Blockchain Assisted Gamified Learning and Augmented Reality Driven NextGen e-Learning Ecosystem for STEM Education

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Abstract. : The high pace rise in e-Learning demands has revitalized academia-industries to achieve scalable EdTech solution. Despite numerous digital solutions, the complex nature of science, technologies, engineering, and mathematics $STEM$ education makes most of the state-of-art method limited. STEM education requires e-Learning model to be more interactive, socializing, engaging and cognitive to inculcate self-realization. Gamified learning and augmented reality techniques serves as an e-Learning mechanism; however, there is no potential framework employing these approaches to fulfill STEM learning demands. Considering it as motivation, in this paper a robust Blockchain Assisted Gamified Learning and Augmented Reality Driven NextGen Ecosystem for STEM e-Learning is proposed. The key components of the proposed conceptual e-Learning framework are the blockchain smart contract, decentralized data storage, subject-specific content READ $read, edit, add, delete$ functions, personalized display, Quick Check, Prompt Check, Reality Corner, etc. Considering the need of the secure decentralized e-Learning framework the proposed framework employs blockchain smart-contract provision that enables seamless multi-party data access and computation. Distributed data storage is proposed to provide decentralized access to the students and teachers to improve system scalability and availability. Virtual Reality section provides content adaptive augmented reality solutions, demonstration etc., which can be contributed by both teachers as well as students. The conceptualized model is designed in such way that it motivates STEM students to engage more, socialize and enjoy the platform to yield superior outcomes. It can improve their self-realization, cognitive behave, problem solving ability and consistent amongst the students. Moreover, it can be vital for teachers as well as it can make overall teaching more flexible and productive.

Keywords: STEM Education, e-Learning, Augmented Reality, Gamified Learning.

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1 Introduction

The high pace rise in global population and allied competitive demands have alarmed and/or revitalized industries to innovate and achieve optimal solutions to meet the fundamental as well as human-centric solutions. On the contrary, rising population and limited resources have stressed contemporary educational system, thus demanding a decentralized, scalable and adaptive-to-all approach for STEM education [12]. To cope up with such high demands, academia-industries have been exploiting different digital media including EdTech solutions for scalable educational deliveries. Yet, fulfilling expectations and synchronizing STEM educational demands have remained a challenge.

To improve educational deliveries and allied performance numerous EdTech solutions have been proposed for STEM learning [13]. However, the need to integrate different learning paradigms, content types and interactive problem solving has been realized [13]. The scalability of such e-Learning solutions has increased many folds with the availability of smart-phones and affordable computers and laptop by tech-oriented young-generations who are inclined towards technologies-based learning [13]. In sync with such behavioral transition, the use of e-Learning and varied EdTech solutions emerged are gamified learning, virtual reality, and augmented reality have gained widespread attention. These EdTech approaches provide better illustrative learning ecosystem with interactive problem solving, personalized simulations and decentralized access that resembles a real-world teaching paradigm with higher flexibility and accessibility [6].

Most of the existing literatures merely hypothesize standalone suggestion to improve e-Learning; however, there exists very limited efforts where the authors could contribute a complete (say, end-to-end) conceptual model for e-Learning (for STEM education). In such case, the method suggested for one problem is not in sync with other problem and allied viable solution. Though, gamified learning and augmented reality can be effective to meet personalized objective(s); yet, amalgamating them together to achieve optimal performance requires conceptualizing the solution optimistically. Even EdTech firms require introducing a robust solution which could fulfill overall aspects and need of STEM learning with optimal performance. Unfortunately, there exist no such solution which could address aforesaid demands to yield a robust augmented reality driven gamified learning environment for STEM education. It can be considered as the key driving force behind this study.

In this paper, a first of its kinds augmented reality driven gamified learning environment is proposed (conceptualized) for STEM education. The proposed conceptual model encompasses almost major aspects of a decentralized e-Learning platform with secure (autonomous) multi-party access control mechanism, blockchain (smart-contract) driven user-specific data access and presentation model, user-interactive navigation system, optimal virtual reality or augmented reality platform for subject specific simulation, demonstration, personalized simulation and assessment etc. In addition, the proposed model addresses additional sections for subject-specific supplementary content links, solved solutions, contributed problems and allied solutions, query sections, response section, reward sections, display setting menu, group-study section with reward option, innovative reward mechanism, etc. Summarily, the overall conceptual model provides strategic solution for almost all problems and expectations that augmented reality driven gamified learning environment for STEM education demands under decentralized operating ecosystems. This paper is prepared in such manner that it can be employed as a framework for industrial development and manual to design or re-design STEM-oriented e-Learning model.

The other sections of this manuscript are divided as follows. Section 2 discusses the background and related works, while Section 3 presents the proposed conceptual model. Section 4 presents conclusion and inferences, while the references used are given at the end of the manuscript.

2 BACKGROUND

This section primarily discusses the fundamental of different state-of-art EdTech solutions and their hypothesized efficacy towards STEM learning. As discussed in the previous section, gamified learning and augmented reality retain potential to serve STEM education in more effective manner; provided the contents are curated (and presented) optimally. In sync with this, this section briefs the fundamental of the gamified learning methods and augmented reality towards STEM learning.

2.1 Gamified Learning

Gamified learning can be defined as a paradigm employing interactive task-based learning encompassing proactive reward facilities, group-based learning, feedback-driven interaction etc. [15]. Literatures infer that the collaborative access, reward-based motivation, multiple-levels driven learning environment etc. make gamified learning a robust and viable approach for effective e-learning. These functional efficacy and engagements can be vital towards science education [15]. In gamified learning approach, each problem can be designed as a game, where students try to give answer for the said problem and this cycle goes on for large set of questions, subjective contents, problems etc. Though, this mechanism can have teachers as well, as a player. The ability to accommodate "learn-while-playing" makes gamified learning more efficient to inculcate cognitive learning behave amongst STEM students [3]. The use of gamified learning has been found vital for teachers as well, where it is hypothesized to have higher engagement and reduced one-to-one teaching stress [5]. Here, the use of "educating while entertaining" concept was also suggested to be considered in NextGen EdTech development.

2.2 Augmented Reality

Augmented reality provides user to interact with the real world by applying multi-media features such as text, image, sound, video, animation, hologram and other two-dimensional features [16]. Its ability to provide intrinsic motivational goals makes it more viable towards educational purposes [11]; however, it requires designing the approach optimally to cope up with the pedagogical competencies for educators. The authors hypothesized that the students are usually cognitively-overloaded and therefore can be challenging for teachers to manage content and presentation. The augmented reality tools can provide an environment for elementary students to prepare snippet of tasks done, storytelling, and mini-games to simulate game-based learning [2, 9]. On the other hand, the use of augmented reality in the form of multimedia learning content can make STEM learning more effective [7]. It can also encourage students to have higher group interactivity and cognitive decision-making abilities [18]. The majority of the vital studies have revealed that despite robustness and efficacy the sufficiency and suitability of e-contents and use-cases must be designed optimistically to make aforesaid platforms more scalable [1, 8].

2.3 e-Content Optimization and Conceptualization

Same as the augmented reality-based e-Learning solutions, gamified learning methods too can be effective towards STEM education [8]. [14] backed up stating that the strategic combination of augmented reality and gamified learning can make boring context-based (classroom) learning into more interactive, autonomous and self-driven learning ecosystem [17]. Such e-Learning methods can improve deep learning ability and higher-order thinking [4]. The depth assessment of the literatures has revealed that the augmented reality assisted gamified learning model can be designed with the different open simulators, personalized display setting, navigation control, cross-platform sharing etc. to engage STEM students with better learning cognitive. On the other hand, virtual reality content and presentation should be optimized in such manner that it could be well-suited for science experiments, self-assessment, practices and self-driven cognitive realization. It should also be designed in sync with the real-world science laboratory and experimentation demands, for which 3D models can play vital role. The content should also be synchronized to make it adaptive to both students as well as teachers. In sync with augmented reality driven gamified learning approach, improving both social-interaction, experience as well as knowledge creation is vital [10]. Providing a personalized platform with where the students could make use of different avatars, simulations, solutions (to certain problems), interactive tools or controller etc. to perform cognitive decision and learning, can bring scalability. Moreover, the strategic use of gamified learning and augmented reality can enable students participate in the different learning activities and social interactions where each game is expected to be designed to address a specific problem for which learning has to be provided. It cannot only improve engagement but also their cognitive abilities, problem solving capacity and socialization. To be noted, every student has a definite cognitive load, and hence increasing undesired intrinsic and extraneous cognitive load might suppress their ability to perceive and hence can reduce learning productivity [19]. Furthermore, additional complexity or extraneous cognitive load can reduce their performance and affinity towards learning [10]. Hence, designing content, perceptibility sensitive content-flow, and interactive problem solving are must for e-Learning solutions, especially STEM education. Thus, these key features can be considered as the driving forces to design or conceptualize a robust e-Learning solution for STEM education.

3 CONCEPTUAL MODEL

This section primarily discusses the proposed STEM-oriented Blockchain Assisted Gamified Learning and Augmented Reality Driven e-Learning model and the implementation details.

In sync with the STEM-centric e-Learning demands, the proposed conceptual model considers the following key motives:

1. Blockchain Smart Contract driven Multi-party Authentication and Authorization.
2. Smart-Contract driven User Specific READ functions and Content Synchronization.
3. Personalized Content Display with Customizable Memorization.
4. Content of Interest Specific Virtual Reality (Augment Reality) Solution.
5. Content of Interest Specific Quick Check Window.
6. User Specific Prompt Check Window, and
7. Advanced GUI Setting and Interface for Personalization and Sharing.

The overall designed components, as stated above provide a robust solution with multiple functionalities that eventually can not only help in improving engagement, socialization but would also intend to inculcate self-realization, autonomous practices, feedback-based learning and group learning. This as a result can greatly improve the overall performance of the system. The details of these key components and corresponding implementation are discussed in the subsequent sections.

3.1 Blockchain Smart Contract driven Multi-party Authentication and Authorization (Gateway)

This is the matter of fact that the majority of the existing e-Learning solutions are designed either for individual learning or are applied for classroom-based learning. Such limited uses make these tools non-scalable and undeniably the challenges like security and content availability are the key constraining factors behind limited efficacy. On the contrary, to cope up with scalable e-Learning demands where a large number of students, teachers etc. could be connected together for effective learning guaranteeing scalability is inevitable. To achieve such scalability, distributed computing with interoperability features can be of paramount significance. Interoperability on the other hand can help multiple users with distinct READ functions performing their respective tasks flawlessly in seamless manner. On the other hand, ensuring scalability of the e-Learning solution requires 24/7 content availability in decentralized manner. In the existing state-of-art approaches the solution applies individual components for user verification and data storage that eventually increases computational complexity. Moreover, these approaches don't address the challenge of ransomware, single point attack etc. that can not only hinder overall functions but can also raise data security challenges. To alleviate such problems, the use of Blockchain Smart Contract can play decisive role.

Blockchain is a highly robust encryption modality that preserves data in the form of certain encrypted blocks without saving key credentials. This as a result avoids attack probability and hence makes entire data and ownership anonymous. It improves overall data security feature of the system, and hence reserves efficacy or potential to be used for at hand decentralized e-Learning framework. Considering this feature, in the proposed STEM-oriented e-Learning framework, blockchain driven multi-party authentication and validation is proposed. Noticeably, in blockchain ecosystem, smart contract refers a small chunk of autonomously-functional computer program that comes into existence automatically when the predefined conditions are met.

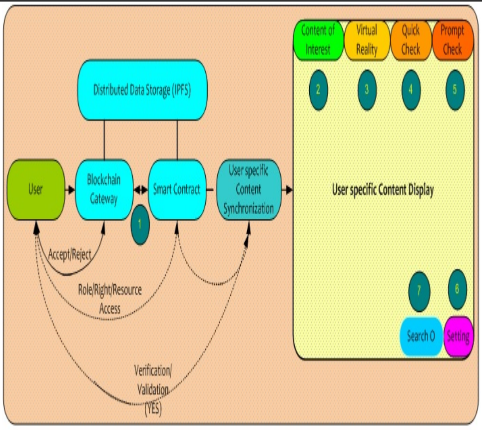

Figure 1: High level presentation of the proposed e-Learning platform

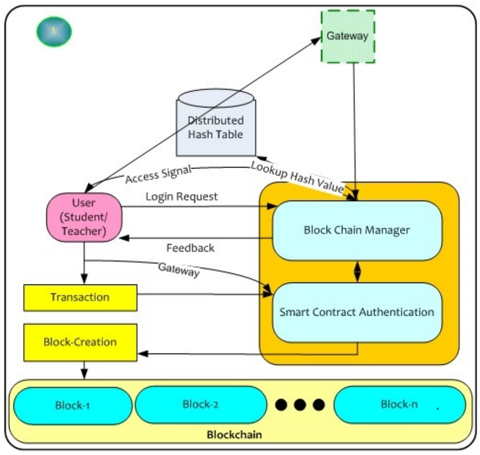

Figure 2: Blockchain Smart Contract Driven e-Learning Gateway and Distributed Data Storage

Unlike classical encryption methods, the smart contract functions in blockchain provide user's specific role, rights and resource access details as well and therefore make overall process more time-efficient and flexible. In our proposed STEM centric e-Learning frameworks figure 1, where there can be the teachers, students and management as the different users with the different roles, rights, and resource access criteria, the use of smart contract seems to be a viable approach. Smart contract can be designed in such manner that in addition to the user's validation and verifications, it could perform synchronization of the entire data and activities for the verified user figure 1. In other words, once a user makes request to the blockchain gateway or e-Learning gateway, the credentials or allied requests are passed to the smart contract, where the smart contract validation model figure 1 and 2 can execute smart contract verifier to validate the user. With affirmative verification results, the smart contract can instruct blockchain manager (BCM) to fetch the user specific data from the decentralized data storage (Ex. Inter-planetary File systems (IPFS) or cloud storage) for future (user-specific tasks).

In majority of the small scale blockchain applications to save resources, firms apply on-chain embedding concept where the data blocks and hash information are stored over the chain itself. This approach can be highly vulnerable for single point of failure attack and can make overall process very complex and exhaustive. To alleviate such problem, in the proposed model, distributed file systems such as IPFS is proposed where the data can be stored and can be retrieved from anywhere. It can improve the availability and scalability of the solution.

Functionally, once receiving the user's access request and verifying the access information, blockchain manager (i.e., BCM) passes the information to the smart contract that validates user's details along with roles and access rights figure 1 and 2. To make proposed model cost-effective and scalable we suggest to use blockchain frameworks like Ethereum, where smart contract acts as a specific account, encompassing data and code with the different users possessing multiple programmable functions. In the proposed model, the registered and valid users can make use of their corresponding Ethereum account to communicate with the smart contracts by applying BCM that can also be called as an application binary interface (ABI). Thus, employing BCM, the functions defined for each task can be triggered by the registered user. In other words, each registered user (i.e., student, teacher and management) can trigger the functions deployed or programmed in smart contracts by passing transaction request. Though, the access level and tasks are validated by smart contract itself. Thus, it limits the access right and tasks for each user and hence retains blockchain data immutable. In this manner, the proposed model enables registered users to deploy their tasks such as data access request, transaction request or access management job. In reference to the Ethereum framework, Ethereum transaction refers the process of transferring ether, which is also called as Ethereum native token. In other words, it states the transfer of data in the form of ether from one account to another. The overall process of user verification and validation using smart contract is depicted in figure 2.

3.2 Smart-Contract driven User Specific READ functions and Content Synchronization

Once verifying the user and validating it for the different roles, rights and resource accesses, the smart contract executes transactions and the e-Learning content details along with user profile details are fetched from the distributed data storage for display (2) figure 1 and 2. The transaction enables the display of the user specific content display (i.e., the only data or activity related to the specific verified user) with user profile details, activity chart, content-of-interest (2), Virtual Reality window (3), Quick Check (4), Prompt Check (5), Setting and personalization (6), etc. The (user-specific) content display layout is depicted in figure 3to 10. The additional benefit of smart contract function or program is that it synchronizes complete data for the requesting user and therefore guarantees privacy preserving nature to ensure seamless data access and transactions. This as a result can inculcate the sense of security amongst the users and hence would motivate users to engage the platform greatly. Summarily, once validating the user, it serves (verified) user only those contents which are belonging to the requesting user. Moreover, the use of smart contract can help constraining READ functions (i.e., Read, Edit, Add, and Delete) and permissions to the user and hence the data privacy preserving can be accomplished.

3.3 Personalized Content Display with Memorization

This component primarily focuses on user specific content display while incorporating diverse measures including gamified learning (5) and virtual reality or augmented reality solutions (3). Once a user gets verified for its role, rights and resources, smart contract routes it to the content display section where the user can see its related contents such as content-of-interest, content specific supplementary links or references, content or problem specific demonstrations, augmented reality driven simulations and illustration, solved solutions, personalized memorization etc. This section provides a complete user interface pertaining to the data display, content personalization, interface control and setting, offers and participation, reward corners etc. Once a user enters to this section, multiple windows or tabs are visible, where each tab provides different data or content.
A. Content List,
B. Augmented Reality or Virtual Reality (VR),
C. Quick Check,

D. Prompt Check, and
E. Setting.

The functional detail of these key components is given in the subsequent sections.

A. Content List

Here, content list (2) provides list of subject specific details, list of sub-topics, supplementary links etc. The layout of the proposed content list model is depicted in figure 3. The content is supposed to be designed in such manner that it provides proper hierarchical content-adaptive navigation. In other words, the main content (say, topic) can have multiple subtopics with abstracted presentation, where the user (student or teacher) can select the content of its interest without undergoing multiple different pages. It not only reduces clutter but also retains engagement over same window for longer period, and hence can be effective to inculcate engagement to make learning effective. The display window can have the multiple sections including "Topic lists" (2), "Content Display" (2), "Virtual Reality (VR) tab" (3), "Quick Check" (4), "Prompt Check" (5), "Setting" (6) and Search (7).

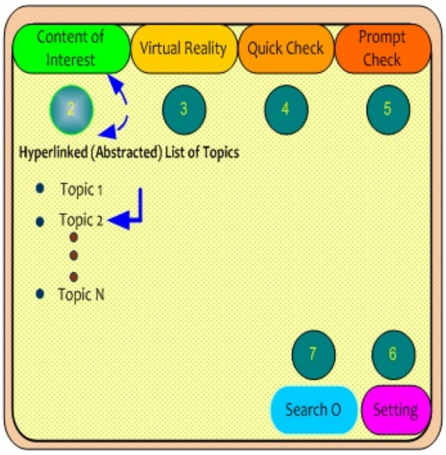

Figure 3: Abstracted view for Content-of-Interest

To make clutter free content presentation with minimum navigational efforts or clutter, the display can be designed in such manner that when "Topic Lists" and "Content Display" are active (i.e., open), the other tabs like Virtual Reality" (3), "Quick Check" (4), "Prompt Check" (5) and "Settings" (6) remains closed or abstracted. Though, the bottom of the display can have a well-designed and catchy Floating Push Button for raising a request, pertaining to the current content window and allied subjective matter. It can make learning interactive with teachers and students. Here, "Raise Query" (Floating) button can navigate a small comment window where the user or student can raise a query, feedback or problem pertaining to the specific content-of-interest (in that open content window). This request can be passed as the feedback window or query to the teacher(s), and therefore can act as a feedback system to make one-to-one interaction between student and teacher. It would not only motivate students, but will help teachers engaging students and solving their problem so as to increase productivity. There can be a small icon or button providing notifications to the user for related offers or rewards. When clicking on that icon, it can navigate to a page where the different socio as well as educational offers can be provided to improve engagement and inculcate gamified learning approach.

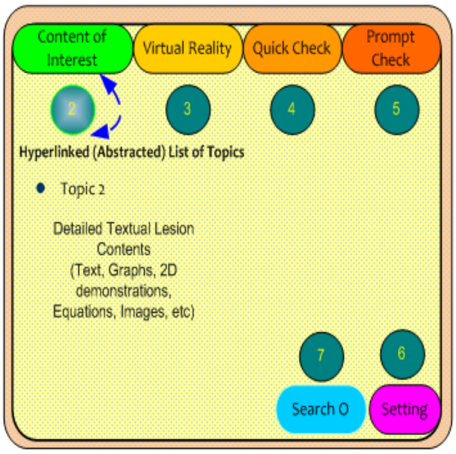

Figure 4: Detailed view for Content-of-Interestr

3.4 Virtual Reality (VR) or Content of Interest Specific Virtual Reality (Augment Reality) Solution

As discussed in previous sections, to improve self-realization and problem-solving skills, augmented reality and/or virtual reality technique can be of great significance. With this motivation in the proposed e-Learning framework VR/AR techniques are proposed to provide 2D/3D presentation of the content of interest, problems and allied solutions. There are numerous researches that suggest that the use of multimedia content can make learning more effective. And therefore, in the proposed model, augmented reality and/or virtual reality driven solutions are provided in Virtual Reality (3) section, where the user can watch different AR/VR solution, simulations, emulations and personalized setting-based simulation options to understand content of interest (1) better. The proposed VR section (3) that remains abstracted when opening content display section, provides simulation, emulation and 2D/3D demonstration of the problems pertaining to the currently opened subject of interest (2). In case a student has opened the content of Newton?s three rules (in Content Display Section), then the VR section is supposed to carry corresponding simulation, emulation or demonstration (multimedia) video content. Noticeably, containing video content with textual data (i.e., merging both VR and Content Display) can reduce refresh rate and can increase loading time greatly. Sometime it can be so heavy that a middle specification-based laptop or mobile would not be able to open the complete content. It can impact students' willingness to participate the e-Learning session or classes. Moreover, such clutter can decisively (and adversely) impact the student's engagement or retention. To alleviate such problems, in the proposed conceptual model, both the textual content display as well as corresponding VR/AR solutions is kept in separate windows. In this mechanism, once a student navigates to the plain textual data study, the related AR/VR solutions, existing problem solutions, queries etc. can automatically be loaded to the other abstracted tabs. Interestingly, such content loading and refresh can take place in background and therefore would not cause any content clutter or disturbance. This as a result can improve engagement and hence attention of the student to make learning effective.

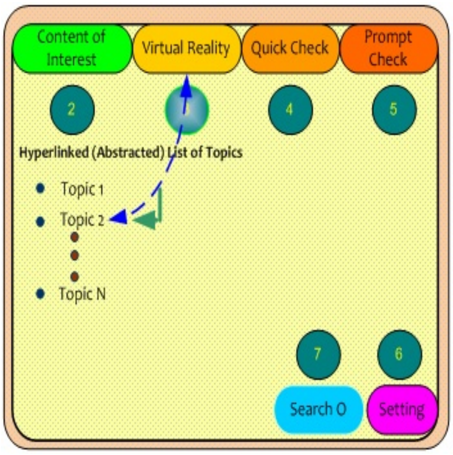

Figure 5: Virtual/Augmented Reality driven STEM Learning Content List

Considering STEM specific VR/AR solution, if a student is learning certain specific subject matter related to human anatomy, the VR section should have the 2D/3D presentation or demonstration of the human anatomy with customizable look, orientation, size etc. In case of chemistry related subjects, if one student is reading organic chemistry topic, the corresponding AR/VR section must have the demonstration, simulation and emulation facilities for molecular structure analysis, bond-formation, molecular kinetics etc. in more attractive and convincing manner. For other STEM subjects as well, the proposed model suggests to possess sufficiently large number of AR/VR demonstrations, solution or simulation options. It can help students understand subject matter more effectively and hence can inculcate self-realization and cognitive behave.

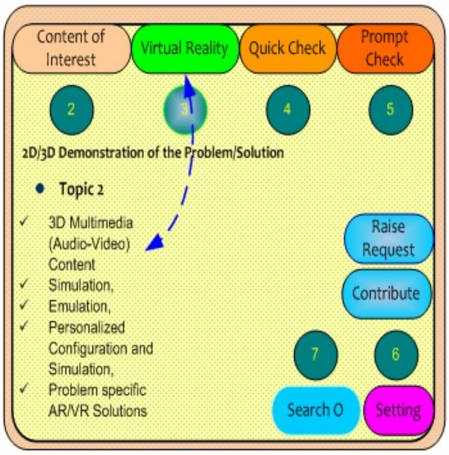

Figure 6: Virtual/Augmented Reality driven STEM Learning Content Display

With such provision, when a student realize difficulty in understanding a specific problem or topic, it can navigate to the AR/VR section where it can find suitable visual (audio-visual can be the optimal) demonstration or simulation of the problem (with the solution of any specific problem). It can make entire learning more efficient and perceptible in addition to the increased engagement and self-realization. Eventually, it can improve learning efficiency of the student. An illustration of augmented or virtual reality driven e-Learning is given in figure 7.

To amalgamate gamified learning with such AR/VR solutions, this section 3 figure 6 can have the strategically located navigational space for creating content, offering content, requesting content etc. to make it shareable. Here, a student or teacher can contribute a solution, simulation or any problem specific content at the cost of certain rewards or coupons. This approach can motivate students as well as teachers to engage the platform and hence such intrinsic motivation would yield improved socialization, connectivity, interaction and therefore superior performance. This approach can invite a large number of users (i.e., students

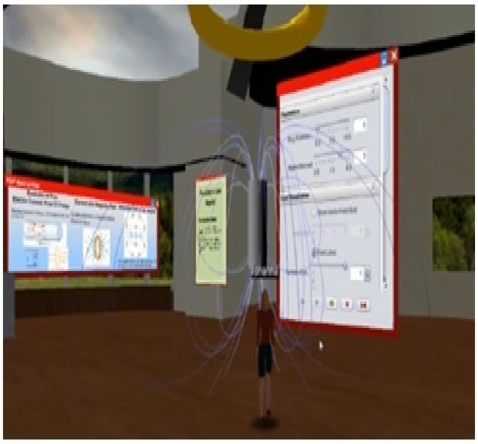

Figure 7: Illustration of Virtual Reality in STEM learning

and teachers or professionals) to contribute their expertise or solution at the cost of certain monitory benefits (say, rewards). This section can also provide the option for raise request and contribute, where the first option can be used by the user to make certain request (pertaining to the problem, difficulty in understanding the problem or solution, or certain solutions for a specific problem). On the contrary, the contribute section would provide opportunities to the user to contribute solutions in the form of "Answer to Certain Question", "Simulation Outputs", "Solution to a raise Question", "Query", etc.

3.5 Content of Interest Specific Quick Check Window

Similar to the VR/AR contents where the focus is made on providing sufficiently information rich content to achieve knowledge cycle, the proposed conceptual model employs (or add) a section named Quick Check (4) that intends to provide different supplementary information pertaining to the content of interest (2). In other words, Quick Check Window (4) that remains abstracted initial (until triggered) provides different supplementary links, solved solution by students and teachers, other supporting details or data etc. For example, in case a student has selected Fourier transform as subject of interest, which is displaying over the main content window, then the Quick Check section (4) is supposed to accommodate or carry additional information such as links pertaining to "the use of Fourier transform", "Types of Fourier transform", "Use of Fourier transform in digital communication", "Solving Fourier transforms", "Orders of Fourier transform", etc. These all links can be provided with hyperlink support or any external link support to allow users navigating to that specific page for depth understanding or study. It can help users understanding the subject or topic in broader spectrum or in depth. It can make learning more productive and cognitive. In addition to the aforesaid links, the subject specific contents including "solution of the problem(s)" contributed by other students or teachers can be displayed in Quick Check window. This section can also have the external link facility to suggest different search specific or content specific web-links, blogs, YouTube videos, Wikipedia etc. In this manner, when a student at first lands on "Content Window" page, it can get fundamental and detailed discussion of the content of interest, subsequently AR/VR section can help him/her to get more realistic understanding and self-realization.

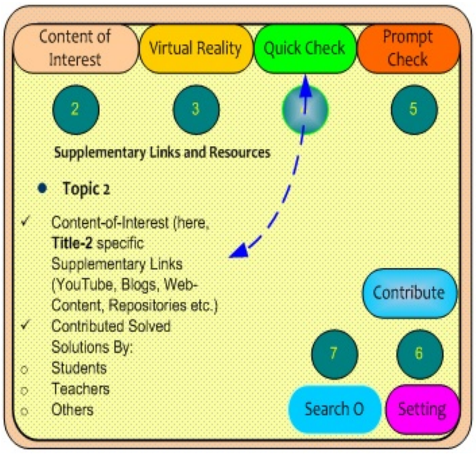

Figure 8: Quick Check option for Content-of-Interest specific external links or resources

In the subsequent step, the student can navigate to the Quick Check section (4) to get more information pertaining to the problems or the content contributed by other students or teachers. It can complete the knowledge cycle where a student would have all-around information pertaining to the subject of interest. It can improve overall productivity, decisively.

3.6 User Specific Prompt Check Window

This section is completely dedicated towards gamified learning approach, where the focus is made on providing different socializing, engaging tasks to complete knowledge cycle. For instance, the provision of a platform where the student can find the list of upcoming (subject specific) Quiz competitions, join group study, Respond Content Request or Response Request by other users, etc. (5). Noticeably, the aforesaid tasks are based on certain reward system, where joining a Quiz can give certain reward to the participants. Similarly, contributing certain solution or helping others in problem solving (online) can avail certain reward for the student. In the same manner, the reward can be provided to the student(s) for their active group study period or online subjective activities. Furthermore, this section can have the option to create an offer where a student can raise request or query towards certain subjective problem. Answering such problems or providing answers to such questions or problems can enable respondents getting certain reward(s). This practice can engage student and inculcate socialization amongst them to be more active. The prompt check section can also have the provision of "Invitation", where the students or teachers can invite students to participate Quiz, Group Study etc., where the participants would be provided certain reward for the same. It can improve overall learning experience and performance.

Noticeably, the user interface would be designed in such manner that for every activity including offers, rewards, content addition, socialize request etc., the notification must reflect over the tool icons. For such provision, real-time notification plugins can be taken into consideration. To ensure optimal interactivity amongst students and teachers this section also provides a dedicated option for assignment submission, evaluation and review section. It can help ensuring more scalable and decentralized learning possible to improve overall learning efficiency. The framework can also be designed with real-time communication including chat facilities and video call or screen sharing. It can be more effective to engage students and make platform productive. The overall proposed functional components under prompt check window (5) are given in figure 9.

In this section, the addition of a web-page can be made, especially for online test facilities. In other words, in prompt check model (5), the teacher would be able to add questionnaires in the different patterns (say, multiple choice as well as subjective detailed discussion), which would be notified automatically to the students. Once getting that notification the student(s) might join the test and can complete assessment cycle. Here, the participants can be provided certain reward as well so as to engage and motivate them to be consistent. This approach would help teachers to perform time-efficient and easy term tests or other quick tests. It can have affirmative or encouraging impact on students' performance.

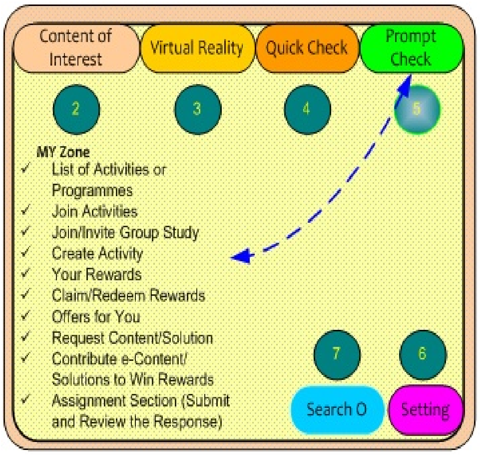

Figure 9: Prompt Check option for the different offers, activities and rewards

3.7 GUI Setting and Interface for Personalization and Sharing

This is the common window, mainly attached to the strategically comfortable place on the display. In sync with the human vision comfort and minimum clutter problems, such window can be presented in the form of abstracted icon, placed optimally at the right most bottom. Once triggering, this window can surface as a broad screen with multiple options such as "Display Setting", "Brightness Setting", "Window Personalization", "Active Period", "Activate Navigational Logs", "Screen Record", "Activate Marker", etc. In addition to these, this section can have the "Active Sharing" facility, where the users (i.e., students or teachers) can take printout of the current window or content specific display, etc. The GUI must also have marker facility where the user can drag it for its personalized content marking (for better memorization). It can also help in feedback-based query solving to complete learning cycle. Similarly, this interface setting must have the provision for "Video Only Setting", Video-Audio Setting", "Resolution Setting" etc. Here, "Video Only Setting" can help muting the audio content so as to make it comfortable for those preferring only video demonstration. Similarly, "Video-Audio Setting" can have the option to control volume, equalizer etc. Resolution Setting can help students or teachers setting their expected resolution to cope up with resource availability, comfort etc. Summarily, this section primarily focuses on system setting and allied control to make e-Learning comfortable and enjoyable.

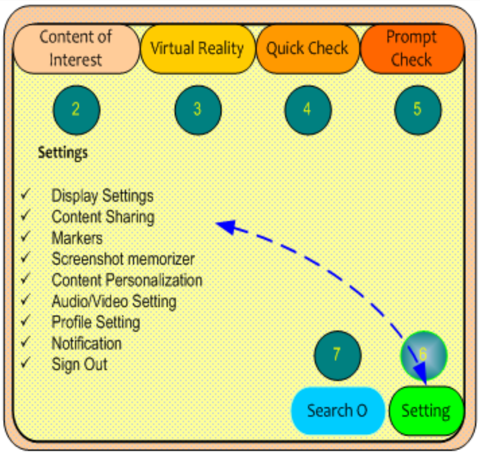

Figure 10: Setting Window for personalization and settings

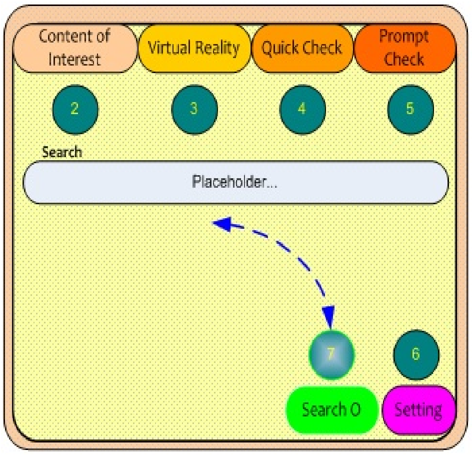

Figure 11: Search Window

3.8 Search

This section provides a dedicated window for content search, where certain advanced data mining driven search concept can be employed. In other words, the search function is proposed to be designed in such manner that it could work precisely with auto filling, auto error correction, within system or web-search facility, repository specific information, etc. This facility can reduce Google-based search dependency and can retain user to be in sync with the contents studied or learnt (1-2-3). To improve search efficiency, certain advanced mining concepts such as semantic information driven search, latent semantic or ontology driven search, high frequency itemset mining based search facility etc. can be employed. Noticeably, these approaches can make overall processing smooth, timely and more engaging. The reduction of clutter data search and ambiguity can motivate students to engage with the solution and hence can be effective to achieve better learning performance. Thus, implementing overall conceptual model (1-7), a robust e-Learning solution can be achieved that not only can improve engagement, socialization, interactivity, but can also inculcate the sense of self-realization, cognitive behave, intrinsically motivated etc. Consequently, it can help achieving superior performance of the students, especially learning STEM subjects. Since, the overall conceptual model is designed in sync with the demands of STEM subjects (learning), it can be of paramount significance for STEM learning or teaching facilities.

The feature characterization of the proposed e-Learning conceptual model is given in Table I.

4 CONCLUSION

In this paper, a first of its kind conceptual model was proposed for STEM-oriented e-Learning system. In sync with the depth assessment and allied inferences the proposed conceptual model addressed almost every aspect of secure and productive gamified learning and augmented reality-based EdTech demands. Recalling the fact that STEM education and allied student's demand the e-Learning solution to be more engaging, intrinsically motivating, cognitive etc., this research conceptualized a robust e-Learning model encompassing strategically amalgamated gamified learning and augmented reality provisions. Moreover, to ensure decentralized and seamless e-Learning provision, blockchain smart contract model was proposed that not only authenticates or validates the user (for further resource access), but also synchronizes contents for corresponding (authenticated) data access and allied READ tasks. Summarily, this work designed a robust Blockchain Assisted Gamified Learning and Augmented Reality Driven NextGen Ecosystem for STEM e-Learning. To cope up with the secure multi-party computation and decentralized (seamless) data access, the proposed model employs blockchain smart contracts that in sync with decentralized data storage validates user(s) and authorizes its role, rights, and resource access credentials. It helps synchronizing (validated) user specific data for further learning and allied READ functions. It can make proposed model more scalable serving students, teachers and other members without revealing or losing data preserving capacity. The proposed model suggests user friendly graphical user interface to perform display setting, personalized content sharing and creation, group participation, self-

Table 1: Feature characterization of the proposed model

SN	$Features$	$Results$
1	User Login and Authentication	Yes
2	Privacy Preserved Data Security	Yes
3	Authorization driven User Specific Auto-data synchronization	Yes
4	Textual data discussion	Yes
5	Multimedia data presentation	Yes
6	Augmented reality/Virtual Reality Simulation/Emulation and personalized simulation (or Test)	Yes
7	bAdvanced data mining or web-mining driven auto-data (or link) recommendation (Quick Check)b	Yes
8	Online Assessment (Quick Test/Subjective Test)	Yes
9	Group Learning	Yes
10	Activity Participation	Yes
11	Reward System (Propose, Claim, Redeem)	Yes
12	Interface/Display/Content Personalization	Yes
13	Advanced Report Generation	Yes
14	Clutter Data Suppression and Abstracted Content of Interest Presentation	Yes
15	Content Sharing (Printing and Screenshot Sharing)	Yes
16	Activity Creation/Invitation/Participation	Yes
17	Content Request/Contribute/Rewarding/Sharing	Yes
18	Online Assignment Submission/Verification/Evaluation/Notification	Yes
19	Custom STEM e-content solution provision and reward	Yes
20	Advanced Display Setting and Personalization	Yes
21	Profile Edit/Share/Delete	Yes

realization, etc. Moreover, the virtual reality section provides search or display adaptive augmented reality solutions, problem solving demonstration etc. serving multiple stakeholders. To improve cognitive, behave and self-realization augmented reality and/or virtual reality zone is included strategically that can help students visualizing topic specific solutions, simulations, emulations, solutions in two or three-dimensional views. It can be decisive to improve intrinsic and cognitive abilities in students. To make learning fun with knowledge sharing, the proposed conceptual model embodies gamified learning section where the students can join group, watch or read solutions, create solution, share solutions pertaining to the topic of interest. These key functions can be designed in sync with certain reward functions so as to engage students greatly. The (STEM related educational) contents flow (say, navigation) are designed in such manner that for any specific subject (or topic) of interest, it provides VR solution, quick checks (supplementary links or allied resources), group participation etc. on the same window that suppresses clutter of content to make it more influencing and engaging. In addition to the Quick Check facility, Prompt Check too can be vital to engage students, where content or solution specific rewards could be provided. This section can have the window to provide options for Quiz participation, competitive programmes, group study, where for each activity there can be certain reward facility to the users. The user interface is conceptualized in such manner that it motives students to continue using the platform for better retention, socialization, engagement and hence higher productivity. The overall characteristics of the proposed conceptual model affirm its robustness and efficacy towards real-time STEM e-Learning solution. The design contributed is presented in such manner that the industry can consider it as ready to implement solution for future EdTech development. Interestingly, this framework can be effective not only for the students but also for the teachers who can explore key components like Quick Check (for additional learning content, to self-realize the STEM problems and allied solutions visually which can stimulate and revitalize their abilities to teach better), Prompt Check (for contributing STEM data content, enabling their skill reach maximum, performing online assignment test, subjective tests etc.). Thus, the proposed framework can be of vital significance for the academia-industries.

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