Traditional, Video and Extended Reality (XR) assisted Flipped Classroom teaching methods: an approach and comparison

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***Abstract*— This paper examines the comparative effectiveness of three distinct Flipped Classroom (FC) teaching methods in the context of Power and Electrical (PE) engineering education: Traditional Flipped Classroom (TFC), Video-Assisted Teaching Methods (VAFC), and Virtual Reality Flipped Classroom (VRFC). The study incorporates valuable feedback from students who experienced these methods and provides an evaluation of their perceptions. A cross-over methodology for comparing these FC methods is presented. The VAFC method is perceived to be an effective approach and preferred over TFC and VRFC by students. The paper also provides Teachers' perception in implementing above FC methods, which outlines a process for developing VAFC and VRFC teaching resources. Operational difficulties in implementing such methods are highlighted, especially in the context of fast-paced, privately-catered undergraduate education sector striving for implementing non-conventional teaching methods.**

Keywords—Flipped Classroom, Extended Reality, Virtual reality, Video-assisted teaching, Power Engineering, Higher Education, Pedagogy

I. Introduction

The field of power engineering is integral to the growth and development of Asian economies, given the increasing demand for electricity to fuel industrialization and modernization. As universities in Asia strive to produce a skilled workforce in power/electrical (PE) engineering, innovative teaching, learning, and assessment methods are crucial. Especially in Nepal, electrical engineering market is poised for growth due to its abundant hydropower resources and increasing demand for electricity [1]. The country has seen increasing demand for electricity due to industrialization, urbanization, and economic growth.

Education landscape in universities from Nepal has been striving form modernisation. With many-fold increase student numbers as compared to 1990s and similar growth in local collages affiliated with major universities, Education sector is transforming into fast paced privately-catered education, especially undergraduate education [2]. This requires employing specialised faculty members to deliver PE engineering programs modules. It was reported [3] that new lecturers and teaching staff undertaking teaching profession in Higher Education may not be trained to adapt this profession; especially in developing Asian countries where Education sector is largely privatised, and it is subjected to extreme student recruitment targets. Al-Samarraie [4] suggest a pedagogy knowledge is essential in educators to effectively undertake teaching activities, facilitate learning, and promote the holistic development of students. Pedagogy awareness provides a foundation for creating engaging, inclusive, and student-cantered learning environments, ultimately leading to better educational outcomes.

eAccess Erasmus+ funded project [5] has partnered with two institutions in Nepal, namely Kantipur Engineering Collage (KEC) and Pokhara University (PU). The main objectives of eAccess project are aligned with Capacity Building in Higher Education (CBHE), where 5 Asian Universities are collaborating with 3 European Universities for modernising PE Engineering curriculum. To meet the increasing demand for PE engineering professionals, Asian universities need to adapt and innovate their teaching methods [3]. This regional challenge has been addressed in eAccess project and one of the initiatives of implementing FC methods at KEC has been presented in this paper.

The flipped classroom approach is an effective pedagogical strategy for engineering education [6]. This paper explores the use of flipped classroom teaching methods, namely Traditional FC, Video-assisted FC and Virtual Reality (VR) assisted FC in PE engineering subjects at KEC. The paper investigates different approach of implementing FC methods for delivering Engineering modules, explores effectiveness of video-assisted pedagogy within FC and XR-assisted methods for teaching PE subjects. While the broader research aim is to implement appropriate Flipped classroom methodology for delivering PE Engineering subjects in Asian Universities, this paper reflects on students' and teaching staff's experience on adapting to different modes of FC at KEC. Some of the objective of this study is to develop teaching and Learning resources which includes production of video contents/lectures and configuring 3D models and virtual environment for implementing XR/VR assisted FC. Corresponding sections, elaborating above objectives are structured in the paper, followed by capturing implementation experience by staff and use experience by students.

II. FLIPPED CLASSROOM MODELS AND APPROACHES

Traditional classroom lectures are generally a prominent teaching method exercised widely in HE; especially, during past decades [6]. It is identified as a passive, instructor-led learning method, where students receive a subject knowledge in the classroom without actively engaging in the learning process. It is well reported that the traditional lecture-based teaching methods remains unfulfilling towards engaging students actively, encouraging critical thinking, and promoting problem solving skills [6]. In the context of power engineering, which requires practical application of theoretical knowledge, a more interactive and student-cantered approach is necessary. There has been a shift towards more interactive and technology-enhanced teaching methods in recent years. Flipped classrooms, where students study course materials independently before class and engage in collaborative activities during class time, has been widely reported as effective teaching method as compared to traditional lecture-based delivery [4].

Typical FC approach involves releasing teaching resources (lecture notes, videos, digital resources etc) before the scheduled classroom lecture. These resources are given to students with an objective list, which provides a rational for reading/using pre-class resources. This is followed by classroom activities, which focuses on using pre-class resources for active learning methods such as group discussion, reflection, quiz, problem solving exercises etc. This facilitates student taking ownership of their learning, rather than participating in instructor-led classroom lectures.

Although FC methods are gaining popularity in Asian universities, there are scalability challenges. Dhamala et al [2] highlights a cultural factor, where traditional classroom teaching methods are driven by strong respect of authority. Shifting the role of this authority to facilitator can be challenging and difficult to adapt for students as well as faculty members. This also highlights a need of instructors' training for effective pedagogy adaption. FC implementation for Engineering and technology discipline has been widely reviewed in the literature [4]. However, comparative effectiveness of various types of pre-class resources in FC implementation is under-represented in the literature.

A. *Traditional FC*

Authors would like to address "Traditional FC" in the context of current teaching practices at KEC. While traditional classroom lectures remain a most exercised practice at KEC, there has been good evidence of implementing contemporary teaching methods for delivering PE Engineering subjects. Most teaching and learning resources are in the form of physical (printed) and digital copies of lecture notes, textbooks, presentation, data sheets, standards etc. At the time of piloting this FC model at KEC, above "traditional (text-based)" resources were utilised for FC implementation as shown in Figure 1. Thus, this teaching method in this paper is addressed as a "Traditional FC", where students were given digital and physical resources before the scheduled classroom session.

FC implementation reported in the available literature is largely utilising mixed pre-lecture resources such as text-based lecture notes and pre-recorded videos. Authors found that the explicit use of text-based resources (Printed or Digital) for FC are not widely reported in the literature. Thus, comparative effectiveness of text-based resources and video-based resources is not well understood in the literature. Effectiveness of FC implementation with (only) text-based pre-class resources cannot be disregarded as it is widely reported that producing lecture video resources require specific tools and skill-sets, which are not accessible in all teaching institutes in Nepal [3].

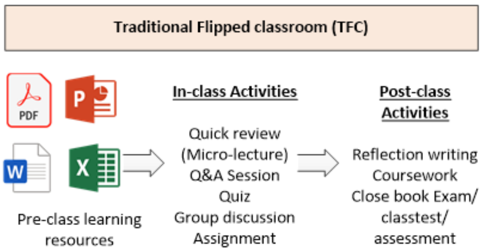

Fig. 1. Illustrates pre-lecture digital or printed resources for "Treditinal FC", which are primarily digital textbased documents or printed notes.

B. *Video assisted FC*

Audio and visual media can be highly effective tools within a Moodle course. Students can view material from the Web, catch up on lectures they have missed, and view demonstrations of the content discussed in class [7]. Use of video resources in Engineering education and within FC implementation is not new. It has been established that video resources can facilitate active learning by visualising Engineering principles [8], makes it easier for students to remember critical concepts [9], also contribute towards students' cognitive capabilities [7]. However, there has been overwhelming indication of the duration of the lecture videos impacting students' perception on FC [9]. Guo et al [8] have reported that even high quality pre-recoded classroom lectures can be made more engaging by segmenting it on VLE. Shortening pre-recorded lecture videos into set of segments has been most reflected comment of the video-assisted pedagogy.

An overview of video-based teaching and learning was reported by Cattaneo et al [7]. They have advocated that video can make connections between learning contexts, for example, work-based and school-based or school-based and home-based. Video can also blur the boundary between formal, informal and non-formal contexts by letting teachers and learners create 'informal' learning within 'formal' learning experiences and vice versa. Similar video assisted pedagogy is implemented for teaching manufacturing themed subjects by Shih et al [10]. A correlation between learning performance and video-assisted pre-class resources is still ambiguous, however high performing students tend to assess it more frequently than their counterparts [11].

Higher education establishments with limited availability of e-learning knowledge or e-learning resources experiences difficulties, especially, when lecturers lack knowledge as well as resources [12]. In case of Nepal, resources available at local collages presents various challenges. While reviewing the state of the Science and Technology (S&T) education in Nepal, Dhamala et al [2] reports 100% of participating institutes expressed lack of trained faculty members to adapt innovative teaching and learning methods to deliver S&T programmes. They have highlighted faculty members are not oriented in IT in S&T. The use of traditional teaching methods still exists, and there is a lack of new concepts, support and adaptation of state-of-the-art resources such as digital content creation tools required for implementing video-assisted or other FC methods [3].

This indicates that FC implementation can be influenced by available resources (technology and tools), thus needs more scrutiny for its effectiveness with different types of pre-class learning resources. Neaupane [13] has presented a video production guidelines for FC implementation while identifying challenges in developing nations like Nepal.

C. Use of XR technology in PE industry

Today, forefront of communication and visualisation technology is presented through Extended Reality (XR), which underpins Virtual reality (VR), Augmented Reality (AR) and Mixed Reality (MR). XR in PE industry is used for training personnel in power plants, helping them understand complex equipment and procedures. VR simulations can provide a safe and immersive environment for learning [14]. AR technology can be employed for maintenance and repair training where information layer cab be superimposed on the physical equipment. These technologies enable engineers to create 3D models of power systems and visualize them in a real-world context, aiding in the design and planning phases. It facilitates remote collaboration among global supply-chain, allowing them to work together on power and electrical projects regardless of their physical locations. XR is also exceedingly exploited for safety training high-risk electrical environments, helping workers understand potential hazards and safety procedures in PE industry. MR can provide real-time data visualization for grid operators, helping them monitor and manage the electrical grid more effectively.

D. Use and effectiveness of XR technology for Teaching and Learning

Academic institutions are also adapting XR technology for delivering relevant programme modules. There are many studies reporting use of XR technology for architecture, engineering, and construction (AEC) industry, Healthcare, Nursing and Medical education. However, implementation of XR technologies for PE programmes are not reported widely in the literature [15].

Matovu et al [16] have reported five rationales for adapting XR technology for Teaching and Learning; namely Visualisation of abstract concepts, Enhancing learning experience, Practical skills development, Virtual field trips, and Providing first-person experiential learning opportunities. These rationales can provide a basis for evaluating students' perception on learning through XR resources. Moreover, these rationales can provide a scale for measuring levels of XR integration features as shown in Figure 2. Use of XR for teaching and learning can be categorised as experiential learning (EL) model [17]. EL consist of four phases; i) Concrete Experience, which involves active participation and direct engagement with the subject matter, ii) Reflective Observation, where learners reflect on their experiences of applying learned knowledge iii) Abstract Conceptualization, where learners attempt to consolidate experiences by forming general principles and theories, and iv) Active Experimentation, where learners apply the theories, concepts and knowledge they have developed to new situations. XR has been positioned and perceived as a teaching and learning method, model, tool, pedagogy approach in a literature [18], making it versatile pedagogical subject area.

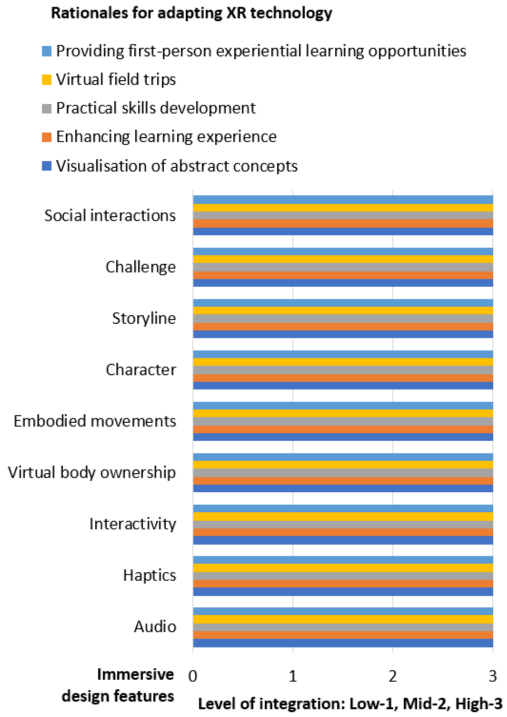

Fig. 2. A dashboard for measuring Level of integration of the immersive design features, adapted from [16]

Xiao-Dong and Hong-Hui [19] have implemented VR for blended flipped classroom for teaching college English, as it can enable formal or informal learning, anywhere and anytime. This study was completed through exploiting commercially available mobile based VR platform called "Smart English" for realising experiential learning. Students were given pre-classroom learning resources such as micro-videos and notes. Students were encouraged to use VR platform during off-class, independent study time. Author reported difficulties in adapting to the new roles in the FC implementation, for both students to be at the centre of the learning and teachers as a guide and facilitators. Another case study [20] implemented FC in the anatomy learning while providing pre-class resources in the form of notes, videos and augmented reality. It found video resources were favoured by students and students who utilized augmented reality in their studies tend to have grades that exhibit a more pronounced grouping, resulting in reduced dispersion in comparison to those who used other pre-class resources. VR field trips were introduced by Wong et al [21], where students were obliged to complete the virtual reality tour (using 360° images) and attempt a graded quiz as part of pre-class activity. It was highlighted that educators need to seamlessly integrate these virtual experiences with follow-up activities suitable for FC. This was challenging as preparation of VR resources (pre-and-post-production of 360° images) come with associated costs and require a commitment from both educators and students. Nevertheless, the virtual reality field trip in FC was reported as a promising approach since it alleviates the burden of time and logistics of a real field trip.

Creating immersive educational content has consistently presented its set of difficulties. VR, for instance, demands substantial graphics processing capabilities to ensure a seamless and valuable user experience. Review papers [22] have highlighted concerns about the limited availability of instructional designs for integrating VR/AR content into their classrooms. This limitation underscores the scarcity of XR resources, with no guarantees that these materials align with students' learning objectives. In addition, cost, administrative complexities, support requirements, and the intricate process of content creation, equipment maintenance, and staffing, have all been highlighted as key apprehensions for small to medium-sized public educational institutions involved in implementing educational XR. These limitations provide guidelines for selecting appropriate XR resources (Technology, Software packages, hardware etc) for implementing XR technology in delivering UG modules.

III. Methodology and Integration Approach

As identified in previous section FC implementation in HE is not new. However, use of evolving technology within FC provides a range of implementation methods. Some of these methods are implemented at KEC as part of this pilot study. Traditional FC approach, as elaborated in Section II is compared with evolving methods (video and XR) of creating pre-classroom learning resources. Objective of this capacity building initiative is to reflect on students' and teaching staffs' perception on adaption.

Selected PE topics for implementing FC teaching model include introduction to Power Transformers and CD machines. Traditionally (non-FC), these topics are taught in a classroom session using a PowerPoint presentation, where students receive topic information, explanations, and insights from an instructor in a structured setting. A presentation includes lecture notes and pictures from text from a textbook. Following the lecture session, corresponding lecture overheads (notes, presentations, chapters etc), assignment (tutorial topic, problem statement, coursework etc) are given to students on a Moodle site. Students are expected to engage with scheduled tutorial and lab sessions for fostering technical understanding regarding the topic.

As a part of this pilot study, a cross-over investigation [23] was conducted to capture students' perception on various methods of FC. The objective of the study is to compare Traditional FC methods with Video and XR assisted pre-class activities. Thus, students were randomly divided into three groups for cross-over testing of i) Traditional FC ii) Video-assisted FC and iii) XR-assisted FC. Corresponding pre-class learning resources were released 1 week before the classroom session for students to engage with. Figure 3 illustrates a cross-over study design. Each group undertakes at least 2 types of FC methods, so student experience can provide a comparative experience of these methods.

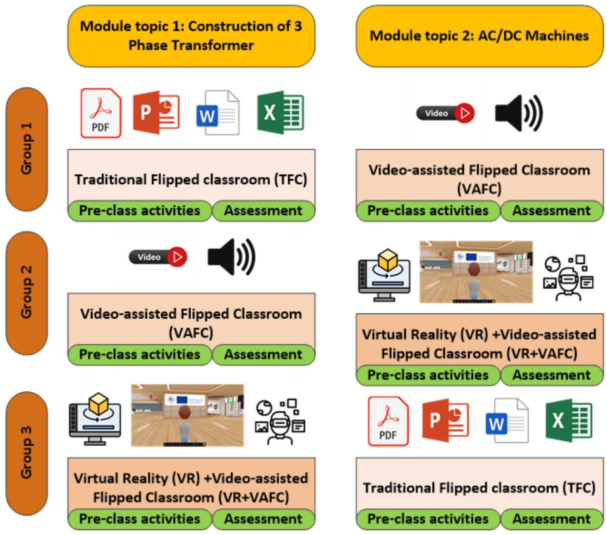

Fig. 3. FC implemetation methods and cross-over approach

A. *Module and Coursework design and including FC delivery methods (KEC)*

In this pilot study, students were given pre-class class activities for adapting to traditional FC method as shown in Figure 1. PowerPoint presentations and lecture notes are released one week before the classroom session. Students were given structured instructions to engage with these resources and complete basic tasks (informal quiz) before attending the classroom session. The classroom session was started with a micro-lecture, followed by focused discussion on technical aspects of the selected topic. Students were expected to participate in follow-on tutorials and labs. Corresponding learning outcomes were assessed using different assessment methods as listed in the module/course descriptors.

B. *Development of video assisted teaching FC resources*

Pre-class lecture videos can be delivered to students in both, off-line (downloadable) as well as on-line (streaming) formats. Producing these lecture videos requires a webcam device and dedicated video-capturing/editing tools. Some of these video-editing tools are free to use and some of them can be purchased through license. Both options are explored during this pilot study. A process for producing video lectures is outlined below:

Step 1: Creating lecture presentations in alignment with the course modules in advance can enhance student engagement. Students are more inclined to remain attentive during well-structured presentations and are more likely to watch lecture recordings in their entirety.

Step 2: To record lectures, a microphone setup or dedicated digital voice recorders can be used. These recorded lectures can be saved in audio formats like MP3 or WMV, or in video formats such as AVI, WMV, MPG, MP4, or MKV. This enables the capture of presentation slides or the display screen.

Step 3: Selecting an audio/video hosting platform can be a strategic task as it depends on available resources at the university. This platform can influence accessibility and how students engage with pre-class video resources. Table 1 provides few examples of Lecture capture tools and hosting platform.

TABLE I. LECTURE CAPTURE TOOLS AND HOSTING PLATFORMS

Lecture capture tools	Method descriptions
Microsoft Teams	Licensed through the organisation
Zoom	Free / Licensed through the organisation
Powerpoint	Licensed through the organisation
Free/commercial recording/screen capture software	Free / Licensed through the organisation (Camtasia, Bandicam, Screencast-O-Matic, Flashback express etc)
Moodle	Moodle provides built-in tools to record audio and video.
BigBlueButtonBN	BigBlueButton is an open source web conferencing system for online learning.
Xbox game bar	Free with Windows 10
Audio and video hosting platforms:	**Method descriptions**
Microsoft Streams	Licensed through the organisation. Automatic generation of captions/subtitles
Clickview	Licensed through the organisation. Interactive videos to formatively assess your students
BigBlueButtonBN	BigBlueButton is an open source web conferencing system for online learning.
Echo360/ eStreams/Medial	Licensed through the organisation. Lecture capture/hosting platforms
H5P	Moodle provides a built-in tool called H5P which includes the ability to upload video and audio content within content types using its own player.
Youtube / Vimeo	youtube/Vimeo channels for hosting lecture series.

Step 4: Setup work environment and recording resources to optimize audio and video quality, which involves selecting a well-illuminated room or office and arrange the webcam to capture the head and shoulders while maintaining an eye-level perspective.

Step 5: Once the lecture materials and recording setup have been prepared, one can initiate the process of recording a test video. This video serves as a practice session for not only the presentation but also for assessing sound, lighting, and the overall quality of the video. This is followed by optimising a recording set-up for better video lecture capture.

Step 6: Setup the process for recording and editing lectures with video capture software application. One effective method is to record the entire lecture in smaller, discrete video files, typically spanning 10-15 minutes and covering 5-7 slides each. This approach offers the advantage of simplified editing, updating, or revising of specific segments if needed, without the need to edit or re-record the entire lecture session. The benefit of pre-recording lectures in shorter segments is that it allows for the independent editing of individual clips related to specific slides.

Completing the recording of a series of videos will result in various video, audio, picture and data files. Ensuring the secure and organized storage of these files is of paramount importance for accessibility and traceability. To achieve this, the implementation of a rational folder structure for recording storage is advised. Typically, this involves creating a primary folder for the course, followed by sub-folders designated for each section of the course. Within these section folders, further organization can be maintained with folders dedicated to individual videos. Consistency in adhering to this system once it is established is key to maintaining an efficient recording storage approach. These individual files can subsequently be amalgamated during the post-editing phase to produce a complete lecture session video file. Few examples of video editing tools are Camtasia (Commercial licensed tool) or OpenShot, Shotcut Video Editor (Free and opensource video editor), Microsoft video editing pre-packaged tools (pre-packaged in Windows).

Step 7: After recording the module lectures, the next step is to upload these video files on Moodle module site. Recorded lecture videos can be shared in a variety of methods shown in Table 2

TABLE II. VARIOUS VIDEO FILE SHARING METHODS ON MOODLE

Video file sharing methods	Method descriptions
Add a File to a Moodle Course	download and off-line engagement
To create a hyperlink using the HTML Editor Toolbar	download and off-line engagement
Add a URL resource to a Topic	download and off-line engagement / online streaming
Upload a Video or Audio File to Moodle	online streaming
Embed Media Using "Embed Code" (Instructors Only)	Online streaming. Embedded link can be generated from most Audio and video hosting platforms.

Interactive Video Lectures (IVL) refer to digital video presentations that incorporate interactive elements. These elements encompass features like indexing, information nodes, quizzes, and hyperlinks positioned within a recorded video. This technological approach empowers students to actively participate and connect with the recorded FC pre-class activity lectures. Some examples of Interactive lecture video authoring tools are provided in Table 6.

TABLE III. INTERACTIVE LECTURE VIDEO AUTHORING TOOLS

Interactive lecture video	Method descriptions
Microsoft Streams	The Forms integration into Microsoft Stream helps to make videos more engaging and interactive for learners, while giving trainers a way to understand how well the information is being comprehended.
Clickview	It can add an interactive layer of inbuilt questions or problems to any existing video. A range of different question types such as multiple choice, short answer or annotation can be configured.
H5P	It enables web-based interactive learning content for students within Moodle. There are range of activities to choose from such as games, quizzes, presentations and interactive videos.

C. Development of XR assisted teaching resources for FC

VR assisted teaching resources includes digital assets (visualisation models, virtual environment, interaction) for students to interact with, which will help enhance their understanding of the subject. Prior to implement this method, XR technology feasibility study was undertaken. This involved reviewing required resources at KEC for introducing VR assisted teaching approaches. Immersive web environment approach was preferred over dedicated VR headset due to cost considerations. Hence, FrameVR platform was selected as a part of this case study. FrameVR environment provides a web based immersive virtual environment for asynchronous pre-class activities. It can launch from any browser from desktop, laptop, mobile, tablet or VR headset. It allows users to create immersive VR experiences, including 3D environments and interactive content. It supports real-time collaboration, enabling multiple users to collaborate in the same virtual space, making it a feasible tool for asynchronous group work. Most desirable criteria for selecting FrameVR is its capability to integrate various types of visualisation and multimedia assets, such as 3D models, videos, and audio, enhancing the richness of VR experiences. Thus, virtual field trips and scientific simulations in PE subject area can be configured using this platform and used for pre-class activities for implementing FC approach. A process for producing XR assisted teaching resources is a complex and multidisciplinary process that involves various stages outlined below in Figure 4:

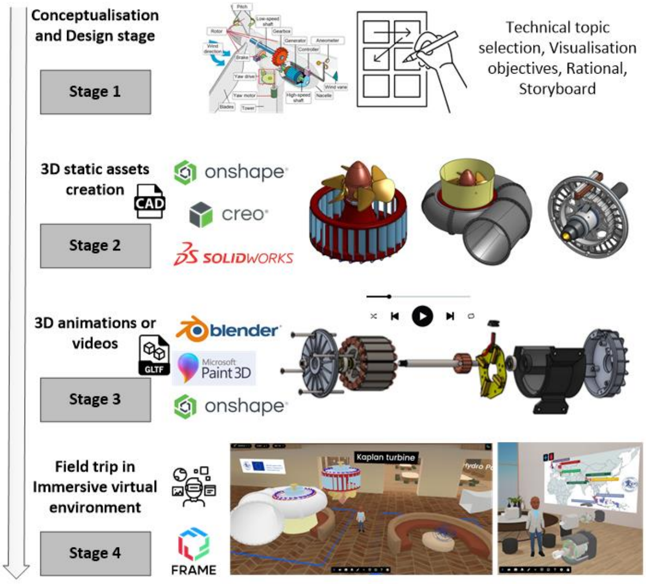

Fig. 4. 3D asset creation process for configuring a virtual field trip in an immersive environment for XR-assisted FC

Step 1: Conceptualisation and Design stage, where technical topic, visualisation objectives, rational (as shown in Figure 2) and VR resources (technology, hardware, and software) are selected. This includes creating a storyboard, which depicts stages of experience and interactions expected in the immersive environment.

Step 2: 3D static assets creation stage, where 3D assets such as 3D models, pictures, videos, animations, and other media assets are produced be used in the VR environment. This stage can be very critical as producing these digital assets requires specialised skills and knowledge in CAD and visualisation. For this pilot study, a process and resources illustrated in Figure 4 were employed for producing digital assets for XR assisted field trips. For example, 3D models of Transformers and AC/DC machines were configured with commercial CAD packages such as SolidWorks or Creo (Figure 5).

Step 3: Some of the CAD packages can be utilised to produce process simulations. These simulations can be captured in a video format (.avi, .mp4 etc) or in an animation format (such as. glb, .gltf etc). Unlike video formats, an animation format file can contain both 3D models and animations in a single file. Sophisticated animation content including keyframes, skeletal animations, and morph targets can be packaged inside animation format files, which can be inserted and visualised into VR immersive environment.

Step 4: Digital documents, video-audio media and animation assets can be inserted into FrameVR's virtual immersive environment. Students can access this environment before classroom session. It is important to guide students throughout this virtual field trip using annotations, messages and navigation indicators. As students progress with the field trip, they are guided with objectives of the field trip, learning outcomes and informal assessment quiz questions.

D. Capture students experience of FC models

Students were invited to provide comparative feedback after each group had completed two identified topics using at least two different FC methods. 84 responses were received. As shown in Figure 3, Group 1 consists of 36 students and engaged with 2 identified topics with Traditional FC (TFC) and Video-assisted FC (VAFC). Group 2 consist of 31 students and engaged with VAFC and VR-assisted FC (VRFC). As highlighted in stages for developing XR assisted teaching resources (Figure 4), VR immersive environment was combined with 3D models as well as lecture videos. Thus Group 2 has engaged with video resources as a part of VAFC and VRFC methods. Group 3 with 17 students engaged with TFC and VRFC methods. Following question were asked in the survey.

Q1: "Describe your experience of engaging with Traditional Flipped classroom (TFC) teaching method for learning this subject area, what worked best?"

Q2: "Describe your experience of engaging with Video assisted teaching methods (VAFC) for learning this subject area, what worked best?"

Q3: "Describe your experience of engaging with Virtual Environments, Virtual models and assets for learning this subject area, what worked best?"

As these questions are concern with FC methods, Group 1 responded to Q1 and Q2. Similarly, Group 2 responded to Q2 and Q3 and Group 3 to Q1 and Q3.

IV. Descriptive Feedback and Key Findings

A. Students' perception on FC models

TFC: It should be noted that FC approach was new to selected students. Several responses appreciated having access to study materials and lecture content before the introductory class. This preparation allowed them to review the material in advance, which increased concentration and made the lecture more effective. It was identified by students in the feedback that *"the TFC method encouraged questions and discussions, which helped in understanding the subject matter"*. Some respondents noted that the *"question-raising"* session after self-learning was a valuable aspect of this pedagogy. Many feedback responses indicated that TFC allows for more personalised attention from the teacher and deeper engagement with the material, especially through interactive activities and discussions. This was an encouraging experience for students as a primary objective of FC methods to facilitate student centric learning is observed through the survey feedback. However, few students highlighted that TFC required extra effort and time to study the material provided shortly before the lecture. They suggested that providing materials at least a week in advance would enhance the effectiveness of TFC. While collected survey data can be analysed statistically (limitation of the study), descriptive feedback from students indicates that TFC appeared to be more effective for those who engaged with the pre-class materials and had some prior knowledge of the topic.

VAFC: The feedback from students on video-assisted teaching methods (VAFC) was quite positive and provides several key findings and insights. Many respondents found that video-assisted methods were time-saving and made it easier to grasp the basic knowledge of the subject, particularly for theory-related content. students appreciated the flexibility of accessing video lectures at their convenience, which was a significant advantage over traditional methods. Many students iterated benefits the repetition and review feature of VAFC, commenting "*videos allowed for the review of material, providing an opportunity to rewatch and clarify doubts, which was particularly beneficial*". Capturing student feedback is indicating that video-assisted methods enhanced self-learning, improved understanding of topics, and helped in grasping difficult concepts. Respondents suggested that video-assisted teaching methods work best when used in combination with other methods, such as TFC. Some respondents mentioned that the quality of video explanations, including clear audio and visuals, could be improved. One notable feedback suggested *"incorporating opportunities for students to provide feedback and ask questions about the videos can increase engagement with the material"*. This indicates, incorporating interactive activities and assessments alongside videos could further enhance student engagement and understanding. Providing opportunities for students to ask questions and provide feedback on videos can increase engagement and comprehension. However, in this FC method, students were expected to engage with video lectures asynchronously before the scheduled classroom session. This comment indicates that students were expecting some interaction with teaching staff or peers while engaging with VAFC pre-class activities.

VRFC: Many students found that immersive virtual environment was beneficial for visualisation. It helped them understand and visualise the internal parts and structures of electrical machines, such as AC/DC machines and power transformers. It was commented that the immersive and interactive features of VRFC was beneficial, providing a 3D view that made it easier to understand the subject matter. Several respondents mentioned that VR made learning more enjoyable and creative. It allowed them to view the machines and their parts closely, enhancing the learning experience.

However, some respondents faced technical challenges, such as lag or the VR program not running smoothly, which affected their experience. A few students expressed dissatisfaction with the quality of the VR models, suggesting that they found better 3D models online. One notable comment state *"Models were not of good quality which made the experience almost useless. It was worse than 3D models of transformer I found from googling. It was even harder to understand than pictures"*. This visualisation aspect was observed while configuring virtual assets in FrameVR's immersive environment. Figure 5 illustrates visual quality of Power Transformer during stage 3 and stage 4 (Figure 3). It can be observed that model rendering with edges provides better visualisation experience for complex models such as Power Transformer.

Comparative comments from survey feedback: As students participated in FC for the first time, many comments are advocating the use of TFC over non-FC teaching models. Learning experience through in-class activities such as group discussion and informal questions provided an opportunity for interaction in the class. Many comments have highlighted that interaction element was missing in previous lecturer led, non-FC teaching methods. Some confusion in understanding key terms of the subject area was reported in the TFC method while comparing it with structured classroom lectures.

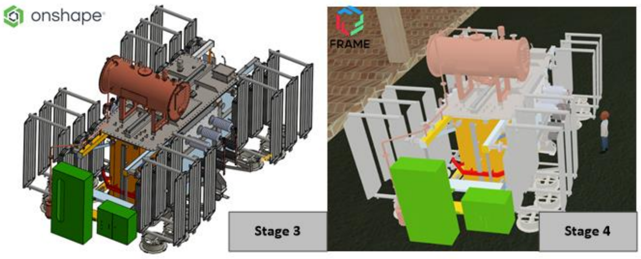

Fig. 5. Visual quality of Power Transformer during stage 3 and stage 4 of configuring and visualising 3D assests

Video-assisted teaching methods were favoured by some respondents over TFC for their clear visualization and the *"question-raising"* session after self-learning. 37.78% respondents preferred VAFC as a preference 1. The use of video lectures including VR assets helped students visualize complex components of the transformer and AC/DC machines, enhancing their understanding of the subject. Overall students' perception on VRFC is "enjoyable learning experience", as compared to non-FC and TFC. However, some comments regarded VRFC as a challenging learning method to adapt as compared to TFC. Difficulty in visualising and interacting with digital models in FrameVR's immersive environment has reiterated in the feedback. VAFC has been immerging as a most preferred method form the survey feedback. VRFC is preferred by 15.56% respondents, as compared to 26.67% TFC and 20% Non-FC (ie lecturer led delivery) as a preference 1.

B. *Operational challenges for implementing FC models*

Initial assessment of procuring VR headsets for a pilot study was deemed significant investment for KEC as scope of this study was limited to Electrical Engineering programme. VR/XR systems demand high-bandwidth internet access, which may not be accessible to all students. A typical entry level VR with equivalent of SD resolution requires a bandwidth of 100Mbps, which can demand 400Mbps infrastructure for HD video resolution [24]. This was reported as challenging scenario for students and for staff to engage and access VR pre-class resources in immersive environments. Ensuring that video, VR/XR pre-classroom activities are accessible to all students, including those in remote areas of the country or with economic hardship, is recognised as a challenge [2].

Teaching staff involved in this pilot study have expressed concerns regarding creating educational content for VR/XR, as it can be time consuming and resource intensive. Nevertheless, some staff members expressed this experience as creative, rewarding and stimulating. They advocated dedicated staff-development time for implementing such non-traditional pedagogical methods using new technologies such as VR/XR. Figure 4 illustrates multi-disciplinary skillsets are required for developing VR/XR digital assets. It was reported that such a multi-disciplinary skillset is meagre as it involves expertise from CAD, Visualisation and graphics and XR subject area. Thus, integrating VR/XR into existing curricula and new pedagogical methods can be challenging for educational entities such as KEC.

V. Conclusion

The feedback collected from students regarding the three teaching methods, Traditional Flipped Classroom (TFC), Video-Assisted Teaching Methods (VAFC), and Virtual Reality Flipped Classroom (VRFC), provides valuable insights into the students' perception of each approach. TFC method was well received by students as compared to lecturer led conventional classroom teaching methods. VR was generally perceived as an effective tool for visualizing and understanding the internal parts of electrical machines. The immersive and interactive nature of VR was appreciated, but technical issues and hardware limitations were noted as potential drawbacks. VAFC emerged as a preferred method, with many students citing advantages such as personalised pace, flexibility, and the ability to review pre-class learning resources.

The paper also outlines the process for producing teaching resources for VAFC and VRFC methods. This pilot study of implementing different FC methods at KEC can represent complexities and operational difficulties of producing these resources. This capture Teachers' perceptions on operational feasibility of these methods to implement. Thus, experience captured in this paper should be considered before implementing FC models in developing nations like Nepal, especially where privately established undergraduate education sector is striving to modernising UG programs that are inclusive and aligned with the international education practices for fostering a knowledge-based society.

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