skills of using technology, three items from the attitude towards study management, and one item from the readiness towards blended learning. Following item analysis using Principal Axis Factoring (PAF), we were left with a total of 24 items. Six constructs accounted for 60.65 percent of the total variance. Table 15 summarizes the items loaded on the various criteria. Cronbach's alpha values for all factors were adequate. Although Cronbach's alpha for the constructs' basic skills of using technology (0.612) and readiness towards blended learning (0.624) have a value less than the generally used cutoff of 0.7, in the case of exploratory research, a cutoff of 0.60 is acceptable (Hair Jr et al., 2009). Although some of the items had been put on factors for which they were not intended, a closer study of the items found that they accurately mirrored the factors on which they had been loaded. The construct attitude study management technology was abolished when its components were eliminated or shifted to other variables. As an outcome, hypothesis H_6 was not supported.

Table 15 Summary of Factors Using Principal Axis Factoring

Construct	Items	Mean	Std. Dev.	LF	NT	OL	CL	BST	BL
Learning Flexibility (LF)	I would like to access the class materials in my own time	3.281	0.618	.498					
	I would like to access the class materials at my own pace	3.285	0.647	.825					
	I would like to access the class materials in my own space	3.374	0.644	.795					
Openness to new technology (NT)	I prefer technology while learning	3.557	0.531		.522				
	Access to all digital learning materials helps me understand my lesson Precisely	3.349	0.815		.767				
	I would like to be in charge of my learning	3.498	0.682		.518				
	I would like to keep myself updated with new educational technology	3.553	0.507		.560				
	I believe technology improves my quality of learning	3.557	0.515		.521				
Attitude towards online learning (OL)	I believe online tasks help me build my learning capacities	3.166	0.807			.475			
	I am comfortable with self-directed online learning	2.855	0.899			.785			
	I do not feel isolated in an online classroom	2.609	0.867			.707			
	I believe online learning helps me to prepare well for my future endeavors.	2.885	0.867			.634			
	I prefer an online platform to communicate with other teachers and students	2.991	0.847			.643			
Attitude towards Face-to-Face Classroom (CL)	I prefer to learn in the face-to-face classroom environment	3.762	0.456				.710		
	I learn better in a teacher-directed face to face classroom	3.745	0.447				.727		
	I believe face to face learning develops my interpersonal and team-building skills	3.757	0.439				.624		
	I prefer immediate feedback from the teacher	3.630	0.542				.624		
	I prefer learning through collaboration with other people in Face-To-Face Classroom	3.617	0.513				.535		
Basic skills of using technology (BST)	I have basic skills in using technology	3.379	0.625					.526	
	I can understand the online instruction for assignments/quizzes/tutorials	3.170	0.617					.606	
	I can manage unwanted situations and download the learning materials	3.243	0.582					.569	
Readiness towards Blended Learning (BL)	I am more comfortable with blended learning than face to face learning	2.740	0.890						.526
	I want to attend courses that offer blended learning	3.149	0.640						.772
	I believe a blended learning environment improved my learning capacity	3.098	0.706						.605
	% of variance explained			17.713	13.657	8.271	7.693	7.106	6.211
	Eigenvalue			4.251	3.278	1.985	1.846	1.705	1.491
	Cronbach's alpha			.766	.730	.784	.780	.612	.624

4.3.2 Confirmatory Factor Analysis (CFA)

Due to the unobservability of latent constructs, they are frequently represented by items. According to the principle of unidimensionality, each object must represent a single latent construct. In other words, the things have a large effect on a single latent construct but have a negligible effect on the other constructions or have no effect at all (Gefen & Straub, 2005). This article used structural equation modeling (SEM) based on partial least squares (PLS) (Gefen et al., 2000). PLS is an excellent technique for predictive applications. Alternatively, the PLS method is ideal for generating predictions since it examines variances and the importance of associations. PLS analysis utilizes two types of models: measurement and structural. PLS offers a CFA by analyzing both models). The measurement model, also referred to as the outer model, shows the latent constructs and their items, whereas the structural model, alternatively referred to as the inner model, describes the connections between the exogenous and endogenous latent constructs (Gefen et al., 2000). Hair et al. (2017) made several recommendations to test the measurement and structural model. It is advised to use the outer loadings of the survey questions and the average variance extracted (AVE) to establish the convergent validity of the measurement model, also known as an outer model. Cross loading and the Fornell-Larcker criterion were used to determine discriminant validity. Additionally, Henseler et al. (2015) recommended analyzing the Heterotrait-Monotrait relationship in order to determine tighter discriminant validity. We studied the route coefficients and the coefficient of determination (R2) in the structural model. It is also recommended to use the bootstrapping approach to determine the importance of route coefficients based on t-values (Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2017). The bootstrapping approach was used to test the hypotheses for both direct and indirect effects.

Table 16 Reliability, AVE, CR of confirmatory factor analysis

Measures	Items	Cronbach's alpha	Composite Reliability	Average Variance Extracted
Learning Flexibility	2	0.835	0.904	0.826
Openness to new technology	4	0.742	0.824	0.486
Attitude towards online learning	5	0.783	0.85	0.535
Attitude towards face-to-face classroom	5	0.786	0.832	0.505
Basic skills of using technology	3	0.615	0.765	0.535
Readiness towards blended learning	2	0.705	0.852	0.745

The reliability and convergent validity of the readiness model were determined using item-level PLS factor loadings, average variance extracted (AVE), and composite reliability (CR). Only those items that exceeded the recommended composite reliability (0.70) values for confirming the measurement model's reliability were preserved during this phase. As seen in Table 16, all 23 item values satisfied the required average variance extract cutoff value of 0.50. Thus, the model's constructions were all sufficiently reliable and valid (Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2017). One item from learning flexibility and one item from the readiness towards blended learning were dropped as the factor loading was below 0.40 (Hulland, 1999). Convergent validity of the construct is still appropriate when AVE is less than 0.50 while composite reliability is more than 0.60 (C. Fornell & D. Larcker, 1981). Also, in the case of exploratory research, Cronbach's alpha cutoff of 0.60 is acceptable (Hair Jr et al., 2009).

Table 17 Factor Loading Matrix

Constructs	BL	BST	CL	LF	NT	OL
Readiness towards Blended Learning (BL)						
BL2	**0.750**					
BL3	**0.963**					
Basic skills of using technology (BST)						
BST1		**0.478**				
BST2		**0.905**				
BST3		**0.747**				
Attitude towards face-to-face classroom						
CL1			**0.696**			
CL2			**0.933**			
CL3			**0.601**			
CL4			**0.662**			
CL5			**0.607**			
Learning flexibility (LF)						
LF2				**0.986**		
LF3				**0.825**		
Openness towards new technology (NT)						
NT1					**0.715**	
NT2					**0.825**	
NT3					**0.611**	
NT4					**0.649**	
NT5					**0.665**	
Attitude towards online learning (OL)						
OL1						**0.589**
OL2						**0.813**
OL3						**0.778**
OL4						**0.769**
OL5						**0.684**

Individual Item Reliability measures how well multiple-item scale measurements represent the real score of the latent variables compared to the error. Table 17 shows that all variable loadings are larger than 0.40.

Table 18 Latent variable correlations among constructs using the Fornell-Larcker criterion

Construct	CL	OL	BST	LF	NT	BL
Attitude towards the face to face classroom (CL)	0.710					
Attitude towards online learning (OL)	-0.088	0.731				
Basic skills of using technology (BST)	0.184	0.002	0.731			
Learning Flexibility (LF)	0.005	0.123	0.062	0.909		
Openness to new technology (NT)	0.209	0.202	0.292	0.297	0.697	
Readiness towards blended learning (BL)	0.105	0.264	0.176	0.076	0.331	0.863

It is clear from Table 18 that each indicator's cross-loading exceeds the underlying construct's own cross-loading, which demonstrates the validity of the measurement model used in this work (J. Hair et al., 2017).

Table 19 Results of Heterotrait-Monotrait (HTMT) Ratio for discriminant validity

Construct	CL	OL	BST	LF	NT	BL
Attitude towards the face to face classroom (CL)						
Attitude towards online learning (OL)	0.226					
Basic skills of using technology (BST)	0.348	0.209				
Learning Flexibility (LF)	0.124	0.201	0.150			
Openness to new technology (NT)	0.371	0.293	0.468	0.373		
Readiness towards blended learning (BL)	0.107	0.302	0.193	0.086	0.374	

As shown in Table 19, all construct values in the model are less than the threshold value of 0.85, indicating that the model has appropriate discriminant validity (Henseler et al., 2015).

Table 20 Collinearity Statistics

Items	VIF
BL2	1.421
BL3	1.421
BST1	1.163
BST2	1.243
BST3	1.305
CL1	1.639
CL2	1.831
CL3	1.449
CL4	1.323
CL5	1.384
LF2	2.059
LF3	2.059
NT1	1.318
NT2	1.515
NT3	1.250
NT4	1.426
NT5	1.404
OL1	1.245
OL2	1.867
OL3	1.678
OL4	1.525
OL5	1.507

Collinearity influences weight estimations and statistical significance. As a result, it is tougher to establish that the projected weights are meaningfully different from zero. Unreliable weight estimates and sign reversal are also possible. Collinearity is analyzed in PLS-SEM using the Variance Inflation Factor (VIF). The variance inflation factor (VIF) values in Table 20 are all less than 5.0, suggesting that the model is not multicollinear (Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2017).

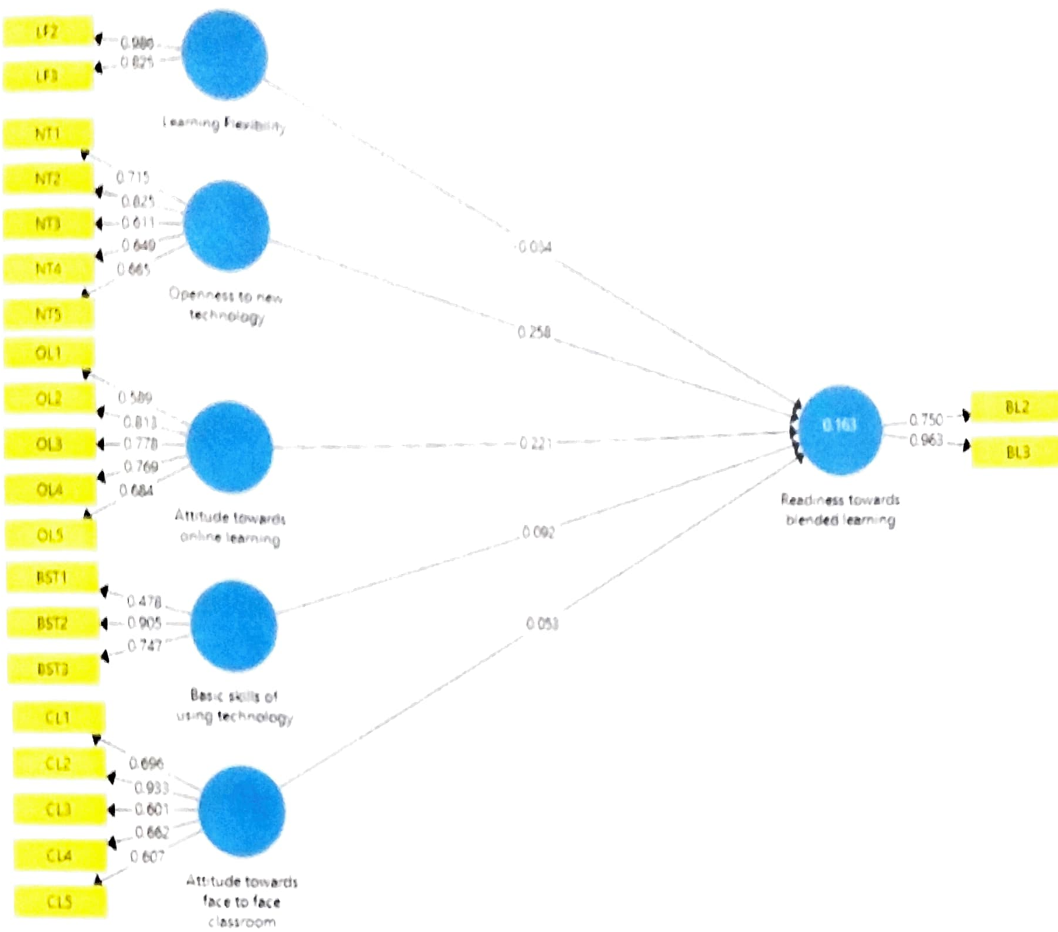

Figure 13 Results of the structural model for assessing TVET students' readiness toward BL

Table 21 Results of Structural Model

Constructs	Predictive explanatory power (R^2)	Cross validated redundancy (Q^2)
Readiness toward blended learning	0.049	0.064

The predicted explanatory power (R^2 value) of variables reflects the extent to which they effectively explain the dependent variables (see Table 21). Cohen (1988) advised that when R^2 values are 0.26, 0.13, or 0.02, respectively, predicted explanatory power could be categorized as significant, moderate, or weak. Our model shows a weak explanatory power ($R^2 = 0.049$) for readiness toward blended learning. This means that the structural model meets model fit criteria. Additionally, we assessed the model's predictive relevance for the latent dependent variables using cross-validation redundancy (Q^2). It is widely used to assess a model's predictive relevance and may be accomplished using the blindfolding method provided in the majority of PLS software solutions. If Q^2 is greater than 0, the model is regarded as predictively significant (Geisser, 1975;

Stone, 1976). The structural model is acceptable based on the data in Table 21 since the exogenous constructs have predictive relevance for the model's endogenous components.

Table 22 Results of Hypotheses testing using path analysis

Hypothesis	Relationship	Std. beta (β)	Std. dev.	t-value	P-value	decision	f^2
H_1	CL->BL	0.053	0.086	0.617	0.538	Not supported	0.003
H_2	OL->BL	0.221	0.064	3.463	0.001	Supported	0.055
H_3	BST->BL	0.092	0.081	1.142	0.254	Not supported	0.009
H_4	LF->BL	-0.034	0.079	0.427	0.670	Not supported	0.001
H_5	NT->BL	0.258	0.062	4.167	0.000	Supported	0.062

The hypotheses test result (Table 22) reveals that hypothesis H_2 attitude toward online learning($\beta = 0.203$, $t = 2.355$, $p < 0.05$) and H_5 openness to new technology ($\beta = 0.221$, $t = 2.653$, $p < 0.05$) have a statistically significant influence on readiness towards blended learning. Thus hypotheses H_2 and H_5 are supported. But, hypothesis H_1 - attitude towards face-to-face classroom learning($\beta = 0.071$, $t = .943$, $p > 0.05$), H_3 - basic skills of using technology ($\beta = 0.1$, $t = 1.307$, $p > 0.05$) and, H_4 - learning flexibility ($\beta = 0.035$, $t = .287$, $p > 0.05$) do not have statistically significant impact on readiness towards blended learning. Thus, H_1, H_3, and H_4 do not support the hypothesis. Cohen (1988) defined f^2 values of 0.02, 0.1, and 0.35 as indicating small, medium, and large impact sizes, respectively. All the hypothesis has a small effect size.

CHAPTER 5 DISCUSSION

It was a daunting task for the researcher to create a compelling and quick prototype convenient for Bangladeshi TVET students and designers, as the concept of blended learning is relatively new for many polytechnic institutions. Notably, amid COVID-19, course instructors are under high pressure to prepare a rapid BL session for their students. The researcher adopted a few approaches in this design and development study of constructing a modified instructional design for a faster and more reliable prototype for a BL environment. There is a strong emphasis in the majority of BL research on the importance of integrating online and face-to-face learning experiences (Mason et al., 2013). It signifies that the two BL components have a complementary rather than a supplemental connection with each other (Lee et al., 2017).

Thus, in this customized ADDIE-RP model, the prototype of each lesson in the design and development section went for multiple reviews and revisions and was subjected to incremental or even complete change. A reflective journal (Cooper & Stevens, 2006) was used throughout the design and development process of this prototype. By adding some elements of RP with ADDIE, it became possible for the end-user to put forward their opinions at the beginning of the designing and development phase. Thus, when this prototype was implemented in a BL environment, it didn't require any significant change, which significantly reduced this prototype's design time and cost. Along with the development of a new prototype, this study attempted to validate the models' content and construct. During content validation of the model, the CVI was used as an indicator to recognize the prototype's content interpretability, comprehensibility, usability, and generality (Lee et al., 2017). The I-CVI > .83 and S-CVI/UA > .60 value was highly indicative of a reliable and satisfactory model (Polit et al., 2007). For construct validation, Technical Acceptance Model (TAM) has been utilized.

Furthermore, we have the Technology Acceptance Model (TAM) to measure the acceptance of this prototype by its end-user. This study attempts to present a framework to recognize students' acceptance of a new teaching-learning prototype. In this study, sixty-seven students of two polytechnic institutes in Bangladesh were engaged to examine the internal consistency, construct validity, and ensure the scales' component structure. The confirmatory factor analysis using smart PLS ensured the items of four dimensions: perceived ease of use, perceived usefulness, the behavioral intention of use, and actual use of the new prototype are heavily loaded to each construct. All the data received from the four subscales, i.e., composite reliability, AVE, and discriminant validity, confirm the factors are also well represented in each item. Thus, the scale was found to be a valid measure to find the acceptance of a new prototype. Hence, in this study using this model, the researcher constructed four hypotheses to acknowledge the actual use of the proposed customized prototype in a BL environment. The structural model reveals that perceived ease of use (PEU) and perceived usefulness (PU) have positively influenced the behavioral intention (BI) to use the prototype and that eventually positively influenced the end-user towards actual use (AU) of this proposed prototype, similar results found in several studies which intended to acknowledge students acceptance towards a new learning platform (Cigdem & Ozturk, 2016; Cigdem & Topcu, 2015; Motaghian et al., 2013; Mursalin, 2020; Park, 2009). It is also founded that perceived ease of use (PEU) has no positive impact on perceived usefulness (PU), which is in contrast with some articles that emphasize the direct positive relationship between them (Akmal, 2017; Cigdem & Topcu, 2015). However, few studies also suggest there is no positive relationship between perceived ease of use and perceived usefulness (Motaghian et al., 2013). Finally, The researcher also wanted to evaluate the usage of this proposed model. Evaluating how well a course or lesson's many components work together to help students meet their learning objectives is important for the design process (Lee et al., 2017). For evaluating the usage of this model, the student's performance was recorded accordingly when the Semester final exam ended, both in blended and traditional setup courses. Many BL studies have discovered significant increases in student happiness or attitude (Bland, 2006; Kellogg, 2009). However, when BL has been compared against traditional approaches in certain research, results have been negligible or minimal (Kellogg, 2009). It was shown in this study using the paired sample t-test - when the proposed prototype is effectively implemented, it supports the hypothesis and ensures this proposed prototype improved students' performance moderately.

Furthermore, to assess the students' readiness for BL, this study investigates six hypotheses.
The first hypothesis states, "Students' attitude towards learning flexibility has a positive influence on being engaged in blended learning." This hypothesis statement is not supported. That means the TVET students of Bangladesh lack the quality of learning flexibility to be engaged in blended learning. Flexibility in learning is enabled through the creation of a computer-generated learning environment, which eliminates the constraints of location and time (Wang et al., 2009). E-learning gives institutions as well as their students or learners greater flexibility in terms of the time and location at which learning material is delivered or received, depending on the content being learned. But, the majority of students in Bangladesh do not have a separate room, which is also important for paying attention in class during lecture time (Al-Amin et al., 2021). According to the findings of our study, TVET students are not yet flexible enough to begin a blended learning program. The lack of resources during the epidemic is a significant hindrance to their ability to be flexible in their approach to blended learning. Only 20 percent of the students had access to a computer or a laptop computer. The rest were entirely dependent on telephones or smartphones. That their involvement with technical resources is below par may be seen in this statement. According to research, the problem of unreliable internet connection during class time, the absence of adequate equipment, apathy in online education, and power outages (Das, 2021) are some of the reasons that need to be addressed in Bangladesh. Because of a scarcity of resources, they would have encountered a tough time adapting to blended learning.
The second hypothesis states, "Students' openness to (new) technology has a positive influence on being engaged in blended learning." This hypothesis is supported in this research, which indicates the TVET students of Bangladesh have a positive attitude toward starting blended learning. This study reveals that the attitude of students toward technology does not appear to be a major worry when deciding whether or not to begin a blended learning course. The adoption of blended learning may be hindered by technological issues such as broadband internet access and computer skills (Smyth et al., 2012), yet today's technologically aware generation of students seems unconcerned about such issues. As a result, despite the fact that technology was included as one of the learning components in the original study model, students' high degree of familiarity with and availability to technology has rendered using technology a non-issue from their perspective. The findings revealed a significant favorable association between online contact and technology, as well as openness for blended learning. This study uncovered the fact that over 90% of students had smartphones, whereas just 9 percent of pupils owned a PC or laptop. This is indicative that students are quite familiar with social media (Facebook, Twitter), search engines, web video (e.g., YouTube), and text chat; however, they are less familiar with tools such as wiki, forums, video chat, and blog according to the results of the study. This revealed that students' comfort level with

Web-based technologies was successfully connected to their capacity to interact and learn when using a computer or smartphone on the internet. Several studies have reported earlier on students' positive attitudes toward technology and their achievement in a hybrid learning setting (Hauser et al., 2012).

The third hypothesis states, "Students' attitude towards online learning has a positive influence on being engaged in blended learning." This hypothesis is supported in this research, which indicates that TVET students of Bangladesh are prepared to start blended learning. In contrast to feelings of isolation and boredom, an online environment defined by a sense of belonging can be advantageous in fostering positive attitudes toward online learning in a blended learning environment (Ausburn, 2004). According to the findings, students' positive attitudes about online learning in terms of access to instructional content, taking responsibility for their own learning, and time management are positively related to online interaction with their peers and lecturers. Additionally, the findings demonstrated a positive association between the online environment and preparedness for mixed learning environments.

The fourth hypothesis states, "Students' attitude towards face-to-face classrooms has a negative influence on being engaged in blended learning." This hypothesis statement is not supported. That means the TVET students of Bangladesh are positive to be engaged in blended learning. There is a negative correlation between attitudes towards traditional classroom learning and readiness for blended learning. The authoritarian classrooms that still exist in both secondary and elementary schools, as well as other factors, may explain why first-semester pupils are more prone to teacher-directed learning, according to some experts (Layne et al., 2008). Even in the digital age, many students still believe that teaching is merely passing on knowledge from one generation to another. There is a direct correlation between the amount of time spent in traditional classrooms and the amount of time spent in mixed learning spaces. There were students who favored face-to-face sessions over virtual ones, according to a UK study of health care students' perceptions of blended learning (Glogowska et al., 2011). It is found that students' attitudes toward blended learning courses varied between low and high-grade achievers (Owston et al., 2013), according to a study among students at a Canadian college. They were less satisfied and preferred traditional classroom education, which would have provided them with a more organized learning environment for those with lower grade point averages who were unable to learn on their own. Furthermore, the online discussion thread may not be as well adapted for critical thinking, lively, and introspective conversations as a face-to-face discussion since first semester students lack conversational literacy/leadership abilities (Stodel et al., 2006). But our study suggests Bangladeshi TVET students have a very positive mindset towards blended learning, and they want to engage themselves in blended learning more for their academic achievement. In the real blended classroom, around 73% of the students joined the blended classroom, though they were not forced to join the classroom and were provided with any technical support.

The fifth hypothesis states, "Students' basic skill towards using technology has a positive influence to be engaged in blended learning." This hypothesis statement is not supported. That means the TVET students of Bangladesh must lack basic skills in using technology to be engaged in blended learning. For students who lack basic technological literacy, this might have an especially negative impact on their achievement in an increasingly digital world (Howard, 2009). Our study found that only ten percent of the students had access to a laptop or computer in this survey. That might be a major factor in their reluctance to use the technology. Despite their openness to new technologies, they have few tools with which to hone their skills using the most up-to-date technologies. Because most students don't know how to type or upload files to the Google Classroom site, they weren't able to tackle the project in its entirety. Only 173 students out of 235 students attended both the online and face-to-face classes. Rest was either absent or only joined the face-to-face class. Only 15 percent of the students attempted the quiz because they were unable to navigate through the classroom alone.

The sixth hypothesis states, "Students' attitude towards study management has a positive influence on being engaged in blended learning." This hypothesis statement is not supported. That means the TVET students of Bangladesh lack the study management skills to be engaged in blended learning. Though study management precisely leads to individual behavior whereby students need to manage themselves to involve in blended learning shows a positive impact on self-pace and self-direct to strengthen blended learning readiness. A study suggests students found it challenging to manage their time in a mixed learning environment where they were forced to learn online as well as face-to-face (Vaughan, 2007). However, the construct study management no longer existed as items loaded on other factors during Exploratory Factor Analysis (EFA). It indicates that study management is not a valid construct to measure the Bangladeshi TVET students' readiness for blended learning.

CHAPTER 6 CONCLUSION

In this study, a digital learning teaching prototype was developed and tested to support teachers/course designers during and after the COVID19 pandemic. The researcher studied extant literature thoroughly to develop a set of technical and pedagogical guidelines, which were used to prepare this effective prototype to be used in the BL approach. The author suggests that when there are limited resources and a short lead time to accomplish a reliable and robust prototype, one can easily approach this prototype. TVET experts and end-users validated this prototype. Content validation was conducted using CVI, which ensured the high reliability and efficacy of the prototype. Then, the researcher used the Technology Acceptance Model (TAM) to validate the items under different constructs: Perceived Use, Perceived Ease of Use, Behavioral Intention, and Actual Use of the prototype. In this study, the researcher used CFA (PLS-SEM) to validate the construction for measuring the acceptance of the proposed prototype. The result derived using the PLS-SEM confirmed the models' construct validity and ensured models' acceptance to be used as an efficient prototype for Bangladeshi TVET students. Eventually, the model's effectiveness was analyzed using the TVET students' semester final exam results, indicating that this prototype moderately improved students' academic performance.

Furthermore, this study investigated Bangladeshi TVET students' preparedness for blended learning, as it has a critical role in post-covid'19 teaching and learning in higher education institutions like Polytechnic and TVET. This study showed that in order to adopt/adapt blended learning at TVET institutions in Bangladesh, students' knowledge and preparedness in many elements of blended learning must be improved and expanded upon. The findings of this study indicate that student preparation to participate in blended learning varies from segment to segment, with lower readiness for some and higher readiness for others. It was discovered that their preparedness for learning flexibility, study management, basic technology abilities, and attitude toward face-to-face classrooms do not allow students to be fully involved in blended learning to its full potential. On the other hand, they had a favorable attitude toward new technology and demonstrated a decent reaction to online learning. This research might assist us in identifying the underlying components that are required to prepare Bangladeshi TVET students for a mixed learning environment in the future. It appeared that many students experienced unstable or no internet connectivity, which was interfering with their learning flexibility and study management because they were unable to take advantage of the most noteworthy feature of online learning, e.g., the ability to "study at any time and from any location."

CHAPTER 7 RECOMMENDATIONS AND FUTURE WORKS

The author recommends that in order to make policy, policymakers should consider students' views and needs and the problems they confront in online learning. The results found from this study could be used to identify the major drawbacks of implementing BL in TVET institutions. Moreover, the TVET institutions and staff should be prepared in terms of technology (hardware and software) to implement learning-teaching in a blended learning approach. This study found that most (90%) TVET students do not have access to a personal computer, which was a barrier that prevented them from honing their fundamental technological abilities. Therefore, this study suggests that the TVET institutions train students to use the technology and provide digital devices when needed.

This prototype needs to be used in other similar courses to observe whether similar results could be found. Again, it is needed to be quantitatively analyzed how much time could be saved using this modified ADDIE-RP framework comparing the ADDIE approach.

REFERENCES

Akmal, A. (2017). Influence of Perceived Usefulness and Ease of Use on Students' Continuous Intention in Learning on-Line English Lessons: an Extended Tam. *UAD TEFL International Conference, 1*, 28. https://doi.org/10.12928/utic.v1.146.2017

Al-Amin, M., Zubayer, A. Al, Deb, B., & Hasan, M. (2021). Status of tertiary level online class in Bangladesh: students' response on preparedness, participation and classroom activities. *Heliyon, 7*(1), e05943. https://doi.org/10.1016/j.heliyon.2021.e05943

Al-Maroof, R. A. S., & Al-Emran, M. (2018). Students acceptance of google classroom: An exploratory study using PLS-SEM approach. *International Journal of Emerging Technologies in Learning, 13*(6), 112–123. https://doi.org/10.3991/ijet.v13i06.8275

Alammary, A., Sheard, J., & Carbone, A. (2014). Blended learning in higher education: Three different design approaches. *Australasian Journal of Educational Technology, 30*(4), 30. https://doi.org/10.14742/ajet.693

Aldoobie, N. (2015). ADDIE Model. *American International Journal of Contemporary Research, 5*(6).

Allen, I. E., Seaman, J., & Garrett, R. (2007). *Www.Onlinelearningsurvey.Com/Reports/Blending-in.Pdf.* papers3://publication/uuid/48E80429-F71A-485D-B612-7EBEAA114EA1

Alshurideh, M., Salloum, S. A., Al Kurdi, B., & Al-Emran, M. (2019). Factors affecting the social networks acceptance: An empirical study using PLS-SEM approach. *PervasiveHealth: Pervasive Computing Technologies for Healthcare, Part F1479*, 414–418. https://doi.org/10.1145/3316615.3316720

Amin, M. K., Azhar, A., Amin, A., & Akter, A. (2016). Applying the technology acceptance model in examining Bangladeshi consumers' behavioral intention to use mobile wallet: PLS-SEM approach. *2015 18th International Conference on Computer and Information Technology, ICCIT 2015*, 93–98. https://doi.org/10.1109/ICCITechn.2015.7488049

Ausburn, L. J. (2004). Course design elements most valued by adult learners in blended online education environments: An American perspective. *Educational Media International, 41*(4), 327–337. https://doi.org/10.1080/0952398042000314820

Banyen, W., Viriyavejakul, C., & Ratanaolarn, T. (2016). A blended learning model for learning achievement enhancement of thai undergraduate students. *International Journal of Emerging Technologies in Learning, 11*(4), 48–55. https://doi.org/10.3991/ijet.v11i04.5325

Binyamin, S. S., Rutter, M. J., & Smith, S. (2019). Extending the technology acceptance model to understand students' use of learning management systems in Saudi higher education. *International Journal of Emerging Technologies in Learning, 14*(3), 4–21. https://doi.org/10.3991/ijet.v14i03.9732

Birbal, D. R., Ramdass, D. M., & Harripaul, M. C. (2018). Student Teachers' Attitudes towards Blended Learning. *Journal of Education and Human Development*, 7(2), 9–26. https://doi.org/10.15640/jehd.v7n2a2

Bland, L. (2006). Applying flip/inverted classroom model in electrical engineering to establish life-long learning. *ASEE Annual Conference and Exposition, Conference Proceedings*. https://doi.org/10.18260/1-2--491

Boulet, G. (2007). Rapid Prototyping : An Efficient Way to Collaboratively Design and Develop E-learning Content. *Unpublished Paper.*, 1–5.

BTEB. (2016). *Course Structure & Syllabus (2016 Probidhan) - Google Drive.* https://drive.google.com/drive/folders/0BynIJ2cATXt3NmxhWC1JTDd3RHc?resourcekey=0-TQlvxKu1a-qzyYQah2KctA

C. Fornell & D. Larcker. (1981). Equation Algebra Unobservable Error : Variables. *Journal of Marketing Research, 18*(3), 382–388.

Cahyono, A. N., Zaenuri, & Subagja, M. (2019). The Design of Blended Learning Modules for Higher

Education. *Journal of Physics: Conference Series*, *1387*(1). https://doi.org/10.1088/1742-6596/1387/1/012121

Carfagni, M., Fiorineschi, L., Furferi, R., Governi, L., & Rotini, F. (2020). Usefulness of prototypes in conceptual design: students' view. *International Journal on Interactive Design and Manufacturing*, *14*(4), 1305–1319. https://doi.org/10.1007/s12008-020-00697-2

Cargile Cook, K., & Grant-Davie, K. (2005). Online Education: Global Questions, Local Answers. In *Online Education: Global Questions, Local Answers*. https://doi.org/10.2190/oeg

Carman, J. M. (2005). *BLENDED LEARNING DESIGN: FIVE KEY INGREDIENTS President Agilant Learning*.

Chin, W. W., & Newsted, P. R. (1998). The partial least squares approach to structural equation modeling. Modern methods for business research. In *Statistical Strategies for Small Sample Research* (pp. 295-336.). https://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=534264

Chitpin, S. (2006). The use of reflective journal keeping in a teacher education program: a Popperian analysis. *Reflective Practice*, *7*(1), 73–86. https://doi.org/10.1080/14623940500489757

Cigdem, H., & Ozturk, M. (2016). CRITICAL COMPONENTS OF ONLINE LEARNING READINESS AND THEIR RELATIONSHIPS WITH LEARNER ACHIEVEMENT. In *Turkish Online Journal of Distance Education*.

Cigdem, H., & Topcu, A. (2015). Predictors of instructors' behavioral intention to use learning management system: A Turkish vocational college example. *Computers in Human Behavior*, *52*, 22–28. https://doi.org/10.1016/j.chb.2015.05.049

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences. In *Statistical Power Analysis for the Behavioral Sciences*. Routledge. https://doi.org/10.4324/9780203771587

Collopy, R. M. B., & Arnold, J. M. (2009). To blend or not to blend: Online and blended learning environments in undergraduate teacher education. *Issues in Teacher Education*, *18*(2), 85–101.

Cooper, J. E., & Stevens, D. D. (2006). Journal-keeping and academic work: four cases of higher education professionals. *Reflective Practice*, *7*(3), 349–366. https://doi.org/10.1080/14623940600837566

Cristiano, K. L., & Triana, D. A. (2019). Google classroom as a tool-mediated for learning. *Journal of Physics: Conference Series*, *1161*(1), 6–10. https://doi.org/10.1088/1742-6596/1161/1/012020

Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results [Massachusetts Institute of Technology]. In *Management: Vol. Ph.D*. https://doi.org/oclc/56932490

Davis, F. D. (1989). Perceive Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, *13*(3), 319–340. https://doi.org/10.5962/bhl.title.33621

de Winter, J. C. F., & Dodou, D. (2012). Factor recovery by principal axis factoring and maximum likelihood factor analysis as a function of factor pattern and sample size. *Https://Doi.Org/10.1080/02664763.2011.610445*, *39*(4), 695–710. https://doi.org/10.1080/02664763.2011.610445

Dennis, A. R., & Valacich, J. S. (1999). Rethinking media richness: Towards a theory of media synchronicity. *Proceedings of the Hawaii International Conference on System Sciences*, *00*(c), 12. https://doi.org/10.1109/hicss.1999.772701

digital inclusion in Bangladesh. (2021). *March*, 1–28.

Dong, H. (2021). Adapting during the pandemic: A case study of using the rapid prototyping instructional system design model to create online instructional content. *Journal of Academic Librarianship*, *47*(3), 102356. https://doi.org/10.1016/j.acalib.2021.102356

Dr. Lucy Winrow. (2019, July). *Dealing with depression at university - The Uni Guide*. https://www.theuniguide.co.uk/advice/student-life/dealing-with-depression-at-university

Dray, B. J., Lowenthal, P. R., Miszkiewicz, M. J., Ruiz-Primo, M. A., & Marczynski, K. (2011). Developing an instrument to assess student readiness for online learning: A validation study

Distance Education, *32*(1), 29–47. https://doi.org/10.1080/01587919.2011.565496
Driscoll, M. (2002). *Driscoll, M. (2002) Blended Learning Let's Get beyond the Hype. IBM Global Services. - References - Scientific Research Publishing*. 2002. https://www.scirp.org/(S(351jmbntvnsjt1aadkozje))/reference/referencespapers.aspx?referenceid=1451858
Drueke, B., Mainz, V., Lemos, M., Wirtz, M. A., & Boecker, M. (2021). An Evaluation of Forced Distance Learning and Teaching Under Pandemic Conditions Using the Technology Acceptance Model. *Frontiers in Psychology*, *12*(October), 1–10. https://doi.org/10.3389/fpsyg.2021.701347
DUNN, S., SEAKER, R., & WALLER, M. (1994). LATENT VARIABLES IN BUSINESS LOGISTICS RESEARCH: SCALE DEVELOPMENT AND VALIDATION /. *Journal of Business Logistics*, *15*(2), 145. https://trid.trb.org/view/552217
Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *Internet and Higher Education*, *7*(2), 95–105. https://doi.org/10.1016/j.iheduc.2004.02.001
Gedik, N., Kiraz, E., & Ozden, M. Y. (2013). Design of a blended learning environment: Considerations and implementation issues. *Australasian Journal of Educational Technology*, *29*(1), 1–19. https://doi.org/10.14742/ajet.6
Gefen, D., & Straub, D. (2005). A Practical Guide To Factorial Validity Using PLS-Graph: Tutorial And Annotated Example. *Communications of the Association for Information Systems*, *16*(July). https://doi.org/10.17705/1cais.01605
Gefen, D., Straub, D., & Boudreau, M.-C. (2000). Structural Equation Modeling and Regression: Guidelines for Research Practice. *Communications of the Association for Information Systems*, *4*(October). https://doi.org/10.17705/1cais.00407
Geisser, S. (1975). The predictive sample reuse method with applications. *Journal of the American Statistical Association*, *70*(350), 320–328. https://doi.org/10.1080/01621459.1975.10479865
Glogowska, M., Young, P., & Lockyer, L. (2011). Propriety, process and purpose: Considerations of the use of the telephone interview method in an educational research study. *Higher Education*, *62*(1), 17–26. https://doi.org/10.1007/S10734-010-9362-2
Hair, Black, Black, Babin & Anderson, Multivariate Data Analysis: Global Edition, 7th Edition | Pearson. (n.d.). Retrieved January 22, 2022, from https://www.pearson.com/uk/educators/higher-education-educators/program/Hair-Multivariate-Data-Analysis-Global-Edition-7th-Edition/PGM916641.html
Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2017). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). Thousand Oaks. *Sage*, 165.
Hair, J. F. J., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate data analysis*.
Hair, J. F., Howard, M. C., & Nitzl, C. (2020). Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. *Journal of Business Research*, *109*(August 2019), 101–110. https://doi.org/10.1016/j.jbusres.2019.11.069
Hair, J., Hult, G. T., Ringle, C., & Sarstedt, M. (2017). A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM) - Joseph F. Hair, Jr., G. Tomas M. Hult, Christian Ringle, Marko Sarstedt. *Sage*, 374.
Hair Jr, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2009). *Multivariate Data Analysis (7th edition)*. https://www.pearson.com/uk/educators/higher-education-educators/program/Hair-Multivariate-Data-Analysis-Global-Edition-7th-Edition/PGM916641.html
Haolader, F.A., Simmert H. & Ihbe, W. (2001). *Technical & Pedagogical Aspects in Designing & Developing Teaching /Learning Environment–Prototypical Realization of ISO-OSI 7-Layer Model. In: Realities in Science, Mathematics and Technical Education. September*.
Harris, P., Connolly, J., & Feeney, L. (2009). Blended learning: Overview and recommendations for successful implementation. *Industrial and Commercial Training*, *41*(3), 155–163. https://doi.org/10.1108/00197850910950961
Hauser, R., Paul, R., & Bradley, J. (2012). Computer self-efficacy, anxiety, and learning in online versus

face to face medium. *Journal of Information Technology Education:Research, 11*(1), 141–154. https://doi.org/10.28945/1633

Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science, 43*(1), 115–135. https://doi.org/10.1007/s11747-014-0403-8

Hoffman, J. S. (2013). *Instructional design -- step by step : nine easy steps for designing lean, effective, and motivational instruction*. iUniverse.

Holt, S. (1994). Reflective journal writing and its effects on teaching adults. *The Year in Review, 3 (Dayton, Virginia Adult Research Network)., Volume 3*, 31–54.

Howard, S. B. (2009). The benefits of face-to-face interaction in the online freshman composition course. *Journal of Online Learning and Teaching, 5*(4), 685–697. http://jolt.merlot.org/vol5no4/howard_1209.pdf

Hulland, J. (1999). Use of partial least squares (PLS) in strategic management research: A review of four recent studies. *Strategic Management Journal, 20*(2), 195–204. https://doi.org/10.1002/(sici)1097-0266(199902)20:2<195::aid-smj13>3.0.co;2-7

Hung, M.-L. L., Chou, C., Chen, C.-H. H., & Own, Z.-Y. Y. (2010). Learner readiness for online learning: Scale development and student perceptions. *Computers and Education, 55*(3), 1080–1090. https://doi.org/10.1016/j.compedu.2010.05.004

Hung, M. L., Chou, C., Chen, C. H., & Own, Z. Y. (2010). Learner readiness for online learning: Scale development and student perceptions. *Computers and Education, 55*(3), 1080–1090. https://doi.org/10.1016/j.compedu.2010.05.004

Instructional Design and Rapid Prototyping. (n.d.). Retrieved January 3, 2022, from https://www.dashe.com/blog/elearning/instructional-design-prototyping-addie/

Jones, T. S., & Richey, R. C. (2000). Rapid prototyping methodology in action: A developmental study. *Educational Technology Research and Development, 48*(2), 63–80. https://doi.org/10.1007/BF02313401

Kellogg, S. (2009). evelop ping On nline Materi ials to Facilit tate an n In nverte d Clas ssroom m Appr roach. *39th ASEE/IEEE Frontiers in Education Conference*, 1–6.

Kerres, M., & Witt, C. De. (2003). A Didactical Framework for the Design of Blended Learning Arrangements. *Journal of Educational Media, 28*(2–3), 101–113. https://doi.org/10.1080/1358165032000165653

Kulvietiene, R., & Sileikiene, I. (2006). the Blended Learning Delivery Design Model. *Conference on Distance Learning and Web Engineering*, 1–5. http://labplan.ufsc.br/congressos/WSEAS/papers/517-192.pdf

Layne, A., Jules, V., Kutnick, P., & Layne, C. (2008). Academic achievement, pupil participation and integration of group work skills in secondary school classrooms in Trinidad and Barbados. *International Journal of Educational Development, 28*(2), 176–194. https://doi.org/10.1016/j.ijedudev.2007.01.001

Lee, J., & Jang, S. (2014). A methodological framework for instructional design model development: Critical dimensions and synthesized procedures. *Educational Technology Research and Development, 62*(6), 743–765. https://doi.org/10.1007/s11423-014-9352-7

Lee, J., Lim, C., & Kim, H. (2017). Development of an instructional design model for flipped learning in higher education. *Educational Technology Research and Development, 65*(2), 427–453. https://doi.org/10.1007/s11423-016-9502-1

Li, M. (2017). Research on the Innovative Practice of "The Flipped Classroom" in the Basic Management Course of Chinese Universities. *Creative Education, 08*(13), 2155–2163. https://doi.org/10.4236/ce.2017.813146

Liao, H. L., & Lu, H. P. (2008). The role of experience and innovation characteristics in the adoption and continued use of e-learning websites. *Computers and Education, 51*(4), 1405–1416. https://doi.org/10.1016/J.COMPEDU.2007.11.006

Lin, K. M., Chen, N. S., & Fang, K. (2010). Understanding e-learning continuance intention: a negative critical incidents perspective. *Https://Doi.Org/10.1080/01449291003752948*, *30*(1), 77–89. https://doi.org/10.1080/01449291003752948

Mahmodi, M. (2017). The Analysis of the Factors Affecting the Acceptance of E-learning in Higher Education. *Interdisciplinary Journal of Virtual Learning in Medical Sciences*, *8*(1), 1–9. https://doi.org/10.5812/ijvlms.11158

Mailizar, M., Burg, D., & Maulina, S. (2021). Examining university students' behavioural intention to use e-learning during the COVID-19 pandemic: An extended TAM model. *Education and Information Technologies*, *26*(6), 7057–7077. https://doi.org/10.1007/s10639-021-10557-5

Marsh, J., & Drexler, P. (2001). How to design effective blended learning. *Sunnyvale: Brandon-Hall*. http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:How+to+Design+Effective+Blended+Learning#0

Martuza, V. R. (1977). *Applying norm-referenced and criterion-referenced measurement in education*. Allyn and Bacon.

Mason, G. S., Shuman, T. R., & Cook, K. E. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education*, *56*(4), 430–435. https://doi.org/10.1109/TE.2013.2249066

McGee, P., & Reis, A. (2012). Blended Course Design: A Synthesis of Best Practices. *Online Learning*, *16*(4). https://doi.org/10.24059/olj.v16i4.239

McGrath, V. (2013). The Handbook of Blended Learning: Global Perspectives, Local Designs Memorial. *Canadian Journal of University Continuing Education*, *33*(1). https://doi.org/10.21225/D51G6H

McLaughlin, J. E., Roth, M. T., Glatt, D. M., Gharkholonarehe, N., Davidson, C. A., Griffin, L. M., Esserman, D. A., & Mumper, R. J. (2014). The flipped classroom: A course redesign to foster learning and engagement in a health professions school. *Academic Medicine*, *89*(2), 236–243. https://doi.org/10.1097/ACM.0000000000000086

McMillan, J. H., & Schumacher, S. (2006). Research in education: Evidence-based inquiry (6th ed.). Boston, MA: Allyn and Bacon. *2006*. https://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=462991

McVay, M. (2000). Developing a web-based distance student orientation to enhance student success in an online bachelor's degree completion program. *Integration of Climate Protection and Cultural Heritage: Aspects in Policy and Development Plans. Free and Hanseatic City of Hamburg*, *26*(4), 1–37.

Meier, J. J., & Miller, R. K. (2018). Fail early and often to succeed: A case for rapid prototyping in libraries. *Library Leadership and Management*, *33*(1), 1–19.

Mijatovic, I., Jovanovic, J., & Jednak, S. (2012). Students online interaction in a blended learning environment - A case study of the first experience in using an LMS. *CSEDU 2012 - Proceedings of the 4th International Conference on Computer Supported Education*, *2*, 445–454. https://doi.org/10.5220/0003963804450454

Miller, B. G. (2008). Metabolic expansion via designed enzyme recruitment. *Abstracts of Papers, 235th ACS National Meeting, New Orleans, LA, United States, April 6-10, 2008 FIELD Full Journal Title:Abstracts of Papers, 235th ACS National Meeting, New Orleans, LA, United States, April 6-10, 2008*, *38*, BIOL-012.

Molenda, M. (2003). In search of the elusive ADDIE model. *Performance Improvement*, *42*(5), 34–36. https://doi.org/10.1002/pfi

Motaghian, H., Hassanzadeh, A., & Moghadam, D. K. (2013). Factors affecting university instructors' adoption of web-based learning systems: Case study of Iran. *Computers and Education*, *61*(1), 158–167. https://doi.org/10.1016/j.compedu.2012.09.016

Mou, J., Shin, D. H., & Cohen, J. (2016). Understanding trust and perceived usefulness in the consumer acceptance of an e-service: a longitudinal investigation. *Https://Doi.Org/10.1080/0144929X.2016.1203024*, *36*(2), 125–139. https://doi.org/10.1080/0144929X.2016.1203024

Mursalin, A. (2020). The influence of the perceived usefulness and the perceived easy use of edmodo on the students'behavioral intention to use edmodo in learning (Students of Fakultas Ekonomi Universitas Panca Bhakti Pontianak). *Journal of Administrative and Business Studies*, *6*(3), 95–103. https://doi.org/10.20474/jabs-6.3.3

Ngampornchai, A., & Adams, J. (2016). Students' acceptance and readiness for E-learning in Northeastern Thailand. *International Journal of Educational Technology in Higher Education*, *13*(1). https://doi.org/10.1186/s41239-016-0034-x

Oliver, M., & Trigwell, K. (2005). *Can "Blended Learning" Be Redeemed?* (Vol. 2, Issue 1).

Onguko, B., Jepchumba, L., & Gaceri, P. (2013). "For us it was a learning experience": Design, development and implementation of blended learning. *European Journal of Training and Development*, *37*(7), 615–634. https://doi.org/10.1108/EJTD-10-2012-0052

Owston, R., York, D., & Murtha, S. (2013). *Author ' s personal copy Internet and Higher Education Student perceptions and achievement in a university blended learning strategic initiative* ☆. *18*, 38–46.

Park, S. Y. (2009). An analysis of the technology acceptance model in understanding University students' behavioral intention to use e-Learning. *Educational Technology and Society*, *12*(3), 150–162.

Polit, D. F., Beck, C. T., & Owen, S. V. (2007). *Focus on Research Methods Handling Missing Data in Self-Report Measures*. 488–495. https://doi.org/10.1002/nur

Poon, J. (2012). Use of blended learning to enhance the student learning experience and engagement in property education. *Property Management*, *30*(2), 129–156. https://doi.org/10.1108/02637471211213398

Poon, J. (2013). Blended Learning: An Institutional Approach for Enhancing Students' Learning Experiences. In *Journal of Online Learning and Teaching* (Vol. 9, Issue 2). http://hdl.handle.net/10536/DRO/DU:30057995

Rahman, N Abdul, Arifin, N., Manaf, M., Ahmad, M., Mohd Zin, N. A., & Jamaludin, M. (2020). Students' Perception in Blended Learning among Science and Technology Cluster Students. *Journal of Physics: Conference Series*, *1496*, 012012. https://doi.org/10.1088/1742-6596/1496/1/012012

Rahman, Noorihan Abdul, & Sahibuddin, S. (2010). Social interaction in e-learning: An overview. *2010 International Symposium on Information Technology*, 1–4. https://doi.org/10.1109/ITSIM.2010.5561324

Ramayah, T., Cheah, J., Ting, F. C. H., & Memon, M. A. (2018). Partial Least Squares Structural Equation Modeling (PLS-SEM) using SmartPLS 3.0: An Updated and Practical Guide to Statistical Analysis. *Practical Assessment, Research and Evaluation*, *4*(October), 291.

Ritter, N. L. (2017). Technology Acceptance Model of Online Learning Management Systems in Higher Education: A Meta-Analytic Structural Equation Mode. *International Journal of Learning Management Systems*, *5*(1), 1–15. https://doi.org/10.18576/ijlms/050101

Rodrigues, I. B., Adachi, J. D., Beattie, K. A., & MacDermid, J. C. (2017). Development and validation of a new tool to measure the facilitators, barriers and preferences to exercise in people with osteoporosis. *BMC Musculoskeletal Disorders*, *18*(1), 1–9. https://doi.org/10.1186/s12891-017-1914-5

Salloum, S. A., Qasim Mohammad Alhamad, A., Al-Emran, M., Abdel Monem, A., & Shaalan, K. (2019). Exploring students' acceptance of e-learning through the development of a comprehensive technology acceptance model. *IEEE Access*, *7*, 128445–128462. https://doi.org/10.1109/ACCESS.2019.2939467

Samuels, P. (2016). Advice on exploratory factor analysis. *Centre for Academic Success, Birmingham City University*, *June*, 2. https://doi.org/10.13140/RG.2.1.5013.9766

Sandjojo, N., & Wahyuningrum, T. (2016). Measuring e-learning systems success: Implementing D and M is success model. *Proceedings of the 2015 4th International Conference on Interactive Digital Media, ICIDM 2015*, *Icidm*, 4–9. https://doi.org/10.1109/IDM.2015.7516343

Shao, J., Lv, Y., & Ye, Y. (2010). Application of prototype method to creative design of basic training in student cultivation. *ICETC 2010 - 2010 2nd International Conference on Education Technology and*

Computer, *4*, 326–329. https://doi.org/10.1109/ICETC.2010.5529672

Sharpe, R., Benfield, G., Roberts, G., October, R. F.-R., & 2006, U. (2006). The undergraduate experience of blended e-learning: a review of UK literature and practice undertaken for the Higher Education Academy. *Retrieved October*, *3*, 2006.

Singh, H. (2003). Building Effective Blended Learning Programs. In *Issue of Educational Technology* (Vol. 43, Issue 6). http://bookstoread.com/framework

Siregar, J. J., Wardaya Puspokusumo, R. A. A., & Rahayu, A. (2017). Analysis of Affecting Factors Technology Acceptance Model in the Application of Knowledge Management for Small Medium Enterprises in Industry Creative. *Procedia Computer Science*, *116*, 500–508. https://doi.org/10.1016/j.procs.2017.10.075

Smith, P. J., Murphy, K. L., & Mahoney, S. E. (2003). Towards identifying factors underlying readiness for online learning: An exploratory study. *International Journal of Phytoremediation*, *24*(1), 57–67. https://doi.org/10.1080/01587910303043

Smyth, S., Houghton, C., Cooney, A., & Casey, D. (2012). Students' experiences of blended learning across a range of postgraduate programmes. *Nurse Education Today*, *32*(4), 464–468. https://doi.org/10.1016/J.NEDT.2011.05.014

Sriwichai, C. (2020). Students' Readiness and Problems in Learning English through Blended Learning Environment. *Asian Journal of Education and Training*, *6*(1), 23–34. https://doi.org/10.20448/journal.522.2020.61.23.34

Stodel, E. J., Thompson, T. L., & MacDonald, C. J. (2006). Learners' Perspectives on what is Missing from Online Learning: Interpretations through the Community of Inquiry Framework. *The International Review of Research in Open and Distributed Learning*, *7*(3). https://doi.org/10.19173/IRRODL.V7I3.325

Stone, M. (1976). Cross-Validatory Choice and Assessment of Statistical Predictions (With Discussion). *Journal of the Royal Statistical Society: Series B (Methodological)*, *38*(1), 102–102. https://doi.org/10.1111/j.2517-6161.1976.tb01573.x

Sullivan, G. M., & Feinn, R. (2012). Using Effect Size—or Why the P Value Is Not Enough . *Journal of Graduate Medical Education*, *4*(3), 279–282. https://doi.org/10.4300/jgme-d-12-00156.1

Suson, R. L., Ermac, E. A., Anoos, W. G., Anero, M. B., Tomabiao, N. J. D., Taperla, I. M., Gantalao, L. C., Capuyan, M. D., Cortes, M. J. P., Belette, J. B., & Espina, R. C. (2020). Prototype learning activities: Road map to academic achievement. *Cypriot Journal of Educational Sciences*, *15*(6), 1535–1543. https://doi.org/10.18844/CJES.V15I6.5296

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tan, G. W. H., Ooi, K. B., Sim, J. J., & Phusavat, K. (2012). Determinants of mobile learning adoption: An empirical analysis. *Journal of Computer Information Systems*, *52*(3), 82–91. https://doi.org/10.1080/08874417.2012.11645561

Tang, C. M. (2013). Readiness for Blended Learning: Understanding Attitude of University Students. *International Journal of Cyber Society and Education*, *6*(2), 79–100. https://doi.org/10.7903/ijcse.1086

Tarhini, A., Hone, K., Liu, X., & Tarhini, T. (2017). Examining the moderating effect of individual-level cultural values on users' acceptance of E-learning in developing countries: a structural equation modeling of an extended technology acceptance model. *Interactive Learning Environments*, *25*(3), 306–328. https://doi.org/10.1080/10494820.2015.1122635

Teo, T. (2012). Examining the intention to use technology among pre-service teachers: An integration of the Technology Acceptance Model and Theory of Planned Behavior. *Interactive Learning Environments*, *20*(1), 3–18. https://doi.org/10.1080/10494821003714632

Thorpe, K. (2004). Reflective learning journals: From concept to practice. *Reflective Practice*, *5*(3), 327–343. https://doi.org/10.1080/1462394042000270655

Tripp, S. D., & Bichelmeyer, B. (1990). Rapid prototyping: An alternative instructional design strategy.

Educational Technology Research and Development, *38*(1), 31–44. https://doi.org/10.1007/BF02298246

Tsai, C. W. (2010). Designing appropriate blended courses: A students' perspective. *Cyberpsychology, Behavior, and Social Networking*, *13*(5), 563–566. https://doi.org/10.1089/cyber.2009.0335

Tsai, Y. R. (2015). Applying the technology acceptance model (TAM) to explore the effects of a course management system (CMS)-assisted efl writing instruction. *CALICO Journal*, *32*(1), 153–171. https://doi.org/10.1558/calico.v32i1.25961

van Griethuijsen, R. A. L. F., van Eijck, M. W., Haste, H., den Brok, P. J., Skinner, N. C., Mansour, N., Gencer, A. S., & BouJaoude, S. (2015). Global patterns in students' views of science and interest in science. *Research in Science Education*, *45*(4), 581–603. https://doi.org/10.1007/s11165-014-9438-6

Vaughan, N. (2007). Perspectives on blended learning in higher education. *International Journal on E-Learning*, *6*(1), 81–94.

Venugopal, A. (2020). Students' readiness towards blended learning in era of Industrial Revolution (IR) 4.0. *Journal of Advanced Research in Social and Behavioural Sciences*, *21*(1), 29–40.

Waltz, C. F., Strickland, O. L., & Lenz, E. R. (2016). Measurement in Nursing and Health Research. In *Measurement in Nursing and Health Research* (4th ed.). Springer. https://doi.org/10.1891/9780826170620

Wang, Q., Zhu, Z., Chen, li, & Yan, H. (2009). E-learning in China. *Campus-Wide Information Systems*, *26*(2), 77–81. https://doi.org/10.1108/10650740910946783

Winarso, W. (2016). Assessing the Readiness of Student Learning Activity and Learning Outcome. *Jurnal Pencerahan*, *10*(2), 81–94. https://doi.org/10.13170/jp.10.2.5246

Wong, G. K. W. (2015). Understanding technology acceptance in pre-service teachers of primary mathematics in Hong Kong. *Australasian Journal of Educational Technology*, *31*(6), 713–735. https://doi.org/10.14742/ajet.1890

Yu, F., Pasinelli, M., & Brem, A. (2018). Prototyping in theory and in practice: A study of the similarities and differences between engineers and designers. *Creativity and Innovation Management*, *27*(2), 121–132. https://doi.org/10.1111/caim.12242

Yusoff, M. S. B. (2019). ABC of Content Validation and Content Validity Index Calculation. *Education in Medicine Journal*, *11*(2), 49–54. https://doi.org/10.21315/eimj2019.11.2.6

Zamanzadeh, V., Ghahramanian, A., Rassouli, M., Abbaszadeh, A., Alavi-Majd, H., & Nikanfar, A.-R. (2015). Design and Implementation Content Validity Study: Development of an instrument for measuring Patient-Centered Communication. *Journal of Caring Sciences*, *4*(2), 165–178. https://doi.org/10.15171/jcs.2015.017

Zogheib, B., Rabaa'i, A., Zogheib, S., & Elsaheli, A. (2015). University student perceptions of technology use in mathematics learning. *Journal of Information Technology Education: Research*, *14*(2015), 417–438. https://doi.org/10.28945/2315

APPENDIX A

Content validation Form for validating Teaching-Learning prototype - designed for Bangladeshi TVET students

Organisation of Islamic Cooperation

Thesis Title: Designing and Developing a Prototype of Digital Learning-Teaching Materials in Blended Learning Approach

Dear Sir/Madam,

Assalamu alaikum. I am inviting you to participate in this research by completing the following survey. This research aims to assess the readiness of Bangladeshi TVET students toward Blended Learning. We are assessing the preparedness of Bangladeshi TVE students for the Blended Learning approach. We have prepared a Blended Learning session for the "Internal Combustion (I.C.) Engine" course using Google Classroom and Face-To-Face classroom. We have used the ADDIE approach to Analyse, Design, Development of this classroom lesson. Now it's time for implementation. To implement this prototype in various TVE institutions, your expert opinion is critical. We will use the Content Validity Index (CVI) to measure the validity of our learning-teaching materials and the platform. Your feedback on the entire experience is the core asset of this research.

Please find below the Google classroom link and class code. Thank you for taking the time to exert your valuable opinion in this research.

Google Classroom Link: https://classroom.google.com/c/MzQ1Njk2Nzg1Mjc0?cjc=b4ytslk
Class Code: b4ytslk
[N.B. Please use your google e-mail account to enter the classroom]
Sincerely,

Shariful Islam Shakeel
MSc in Technical Education (specialization in Mechanical Engineering)
Islamic University of Technology (IUT)
Organization of Islamic Cooperation (OIC)
Board Bazar, Gazipur – 1704

Supervisor: Prof. Dr Md. Faruque Ahmed Haolader, Professor TVE Department, IUT, Board Bazar, Gazipur – 1704

Please rate your answer as follows:

1. Not clear.
2. Item needs some revision.
3. Clear but need minor revision.
4. Very clear.

Content Validity Index (CVI) Chart for Prototype Validation

Constructs	Features	Items/Dimensions	1	2	3	4
Contents Reliability	i.Clearly defined learning goals ii. Alignment of content with educational objectives iii. Exclusion of Unnecessary Information iv. Constructive feedback(i.e., quizzes, self-check questions, exercises, activities, tests, and other practice exercises or testing activities) v.Accuracy of information vi. Consistency of instructional materials with the intended learning outcome	Item 1/Online Class 1 Item 2/ Online Class 2 Item 3/Online Class 3 Item 4/ Online Class 4 Item 5/ Online Class 5				
Comprehensibility of the prototype	i.Prototype actions and understanding ii. Auditory and visual compatibility	Item 1/Online Class 1 Item 2/ Online Class 2 Item 3/Online Class 3 Item 4/ Online Class 4 Item 5/ Online Class 5				
User-friendliness of the prototype	i.A user-friendly interface ii. The ability to divert from the course flow. iii. Distinctive navigation technique iv. The authority of students to evaluate their abilities and practice	Item 1/Online Class 1 Item 2/ Online Class 2 Item 3/Online Class 3 Item 4/ Online Class 4 Item 5/ Online Class 5				
The generality of the prototype	i.Positive Interaction with other instructional designers ii. Reliability of Prototype in designing a comparable course	Item 1/Online Class 1 Item 2/ Online Class 2 Item 3/Online Class 3 Item 4/ Online Class 4 Item 5/ Online Class 5				

APPENDIX B

Reviewers Opinion Journal

Class No.	Item	Clear / Not Clear	Suggestions
Online Class 1	Class lecture ppt/pdf		
	Class video		
	Assignment		
	Class test		
Online Class 2	Class lecture ppt/pdf		
	Class video		
	Assignment		
	Class test		
Online Class 3	Class lecture ppt/pdf		
	Class video		
	Assignment		
	Class test		
Online Class 4	Class lecture ppt/pdf		
	Class video		
	Assignment		
	Class test		
Online Class 5	Class lecture ppt/pdf		
	Class video		
	Assignment		
	Class test		

APPENDIX C

Survey Questionnaires for Assessing the Prototype using TAM

Organisation of Islamic Cooperation

Designing and Developing a Prototype of Digital Learning-Teaching Materials in Blended Learning Approach.

Dear Participants,

Assalamu alaikum. I am inviting you to participate in this research by completing the following survey. This research aims to assess the readiness of Bangladeshi TVET students toward Blended Learning.

You have already attended the "Internal Combustion (I.C.) Engine Principle course in Blended mode. Your feedback on the entire experience is the core asset of this research. You will require approximately 15-20 minutes to complete the questionnaire. Thank you for taking the time to assist me with this research. Under no circumstances are you obliged to answer any of the questions; however, doing so will greatly assist me in completing my study and enhancing my understanding of this research focus. The data will be used solely for academic purposes, and you will remain anonymous.

Sincerely,

Shariful Islam Shakeel
MSc in Technical Education (specialization in Mechanical Engineering)
Islamic University of Technology (IUT)
Organization of Islamic Cooperation (OIC)
Board Bazar, Gazipur – 1704

Supervisor: Prof. Dr. Md. Faruque Ahmed Haolader, Professor TVE Department, IUT, Board Bazar, Gazipur – 1704

SECTION A. Demographic Questions

Instructions:

✓ Would you mind using the tick symbol to complete this section

1. What is your gender?	
Male	
Female	

2. What is the name of your Institute?	
(A)Institute of Marine Technology, Faridpur	
(B)Institute of Marine Technology, Munshiganj	

(3) What is your entry qualification for studying this diploma course?	
(A) Secondary School Certificate (SSC)	
(B) Higher Secondary Certificate (HSC)	
(C) Others	

Instruction: Please answer the following sections according to the next order. There are eight sections in total below.

In section B, please rate your answer by Yes/No

In section C, please rate your answer as follows:

1. Strongly Disagree.
2. Disagree.
3. Agree.
4. Strongly Agree.

Section A TAM for assessing of proposed prototype

Serial	Questionnaires	1	2	3	4
Perceived Usefulness					
PU1	I believe technology improves my quality of learning.				
PU2	I believe web platforms should be used regularly in teaching.				
PU3	I believe a blended learning environment improved my learning capacity.				
Perceived Ease of Use					
PEU1	The prototype has a user-friendly interface.				
PEU2	All the contents in the prototype are easily accessible.				
PEU3	I find it easy to navigate through the classroom.				
Behavioural Intention of Use					
BI1	I would like to keep myself updated with new educational techı				
BI2	I am more comfortable with blended learning than only learning.				
BI3	I want to attend more courses that offer blended learning.				
Actual Use of New prototype					
AU1	I can use all the features of this prototype alone.				
AU2	I can easily take part in the test activities (e.g., quizzes, assignn				
AU3	I can access all digital learning materials and can download/ uı				

APPENDIX D

Survey Questionnaires for Assessing the Readiness of Bangladeshi TVET students

Organisation of Islamic Cooperation

Designing and Developing a Prototype of Digital Learning-Teaching Materials in Blended Learning Approach.

Dear Participants,

Assalamu alaikum. I am inviting you to participate in this research by completing the following survey. This research aims to assess the readiness of Bangladeshi TVET students toward Blended Learning.

You have already attended the "Internal Combustion (I.C.) Engine Principle course in Blended mode. Your feedback on the entire experience is the core asset of this research. You will require approximately 15-20 minutes to complete the questionnaire. Thank you for taking the time to assist me with this research. Under no circumstances are you obliged to answer any of the questions; however, doing so will greatly assist me in completing my study and enhancing my understanding of this research focus. The data will be used solely for academic purposes, and you will remain anonymous.

Sincerely,

Shariful Islam Shakeel
MSc in Technical Education (specialization in Mechanical Engineering)
Islamic University of Technology (IUT)
Organization of Islamic Cooperation (OIC)
Board Bazar, Gazipur – 1704

Supervisor: Prof. Dr. Md. Faruque Ahmed Haolader, Professor TVE Department, IUT, Board Bazar, Gazipur – 1704

SECTION A. Demographic Questions

Instructions:

✓ Would you mind using the tick symbol to complete this section

3. What is your gender?	
(A) Male	
(B) Female	

4. What is the name of your Institute?	
(A)Bangladesh Institute of Marine Technology, Narayanganj	(D)Institute of Marine Technology, Chandpur
(B)Institute of Marine Technology, Faridpur	(E) Institute of Marine Technology, Sirajganj
(C)Institute of Marine Technology, Munshiganj	(F) Institute of Marine Technology, Bagerhat

(3) What is your entry qualification for studying this diploma course?	
(D) Secondary School Certificate (SSC)	
(E) Higher Secondary Certificate (HSC)	
(F) Others	

Instruction: Please answer the following sections according to the next order. There are eight sections in total below.

In section B, please rate your answer by Yes/No

In section C, please rate your answer as follows:

1. Strongly Disagree.
2. Disagree.
3. Agree.
4. Strongly Agree.

Section B: Availability of Resources

S.L	Questionnaire	YES	NO
1.	I have a Smartphone/Computer/Laptop/Tablet		
2.	I have an email account		
3.	I have an internet connection in my place of studying (mobile data or bb)		
4.	I can navigate through any webpages without the help of others		
5.	I can download files using the internet browser		

Section C: Readiness toward blended learning

S.L No.	Questionnaires	1	2	3	4
1.	I would like to access the class materials in my own time				
2.	I would like to access the class materials at my own pace				

3.	I would like to access the class materials in my own space				
4.	I prefer technology while learning				
5.	Access to all digital learning materials helps me understand my lesson Precisely				
6.	I would like to be in charge of my learning				
7.	I would like to keep myself updated with new educational technology				
8.	I believe technology improves my quality of learning				
9.	I believe online tasks help me build my learning capacities				
10.	I am comfortable with self-directed online learning				
11.	I do not feel isolated in an online classroom				
12.	I believe online learning helps me to prepare well for my future endeavours				
13.	I prefer an online platform to communicate with other teachers and students				
14.	I prefer to learn in the face-to-face classroom environment				
15.	I learn better in a teacher-directed face to face classroom				
16.	I believe face to face learning develops my interpersonal and team-building skills				
17.	I prefer immediate feedback from the teacher				
18.	I prefer learning through collaboration with other people in Face-To-Face Classroom				
19.	I have basic skills in using technology				
20.	I can understand the online instruction for assignments/quizzes/tutorials				
21.	I can manage unwanted situations and download the learning materials				
22.	I prefer browsing the website and various new applications				
23.	I believe a change in the teaching-learning environment has a positive influence on my learning ability				
24.	Online discussion and collaboration help me to learn efficiently				
25.	I believe online learning helps organize my time better				
26.	I am more comfortable with blended learning than face to face learning				
27.	I want to attend courses that offer blended learning				
28.	I believe a blended learning environment improved my learning capacity				
29.	I am open to new ideas and concepts				

APPENDIX E

Course Structure and Syllabus of IC Engine Principle

INTERNAL COMBUSTION (IC) ENGINE PRINCIPLE (67911) T P C
2 3 3

Aims:

To be able to develop knowledge, skills, and attitude in the area of the internal combustion engine with special emphasis
on:

- Working principles of IC engines.
- Engine terms, types of engine, valve, and valve mechanism.
- Systems of IC engine.
- Concept of Modern IC engine.

Short Description

Basic concepts of IC engine; Functions of IC engine; Constructional and operational features of IC engine components;
Working principles of IC engine; Types of IC engine; Engine terms; Valve and valve mechanism; Lubricating system;
Cooling system; Ignition and Emission system; Starting, Charging, and Supercharging system; Concept of Modern IC
Engine.

DETAIL DESCRIPTION

Theory:

1. Understand the basic concepts of the IC engine.

1.1 Define engine and IC engine.
1.2 Distinguish steam engine and heat engine.
1.3 Differentiate between CI engine and SI engine.
1.4 Describe the principle of IC engines.
1.5 Mention the various uses of the IC engine.
1.6. Describe the functions of IC engines.
1.7 Explain the importance of the IC engine.
1.8 Explain the role of the IC engine as a prime mover in different sectors.

2. Understand the types of IC engines according to different features.

2.1 Identify the IC engine according to the number and arrangement of cylinders.
2.2 Explain the engine according to the valve mechanism.
2.3 Name the engine according to the cooling system.
2.4 Classify engine according to the type of fuels used.

3. Understand the constructional and operational features, types, and functions of IC engine components.

3.1 Identify cylinder head, cylinder block, and crankcase of IC engine.
3.2 Identify piston, piston ring, piston pin, connecting rod, crankshaft, and camshaft.
3.3 Name the moving and stationary parts of the IC engine.
3.4 Identify and describe the function of cylinder liner, water jacket, bearing, valve, valve lifter, manifold, flywheel,

Rocker arm, valve spring, valve seat, pushrod of IC engines.
3.5 Mention the material used for various parts of IC engines.

4. Understand the working principle of the IC engine.

4.1 Define engine cycles.
4.2 Define two-stroke and four-stroke cycle engines.
4.3 Mention valve timing diagram and its importance for 2-stroke & 4-stroke IC engines.
4.4 State the working principles of 2-stroke and 4-stroke cycle SI and CI engines.
4.5 Distinguish between two-stroke cycle and four-stroke cycle engines.
4.6 Distinguish between diesel cycle and auto cycle.

5. Understand the basic engine terms.

5.1 List the basic terms of the IC engine.
5.2 Define engine bore and stroke length.
5.3 Describe piston displacement, clearance volume, swept volume, and compression ratio.
5.4 Compute mechanical efficiency, volumetric efficiency, and torque.
5.5 Define mean effective pressure.
5.6 Define the air-fuel ratio.
5.7 Determine Indicated Horse Power (IHP), Brake Horse Power (BHP), and Frictional Horse Power (FHP).
5.8 Solve the problem related to IHP, BHP, FHP, cylinder volume, and stroke length.

6. Understand the valve and valve mechanism of the IC engine.

6.1 Explain the functions of valves.
6.2 Explain different types of valves.
6.3 Explain the valve mechanism of IC engines.
6.4 Describe the mechanism of valves according to a different arrangement.
6.5 Compare L-head and I-head valve arrangement.
6.6 Describe the operation of the hydraulic valve lifter.

7. Understand the lubricating system of the IC engine.

7.1 Define lubricants.
7.2 Mention the purposes of the lubricating system.
7.3 Classify lubricants and lubricating system.
7.4 Describe each type of lubricating system.
7.5 Name the components of the lubricating system.
7.6 Describe the methods of bearing lubrication.
7.7 Distinguish between dry and wet sump lubricating system.
7.8 Describe gear type, lobe type, vain type, and plunger-type lubricating pumps.

8. Understand the cooling system of the IC engine.

8.1 Describe the necessity of a cooling system.
8.2 Classify cooling system.
8.3 Describe each type of cooling system.
8.4 List the components of the engine cooling system.
8.5 Mention the purposes of using the antifreeze solution in the cooling system.
8.6 Describe the flushing of the cooling system.
8.7 List the troubles of the cooling system.
8.8 Mention the functions of the thermostat valve, expansion tank, and oil cooler.

9. Understand the Ignition and Emission system of the IC engine.

9.1 Define ignition and emission system.
9.2 Define manifold, catalytic converter, muffler, and silencer.

9.3 Describe the function of the exhaust and intake system.
9.4 Explain the different types of scavenging systems.
9.5 Describe the different types of air filters.
9.6 List the components of the ignition system and emission system
9.7 Describe the ignition system of the CI engine with a sketch.

10. Understand the Starting, Charging & Super Charging System of the IC Engine.

10.1 Classify starting system of IC engines.
10.2 Describe the principles of starting IC engines.
10.3 Describe the manual starting system.
10.4 List the components of electric starting and air starting systems.
10.5 Describe the procedures of electric starting and air starting systems.
10.6 Describe the necessity of a charging system.
10.7 Define supercharging.
10.8 Classify supercharger.
10.9 Describe the methods of supercharging and scavenging.
10.10Describe the functions of the turbocharger.

11. Understand the Concept of Modern IC Engine.

11.1 Define hybrid vehicle.
11.2 Meaning of VVT-i, VTEC, EFI, DOHC, DVVT.
11.3 Difference between VTEC and VVT-i.
11.4 Function of EFI in IC engine.
11.5 Explain the working procedure of the VVT-i system in the CI engine.