Project OSCAR: Open-Source Animations Repository to Foster Self-Regulated Learning

Meera Iyer, Roopali Sharma, Sameer Sahasrabudhe, Anchal Garg, and Ganesh Lokhande

***Abstract*—Virtual laboratories provide scope for fostering self-regulated learning (SRL). Open Educational Resources promote SRL since they offer free access, reuse, and redistribution to teaching, learning, and research resources. Project OSCAR is an online repository of learning objects (LOs) consisting of audio-visual animations and simulations for STEM concepts. This repository provides anytime access to the learners and addresses the lack of laboratory infrastructure and resources in educational institutions. Project OSCAR hosts various types of LOs, 2D and 3D animations; different types of narratives, process explanation videos and interactive simulations; and even a set of free 3D models available for creating your own animations. The design of the LOs in Project OSCAR is based on widely accepted SRL strategies such as self-observation, self-judgment, self-evaluation etc. to present a new experience to the learners. This article explains the overall structure of the repository and the process of LO development. We deliberate on the examples of LOs where the specific SRL strategies are operationalized.**

***Index Terms*—Animations, Self-regulated learning (SRL), Instructional design document (IDD), Learning Objects (LOs), Open Educational Resources (OERs), Open-Source Repository (OSR), Virtual Laboratories**

I. Introduction

Laboratory experience contributes towards the students' learning. It provides a kind of experiential learning. The importance of building scientific knowledge through laboratory activities in science curricula is mentioned in the literature [1] [2]. Laboratory activities promote cognitive development, scientific inquiry, observational, manipulative, and problem-solving skills [3]. Apart from psychomotor skills, the laboratory learning process includes reflective thinking, mental rehearsal of steps involved in procedure, insight development through trial and error and social collaboration while experiencing a phenomenon [4].

In addition to the conventional laboratories, there is an increase in the use of Virtual laboratories since they offer overall reduction in cost, space, risk, and time [5]. The virtual laboratories have been tried as a supportive pedagogical approach and an affordable medium of laboratory instruction in academia [6] [7], since they promote Self-regulated learning (SRL) [8]. Virtual labs benefit in optimization of human resources by reduction of workload on laboratory staff, congestion of space and resource sharing issues commonly encountered in physical laboratories [9] [10]. Virtual laboratories consist of e-resources such as simulations and visualizations, some of which could ideally be Open Educational Resources (OERs). There are many established lab resources available. Top level academic institutions have developed virtual labs to provide easy access and educational support [11].

For developing countries like India with millions of learners in remote and rural areas, availability of basic laboratory apparatus for undergraduate programs and high schools is a challenge. The Government of India has also funded some initiatives, such as Virtual Laboratories (vlabs) portal for school education (SAKSHAT); or Project OSCAR, to create online interactive learning components [12] [13]. This article, focuses on Project OSCAR (Open Source Courseware Animation Repository) which has been conceptualized to provide audio-visual learning and teaching material, technical support and projects in STEM (Science, Technology, Engineering and Mathematics) subjects [13]. This web-based animation repository is easy to use, allows downloads and has content available in multilingual format. Mentors and developers use this platform to collaboratively create learning objects (LOs) to support in-class and online class curriculum. In addition to the animations and simulations, Project OSCAR develops academic projects, instructional design documents, research publications, and other resources. This article presents the structure and features of Project OSCAR in the light of the conceptual underpinnings of SRL by explaining the design strategies used in the development of the LOs.

The structure of the article is as follows: The description of OERs and their advantages in Self-Regulated Learning (SRL) are provided in the next section. The third section describes the evolution of Project OSCAR followed by the fourth section which explains the implementation of SRL strategies in Project OSCAR LOs. The fifth section talks about project outcomes in terms of deliverables such as LOs, research publications, projects, and research publications. In the final section, the relevance of OSCAR as a supplementary supportive resource in the post-pandemic scenario is discussed.

II. Open Educational Resources And Their Role In Self-Regulated Learning

OERs as the name suggests are teaching, learning and research resource/s (books, tutorials, lectures, reading material, research articles, courses, videos etc.) that can be freely used, retained, reused, revised, remixed, and redistributed [14]. Since inception, OERs have become prevalent and are playing an important role in bridging the learning divide and enhancing equity to quality education [15]. OERs

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and laboratory environments provide substantial scope for enhancement of SRL strategies for academic goal achievement [16]. SRL strategies include cognitive, metacognitive, motivational, and affective components of learning [17] [18].

The SRL theories of Zimmerman [17] and Pintrich [18] stem from Bandura's (1986) socio-cognitive theory of human functioning which assumes that people are proactive, self-determined and self-regulated [19]. Zimmerman suggests the following SRL sub processes:

- Self-observation of one's activities,
- Self-judgment of one's performance and
- Self-evaluation by understanding the feedback of the performance [5] [19]

While Pintrich (2004) elaborates the SRL strategies based on three categories [18]

- Cognitive: Rehearsal, Elaboration, Organization, and Critical thinking
- Metacognitive: Goal Setting, planning, self- monitoring, and self-evaluation
- Resource Management: Time and Environment planning, help seeking, collaborative learning, and regulation of effort.

The self-regulated learners are motivated individuals who plan, set and engage in strategies to pursue their goals by effective time management and seeking support when needed [18]. They are active agents in their own learning process as they use metacognition, evaluation and reflection, to monitor their growth towards goal achievement [19]. OERs offer the optimum self-paced learning environment at any time and place which is essential for self-regulated learners. A key requisite for sustained SRL is motivation [18]. It is found that despite organizations that create OERs try to motivate learners by delivering quality content, there exist some limitations. Many of the available OERs are monolithic, non-engaging [20], or may not share the source codes to be further redistributed. Project OSCAR has been planned to overcome these drawbacks and incorporate the advantages of OERs to foster SRL strategies.

III. Evolution And Structure Of Project OSCAR

Project OSCAR was conceptualized and started at IIT Bombay in 2008 and supported by the Ministry of Human Resource Development, Government of India (Fig.1). This is an Open-Source Repository that provides free access to the source code of the animations that can be easily reused and modified by the users. This online, interactive, and animated open-source repository aims to teach STEM concepts from basic to advanced level. It also has an auxiliary purpose to make the repository self-sustaining by training learners to develop these STEM based animations and simulations, collectively termed as Learning Objects (LOs), to manage the repository and also to promote educational research. A LO refers to a digital educational resource pertaining to a single STEM concept [23]. OSCAR is designed to address the paucity of effective courseware available in small units which can supplement a teacher's curriculum.

OSCAR LOs have been made using various interactive technologies such as JAVA, Flash and Blender to be incorporated in classroom and online teaching. The LOs are engaging, interactive, and are available in multiple Indian languages and are free for viewing and downloading. Large scale dissemination of OSCAR was made possible as it was released under the creative commons India 2.5 license. It currently hosts over 450 LOs contributed by OSCAR volunteers and from other sources [13]. The data reveals that these LOs have been downloaded by thousands of users.

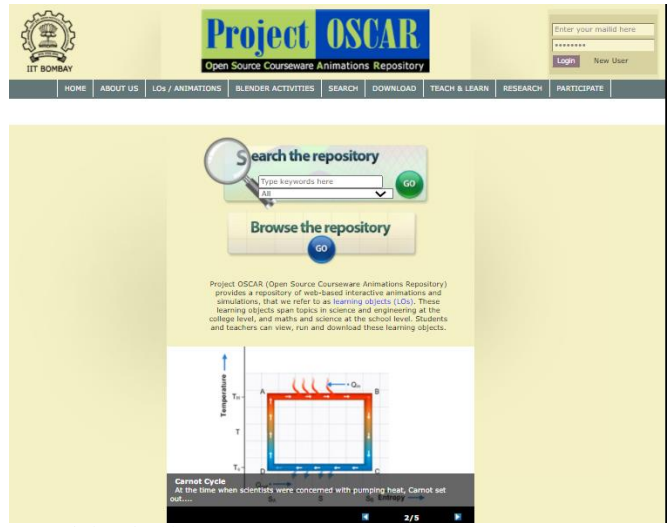


Fig. 1. Website of Project OSCAR.

A. Structure Of Learning Objects (LOs) In Project OSCAR

Each LO in Project OSCAR has six primary components (Fig. 2):

a) The learning objectives that describe what learners will be able to do after completing the LO.
b) A brief description of the concept being explained.
c) A learning activity where the user can engage by specifying and changing parameters to see the outcome.
d) Self- assessment, in the form of a quiz, where a user can self-evaluate his understanding after viewing the LO.
e) References for further reading.
f) Access to download the animation for further use.

Each LO is a stand-alone resource of two to fifteen minutes duration for the ease of cognitive assimilation. The key feature of LOs is its user-friendly intuitive interface that accommodates different learning style, preference, purpose, and pace. Also, it has a voiceover to better explain the concept [13].

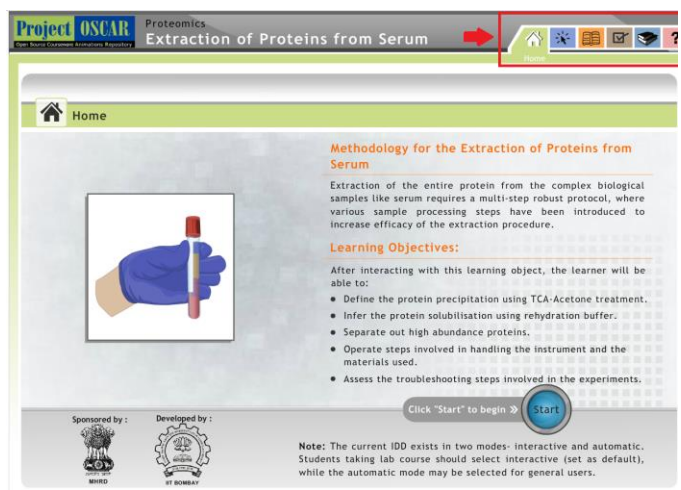


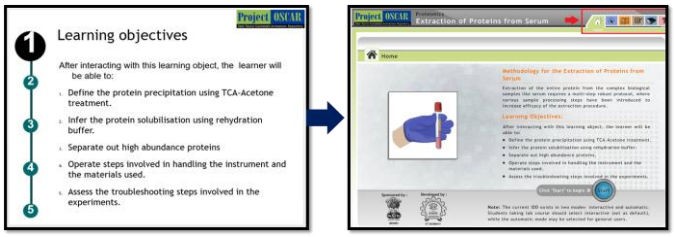
Fig. 2. Structure of a Learning Object.

B. Process Of Creation

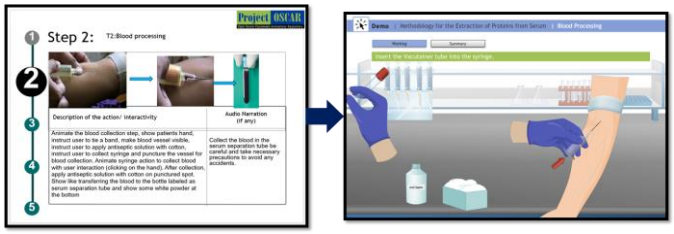
In Project OSCAR, a three-phase process is followed for creation of each LO.

Concept Specification Phase: In this phase, selection and detailing of concepts is done by a mentor who may be a teacher, course instructor or subject matter expert (SME). The mentors interact through the

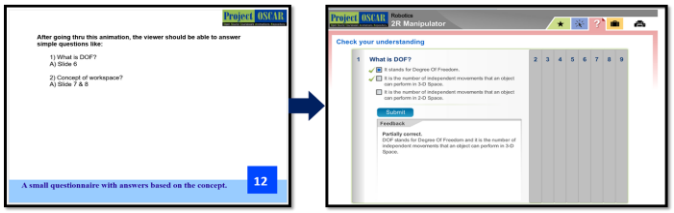
portal with developers or animators. The creation of Instruction Design Document (IDD) for the concept is conducted. IDD details the description of learning objective, the sequence and detail of content, and, the details of self-assessment test with answer key. A storyboard is thus made ready for the animator based on IDD. In the first example, the IDD is shown for creating the LO 'Extraction of Proteins from Serum' and shows the learning objectives slide from the IDD and its corresponding final output animation (Fig 3a). In the second example, the IDD details the instructions and the script for creating the animation and its corresponding final output animation (Fig 3b). Similarly, in the third example, the IDD is shown for creating the LO '2R Manipulator in Robotics' and the corresponding final output of a quiz (Fig 3c).



(a) Example of Learning Objectives in an IDD converted to LO.



(b) Example of Animation Script converted to LO.



(c) Example to Questions in IDD converted to Quiz in LO.

Fig.3. Examples of Development of IDD to LO.

LO Creation Phase: The developer uses the IDD and applet design for coding the LO. They also create animations using various tools.
Testing Phase: The animation is then tested for its accuracy in coding and for content which is then uploaded into the repository upon approval.

IV. Implementation Of SRL Strategies In Project OSCAR LOs

Project OSCAR LOs have been designed to encourage SRL. Each LO helps the learner to observe the process, interact with it and evaluate his/her learning performance based on the feedback, thus helping in the SRL process [17] [21]. Most of the SRL principles are operationalized in OSCAR LOs. In this section, we elaborate the operationalization of some SRL principles by selecting corresponding examples from project OSCAR.

A. Mental Rehearsal

The Extraction of Proteins from Serum is a complex procedure where learners need to observe all the steps carefully (Fig 4). A self-regulated learner activates his/her working memory and stores information to replicate the same, later in the actual lab settings. The LO helps in memorizing the process and it can be run, stopped, and re-winded as many times as the learner wishes. Repetition of the learning material aids in mental rehearsal [18].

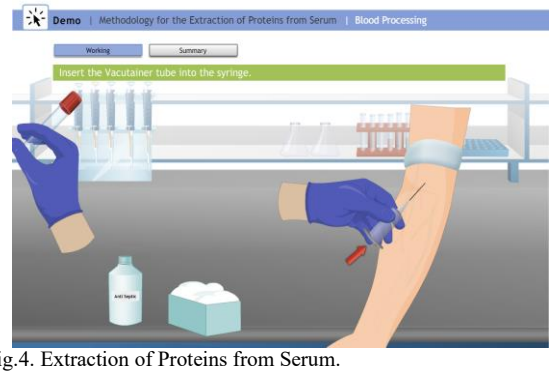


Fig.4. Extraction of Proteins from Serum.

B. Elaboration

The internal tertiary Structure of a Protein myoglobin shows the folded α-helix structure that is embedded inside the chains of the myoglobin (Fig 5). Such visualization of the protein structure is otherwise not possible with naked eye. This is another example of learning through observation. This LO aids in abstract thinking through visualization. The abstract concept is converted into visually concrete images thus promoting comprehension. As mentioned in the Elaboration principle, the learner thus can assimilate the new information with his prior knowledge by paraphrasing, summarizing, and general note taking of the same [21].

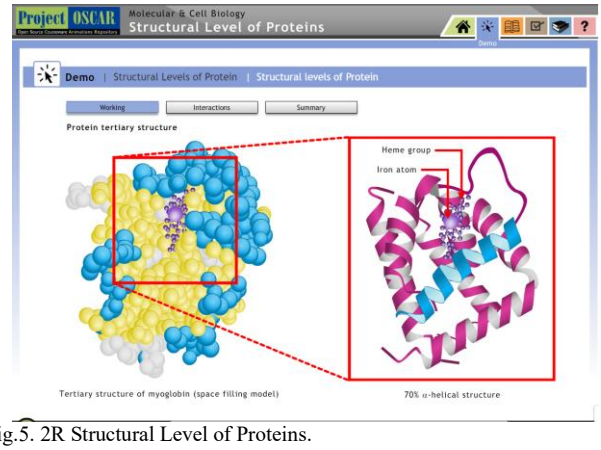


Fig.5. 2R Structural Level of Proteins.

C. Critical Thinking

The animation (Fig. 6) further aids the self-regulated learner to perform the steps and judge their understanding of the concept. It exhibits the working of a 2R manipulator from a Robotics course. One can indicate the parameters and drag the manipulator within the workspace and observe the ways in which the legs would position to satisfy the end point constraints [13]. The learner uses his critical thinking through objective analysis and manipulation of parameters [22]. Based on the results of output parameters, the learner forms a judgement regarding the appropriate input parameters to attain the desired result.

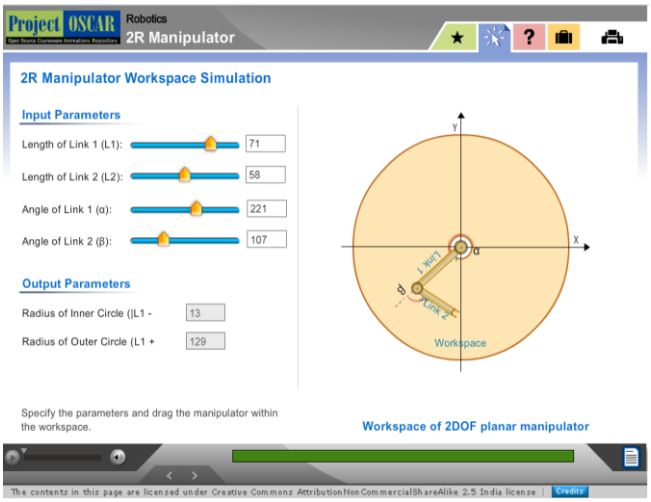


Fig.6. 2R Manipulator.

D. Organization

The LO showing working of a steam turbine-based power plant (Fig 7), demonstrates the flow of steam from the steam generator to the steam turbine that forces the high-pressure rotor to rotate and then flow into the condenser. This LO helps in organizational thinking by cognitively connecting different aspects of the content, thus developing a holistic perspective about the learnt concept [18].

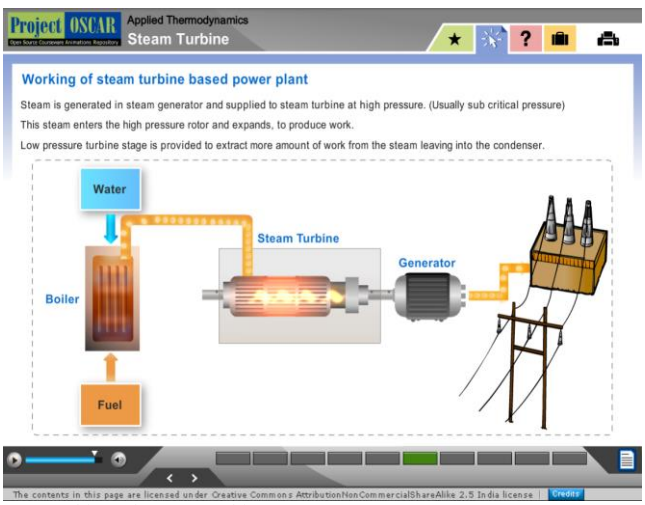


Fig. 7. Working of Steam Turbine.

E. Metacognitive Strategies: Planning, Self-Monitoring, And Evaluation.

Metacognition is awareness and control of one's cognition [23]. A learner sets a goal such as choosing a specific subject. OSCAR LOs have a quiz where the learner can evaluate his/her performance and get feedback on his/her answers (Fig. 8). Through the process of feedback from the quizzes, the self-regulated learner evaluates monitors and restructures further course of action to enhance conceptual understanding further. Thus, the Project OSCAR supports SRL through self-evaluation of one's learning[24]. Each LO in OSCAR facilitates a learner to engage in metacognitive learning strategies.

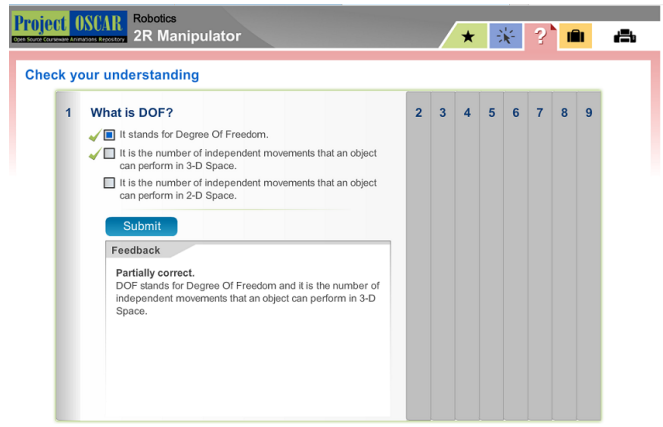


Fig. 8. Quiz supported by feedback.

F. Resource Management: Time And Effort Regulation, Collaborative Learning, And Seeking Assistance

The LOs help learners to plan and control their learning environment by providing the scope to learn at the pace, time and place, convenient to the learners. A learner can regulate his efforts based on his learning style as the LOs contain both text based as well as audio-visual based resources. Project OSCAR facilitates collaborative learning and seeking help from other learners working on the same project as well as from Mentors [18].

Apart from these LOs, the project OSCAR has produced several artifacts that are useful for both the learners and instructors. All the SRL processes are exhibited in the LOs created in Project OSCAR. There are some LOs that cover many SRL strategies simultaneously whereas there are some that may address some specific SRL strategies. In short, all the LOs of Project OSCAR are based on well - researched SRL strategies.

V. Outcomes

In addition to the LOs, initiatives undertaken during the development and implementation of the Project OSCAR have been generating several other tangible outcomes. There are 3D Models, IDDs, undergraduate and postgraduate projects as well as research publications [13]. We will elaborate each of the outcomes in this section.

1) LOs/Animations

Project OSCAR has developed a repository of 457 LOs to support teaching and learning of diverse concepts of mathematics, science, and engineering (Table I). LOs support the teachers and students at both the school level and higher education level. To support teaching learning at the undergraduate and postgraduate level, LOs have been created for diverse Engineering disciplines such as Biochemistry, Bioscience & Engineering in addition to traditional disciplines such as: Chemical Engineering, Civil Engineering, Computer Science, Mechanical Engineering, Metallurgical Engineering, etc. Likewise, LOs have also been constructed for differing areas of basic sciences such as Physics, Chemistry and Biology. The highest number of 81 animations has been created for Biochemistry.

Further, to assist school education, few LOs have been made for science and mathematics courses. High school level STEM concepts are gamified for learner engagement and motivation. In addition to this, LOs in regional languages have been designed for learning and teaching concepts of Math and Science.

TABLE I
NUMBER OF LOS BASED ON DISCIPLINE

Level	Category	Number of available animations/LOs	Download Statistics
UG/PG	Engineering	150	23777

	(Chemical, Civil, Computer Science, Electrical, Electronics, Mechanical, Metallurgical)		
	Basic Sciences (Biology, Physics and Chemistry)	61	3237
	Applied Sciences (Biochemistry, Bioscience, Earth Science, Environmental Science)	109	3307
School	Science and Maths	117	15926
Total		437	46247

A sample LO representing 2D-DIGE Gel Scanning is shown in Fig 9.

Fig. 9. LO - 2D-DIGE Gel Scanning.

2) 3D Models

Free eLearning software that can create 3D animations are sparse and thus BLENDER, an open-source 3D animation suite was used to create animations and simulations. BLENDER supports modelling, rigging, compositing and motion tracking along with editing video content and 2D animations. It is easy to use and its plugins allow the projects to be rendered by any web browser [13].

The project has also been producing an open repository of three dimensional (3D) models created using Blender (Fig 10). These models are equipment from Physics and Chemistry Laboratories that can be downloaded to make animations.

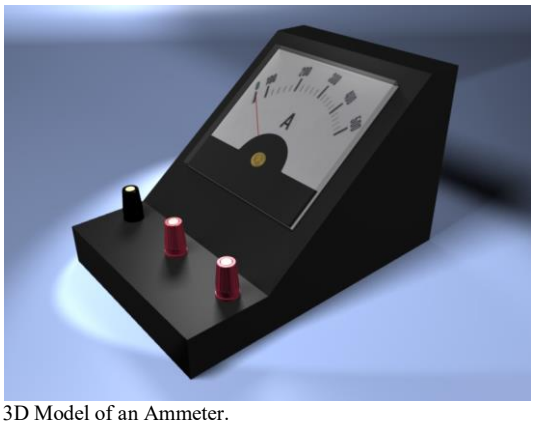


Fig. 10. 3D Model of an Ammeter.

3) Instructional Design Documents (IDDs)

IDDs are documents that detail a systematic procedure of converting a standalone concept into an animation using instructional design principles. This document enables an animator to easily create animations[25]. A total of 187 IDDs have been produced as a part of project OSCAR. These IDDs act as an interface between the Instructional Designer and the Animator and thus aids in creation of LOs. The details on the process to be followed for generating IDD is very well documented and published [26].

4) UG/PG Projects Based On BLENDER

Project OSCAR also includes projects made by UG and PG students based on Blender. These projects are created by students from Engineering domain, who wish to use 3D animation to explain concepts. Some of the student projects include a 3D Ammonia Fountain laboratory experiment for better understanding of the experiment, a 3D interactive content creator for dissemination of educational content, a 3D interactive interface for creating eLearning animations, an interactive learning environment using gesture recognition, interactive circuits using augmented reality, an eLearning application called 3D Netra for enabling school students to learn the concepts of human eye, etc. [13]

5) Research Publications

Research papers are published based on the experience during the Project OSCAR [13]. These research papers provide a roadmap to other researchers interested in implementing similar proposals.

There are several other outcomes of the Project OSCAR such as the trained teachers and students and communities of practice. Also, more artefacts (LOs, 3D models, IDDs etc.) are regularly being developed and added to the OSCAR repository.

The effectiveness of the OSCAR LOs in enhancing self-regulation among the users will be addressed in the upcoming research. As the collected data is insufficient to conduct quantitative data analysis and draw any conclusive inferences, it is considered inappropriate to mention it in this paper.

Researchers who have worked on the OSCAR project have demonstrated its usability and published widely about it. We list some of these papers to highlight the various facets described in these publications.

(i) Usability and effectiveness [25, 27]: Iyer et al. have shown the usability and effectiveness of OSCAR LOs through statistical data about the downloads recorded on the repository. The economic, user friendly and wide accessibility features of Blender for creation of eLearning 3D animations were demonstrated through a case study in the domain of Chemical Engineering.

(ii) Developmental methodology for 3D model creation [28]: The developmental methodology for creating 3D simulations for lab experiments lists the three stages, namely, Modeling, Animation and Adding Interactivity. The paper also provides a path for others to create their own model repository by describing the process of creating 3D models using Open-Source software, BLENDER.

(iii) Cost and time effective LO production through DOM [29]: The domain owner model (DOM) for rapid and large-scale development of LOs, is compared with other asynchronous models, namely, online distributed model, individual faculty model and fully outsourced model. LOs created through this model proved most effective in terms of cost, time, and quality with a mean production time for each LO of 0.375 months.

(iv) ELAM (E-Learning Acceptance Model) [30]: A conceptual framework, ELAM identifies the factors required for acceptance of e-learning by students and teachers. This was done by observing the behavioral intention and actual use of the e-learning technology.

VI. Future Implications Of Project OSCAR

Recently, Flash has been retracted by Adobe, efforts are being made to build animations HTML 5 compliant.

During the pandemic, classes in both schools and colleges are being conducted online in most part of the world. The teachers and course instructors are relying largely on available online material that

is free of cost and of good quality to supplement their classes. The instructors can bank on the advantages that OSCAR offers, especially in the post pandemic situation, where various efforts are being made to strengthen teaching-learning processes. Animations and simulations have become the need of the hour to explain complex concepts to learners as practical and demonstrations in laboratories and in-class teaching remain suspended. Many audit and credit courses are being floated by universities such as MIT, Harvard etc. [31] which are freely available or charge minimal for certificates. However, there remains a deficit of free open courseware that have concepts in a stand-alone manner and which can be used in both online live classes as well as in classroom teaching. Project OSCAR is a promising handy pedagogical web based OER that can easily work on mobile devices, laptops and other devices and can be integrated with existing teaching resources for an enriched learning experience.

The National Education Policy (NEP 2020) released by the Government of India focuses on a student-centric interdisciplinary education. The learner will now be able to take up subjects of his own will in multiple streams, and not restricted to a particular discipline. The LOs of Project OSCAR can prove useful in such a scenario. This policy has furthered the need for self-regulated learning and self-motivation to develop competence and skill in subjects of interest. For example, a student choosing a social science subject and a STEM subject like Physics to pursue in high school will require developing projects that address both domains simultaneously. Project OSCAR holds a futuristic scope of providing a platform to design such projects in the form of LOs.

Further, the implementation of NEP will be challenging to schools and colleges as catering to individualized education programs would require more resources, infrastructure, and teachers. Here again, Project OSCAR can aid in catering to the deficit by helping the learner to access knowledge to gain conceptual understanding in small units. A proposal to make OSCAR a part of NEP and Atal tinkering Labs by assigning singular projects to developers and students to create LOs and 3D models will aid in enriching the existing repository. The educational institutions may collaborate to create LOs and 3D models in different Indian languages. Thus, the focus would be on knowledge acquisition instead of language comprehension to understand STEM concepts.

OSCAR is a supportive and integrative pedagogical tool. The promotion and integration of Project OSCAR in existing MOOCs will be an added advantage as it will make the courseware more engaging and motivating to learners. The development of LOs and 3D models in foreign languages will be helpful to international students. Course instructors and teachers can enrich their lectures and online classes by embedding small LOs from OSCAR. Promoting the LOs in remote areas with lack of adequate infrastructures to support can prove useful to many students. If promoted well, it has the potential to be a supportive mechanism to cultivate self-regulated learning among learners and instructors.

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