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RESEARCH ARTICLE

Sustainable Education for Sustainable Future: Art of Storytelling for Enhancing Creativity, Knowledge Retention on the Acme of Successful Education

MOHAMMAD AFKAR[1], ASLAN GHOLAMI[1], ROGHAYEH GAVAGSAZ-GHOACHANI[1], MATHEEPOT PHATTANASAK[2], (Senior Member, IEEE), AND SERGE PIERFEDERICI[3]

[1]Department of Renewable Energies Engineering, Faculty of Mechanical and Energy Engineering, Shahid Beheshti University, Tehran 19839-69411, Iran
[2]Department of Teacher Training in Electrical Engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Bangkok 10800, Thailand
[3]Laboratoire LEMTA, UMR 7563, CNRS, University of Lorraine, 54500 Vandœuvre-lès-Nancy, France

Corresponding authors: Roghayeh Gavagsaz-Ghoachani (roggav@yahoo.com) and Matheepot Phattanasak (matheepotp@kmutnb.ac.th)

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ABSTRACT Considering the importance of education especially for the newer field of education, the current study proposes a novel teaching method based on storytelling that aims to enhance the creativity of students and improve the effectiveness of learning. The method was applied and analyzed through a one-year teaching course case study to introduce topics regarding renewable energy. Despite traditional education, in which learning occurs through the direct transfer of information, here a plot with the theme of mountaineering and nature using real photos and narration of a fictional story was set for the implementation of the proposed method. Therefore, the unintentional consequences of conventional teaching including quick content forgetting, failure to define the main purpose, improper reaction, and low attractiveness and even effectiveness were prevented. Considering the affective and cognitive domains of Bloom's Taxonomy as well as analyzing the performances of students during the teaching course and their final feedback, the results showed promising improvements including more participation (100%), better retention of content (receiving (75%) and remembering (83.33%)). While the learners preferred the proposed method and found it more effective (75%) and attractive (79.17%) than conventional teaching. Moreover, it was shown that the proposed method can improve education criteria in other affective and cognitive domains and is recommended to be considered for implementation in other complex engineering topics.

INDEX TERMS Education, learning, teaching, engineering, renewable energy, story-telling.

I. INTRODUCTION

In today's world, one of the chief solutions for overcoming engineering problems is to find, establish, or even develop a connection between different fields by considering various perspectives and viewpoints. Examples of such achievements are the creation of new fields of study that require the integration of at least two disciplines with a rich history. For instance, concepts such as Water, Energy, Food, and Environment Nexus were developed as a general solution framework for the challenges regarding the sustainable development of human activities in recent years. Another concept that has attracted lots of attention in the last decades is a more efficient implementation of various renewable energy systems either through real-life experiments [1], [2], [3] or various modeling and feasibility study verifications [4], [5], [6]. The main goal

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is to reduce challenges associated with using fossil fuels and related environmental problems and lead humankind toward cleaner energy [7].

Nevertheless, one of the important issues in promoting a new discipline is an attractive and correct introduction with all capabilities [8], [9]. Since many students tend to take this subject in their supplementary studies, it is necessary to work on the basic scientific concepts through various teaching methods during their undergraduate years [10], [11], [12].

Along with the rapid development of technologies, teaching methods are also expected to be updated [13]. A student who studies in a particular field has different capabilities that can be used to create a lasting education [14]. One of the main challenges in education, which was bolded during the coronavirus pandemic era, has been the failure to transfer concepts correctly and students not connecting with the educational materials [15], [16]. In such a situation, the use of new educational methods can be an effective solution [17]. Education is about teaching people new things and skills, as well as guiding them and giving them instructions so they can learn what they need to know [18], [19], [20], [21].

It's important for teachers to understand that each person learns differently [22]. Today, methods based on virtual reality [9], virtual and remote labs [13], games [23], multiplayer online role-playing games [24], [25], the internet of things [26], educational videos [14], educational cards [27], [28], educational escape rooms [29], e-learning tools such as executive files [17] and simulation [30], and digital peer assessment [31], are used in universities around the world.

While there are various teaching methods, it has been proven that providing a story theme or scenario for teaching materials could be beneficial for learners [32], [33], [34], [35], [36]. Stories can be utilized in various ways to teach scientific concepts. Employing stories with different genres such as historical, fictional, or real forms a perspective. Alternatively, visual or interactive stories can also be utilized from another standpoint. Providing lesson plans through a story will help keep the materials stuck in mind for longer and let them be recalled more easily [33].

A review of the state-of-the-art literature highlights that storytelling provides a structured approach, promotes reflection, and engages multiple sensory modalities, thereby enhancing student interest in complex engineering concepts [37]. Narrative inquiry, which gathers stories from engineering students, has also proven beneficial for gaining insights into their experiences [38]. Storytelling is recognized as an effective method to reduce cognitive load and increase student engagement in engineering courses, making it a powerful teaching tool, even when working with neurodivergent students [39]. The cognitive elements of storytelling are highly effective for developing interdisciplinary skills in engineering students, such as critical and creative thinking [40]. Furthermore, storytelling can be used to incorporate ethical values into engineering education [41]. Consequently, transmedia storytelling in undergraduate engineering programs holds promise for fostering essential competencies in future engineers across diverse cognitive levels [42].

While the satisfaction level increase impacts of storytelling-based education for transfer of knowledge have been previously investigated [18], [43], in-depth assessment of this method in comparison with conventional education as well as evaluation of students utilizing this method was under less attention and verifications. This lack of attention is more crucial in engineering, where student burnout and demotivation are very high [44]. Moreover, the incorporation of storytelling into engineering education presents certain challenges, including the necessity for significant effort and skill development in story creation and teamwork [45]. Furthermore, despite its potential benefits, this approach demands substantial time for strategic planning and content development [42]. Therefore, the current study considers engineering students as the case study to introduce an improved teaching method based on storytelling to enhance students' creativity and improve the quality of education. The contribution of this study is to explore the cognitive and affective reactions of renewable engineering students to the proposed storytelling-based education as part of a semester course. Therefore, parameters such as knowledge attainment and retention, as well as learning attractiveness and motivated experiences, were assessed to compare the improvements of the proposed method as a real-time case study. The paper is organized as follows: Section II introduces the proposed plan; Section III displays the plan's results; Finally, the conclusion is presented in Section IV.

II. METHODOLOGY

The proposed storytelling-based teaching concept utilizes and applies visual and auditory tools to help the learners adapt more effectively and therefore gain more during the learning process. It makes the learner transfer the teaching material to their long-term memory and therefore recall the teaching content by correlating them with the surrounding environment. In line with the primary purpose of this paper, the method was implemented for undergraduate and graduate engineering students to teach them about renewable energy topics during a one-year course. First, the proposed storytelling-based teaching method and its implementation steps are introduced here. Then the techniques by which the effectiveness of the proposed method was tested and verified are explained. To verify the effectiveness of the proposed teaching method, both the quality of knowledge transfer and the level of learning during the course as well as the level of learning satisfaction, were investigated.

A. PROPOSED TEACHING METHOD IMPLEMENTATION

To better define each step of the current method, implementing the proposed method in a course is presented here as a case study. Nevertheless, all the main steps can be integrated into any other lesson plan with proper justification and adaptations. Here, besides determining the general steps

FIGURE 1. Defining a high-priority challenge at the start point.

FIGURE 2. Relating real-life experiences to look for a solution.

FIGURE 3. Stablishing the case condition and developing the boundaries for the defined problem.

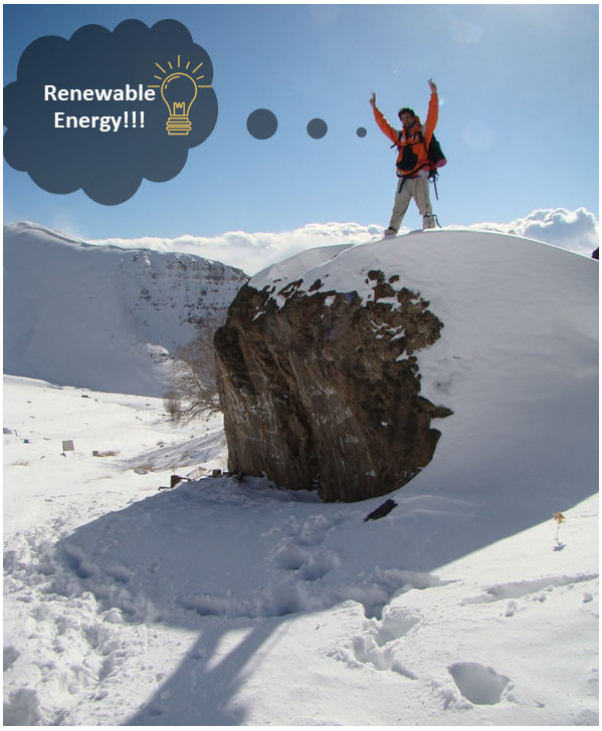


FIGURE 4. Using real-life themes to relate to the nature of renewable energy.

of the method, the implementation in the case study is also presented to clarify the proposed teaching concept further. During the one-year course study, several slides were prepared for the learners. In each case, the learner attempts to connect the slides with the anticipated scientific topic using their curiosity and creativity power. The main goal here is to enhance the ability and capability of learners to correlate the course contents with their daily life experiences and to present scientific concepts to support these correlations logically. Moreover, there are other secondary goals, such as establishing a proper psychological and emotional relationship between the teacher and learners. Figure 1 to Figure 4 shows some of the slides presented in the case study for this work.

Throughout this case study, the teacher aims to introduce the renewable energy concept. For each case, the teacher is suggested to start the story with a routine and daily life challenge and design the storyline with the help of real photos. For the case study presented in the current work, the story begins with the problem statement on the first slide (Figure 1). The challenge considered for the case study was the discharge of a cell phone battery in a campaign through mountains, where there is no possibility of accessing the power grid for recharging. The story's starting point here is a daily life challenge; therefore, each individual could imagine him/herself stuck in such a condition.

As a result, the students subconsciously will feel the course contents will be practical and increase their ability to overcome daily life challenges (Figure 2 and Figure 3). The story's theme of climbing mountains and adventure in nature,

combined with humorous elements, has also been considered to help the student better interact with the topics (Figure 4). For each slide, the teaching process consists of four steps:

Step 1: Express free perception.

In the 1st step, learners were asked to state their perception of the slides freely. The goal here is to activate the students' minds and link the most prominent aspect of their viewpoint to the slide. Therefore, in the future, such linking will help and guide their thinking process to recall the related topics faster and clearer. All the participants should do this step, and everyone must respond in a short time.

Step 2: Find distinct scientific or logical correlations.

In the 2nd step, based on the related topic of the slide, the teacher should guide the students to find and discover any logical connections between each observed slide and the scientific topics of the course. Here, the guided responses for one slide can be linked to others. It should be noted that the implementation of this teaching method can also be altered based on the classes and the vision of the teacher. For instance, the first step can be skipped in some classes (usually after the midterms, when the students are more familiar with the teaching method). Learners directly express the scientific relationship, while in primary classes, applying the free perceptions step is recommended.

Step 3: Link scientific findings in defined frameworks.

In the 3rd step, the learners have to link their scientific perceptions with each other using a chronological or logical framework to express what they have learned in a continuous and integrated scenario. The goal here is to check if they have learned and understood the continuity of the topics presented in the course. The teacher should be very careful and check the student's logical reasoning and correct them whenever they are digressing from the main intended topic of the course.

Step 4: Improve the scientific aspect and summarization.

Finally, at the end of each session and in the 4th step, the learners must summarize the whole scientific topics covered throughout the slides. At this step, based on the developed teaching plan and future topics, the teacher could ask the learner to complete their story and improve its scientific aspects or guess what will be the next chapter of their story (the anticipated topics for the next session, in their opinion).

Preparing the lesson plans and corresponding slides requires careful attention from educators. Each slide must have apparent and deep conceptual links to the course topics. Furthermore, they could be improved during several trials and errors before or after utilizing them in the teaching process. During the lesson plan preparation and implementation of the proposed method, the teacher should guide the learners through the different learning steps based on Bloom's Taxonomy of educational objectives presented in Table 1. For instance, in the 2nd step, the learners must be taught first to list and classify the course's main topics and later use their findings to compare and relate them to corresponding slides.

They have to be guided to state scientific reasoning to support their choices and train of thought. Finally, they would modify, develop or even design a new story based on the knowledge they gained throughout the course.

TABLE 1. Cognitive process dimensions of learning and corresponding scores based on Bloom's Taxonomy of educational objectives.

Dimensions of learning	Corresponding pieces of evidence	Corresponding Scores	
Create	Design, Assemble, Construct, Conjecture, Develop, Formulate, Author, Investigate	A	20
Evaluate	Appraise, Argue, Defend, Judge, Select, Support, Value, Critique, Weigh		17-19
Analyze	Differentiate, Examine, Relate Compare, Contrast, Distinguish, Examine, Question, Test	B	16
Apply	Execute, Implement, Solve, Use, Demonstrate, Sketch		14-15
Understand	Classify, Describe, Discuss, Explain, Identify, Recognize	C	12-13
Remember	Define, Duplicate, List, Memorize, Repeat, State	D	10-11

The educator must continuously check the students' provided responses and estimate their learning level according to the cognitive process dimensions in Table 1. Likewise, the teacher is also recommended to assess the students' conditions based on the affective domains of Bloom's taxonomy (Table 2). Some of the other slides used in the case study to start a dialogue or converge the students' train of thought are presented in Figure 5 to Figure 12. Based on the class conditions and the lesson plans prepared by the teacher, in each session, one or more topics can be covered, and the related slides can be presented. In the case study, after proposing renewable energies as the general solution, the teacher led the students in group work or individual thinking toward finding detailed solutions. For instance, Figure 5 illustrates the starting point for a detailed solution on which the concept of bioenergy could be followed.

Then, as more content regarding the concept is introduced by the teacher, in Figure 6, some of the challenges for the proposed solution in the case study will be listed and classified. Then, in group work (also suggested for homework), the optimized design and conditions for implementing this solution (developing bioenergy) in real-life conditions considering local, social, and technical aspects should be followed. In this way, the teaching contents regarding one of the solutions will be transferred to the students step by step and according to Bloom's Taxonomy of educational objectives.

This cycle can be repeated again for other possible solutions based on the lesson plans in mind. For instance, Figure 7 and Figure 8 are designed to converge the class topics to wind energy. In contrast, Figure 9 and Figure 10 are designed for

FIGURE 5. Introducing bioenergy as one of the possible solutions.

TABLE 2. Affective domains of learning and corresponding scores based on Bloom's Taxonomy of educational objectives.

Dimensions of learning	Corresponding evidence	Corresponding Scores	
Characterizing / Internalizing	Integrates the value into a value system that controls behavior	A	20
Organizing	Conceptualizes the value and resolves conflicts between it and other values		17-19
Valuing	Attaches value or worth to something	B	14-16
Responding	Responds to stimuli	C	12-13
Receiving	Selectively attend to stimuli	D	10-11

solar energy. Finally, toward the end of the lessons, the final solution can be presented (Figure 11).

In the proposed case study, a different real-life solution is mentioned to emphasize the fact that sometimes it is better to think with less complicity to find a solution. Humorous content could also be considered here to improve the filling during the learning experience.

In the final sessions, the teacher should lead the students from the small primary problem with high priority and low importance (here empty battery) to more significant and trickier challenges which might have lower priority but higher importance and impact (attach value or worth to the teaching materials and real-life problems (Table 2)).

For instance, after the environmental pollution problem was mentioned (Figure 12), the learners were asked to discuss

FIGURE 6. Teaching about technical challenges, implementation approaches, and limitations of the proposed bioenergy solution.

FIGURE 7. Introducing wind energy as one of the other possible solutions.

FIGURE 8. Teaching about technical challenges, implementation approaches, and limitations of the proposed wind energy solution.

FIGURE 9. Introducing solar energy as one of the other possible solutions.

FIGURE 10. Teaching about technical challenges, implementation approaches, and limitations of the proposed solar energy solution.

FIGURE 11. Offering a simple solution with a different point of view emphasizes the importance of different perspectives in solving problems.

their opinions about suitable policies for long-term planning, and in fact, the students' attentions were drawn to topics of high importance and low priority that are suitable for future investigation and sustainable development. Here the aim is to lead the students to conceptualize the learning material's value and help to resolve any of their conflict between the newly learned values and other values with the hope to see the students integrate these values into their everyday life based on the affective domains of the bloom's taxonomy (Table 2). In other words, based on how the teacher prepares the lesson plans, the theme, as well as the ending of the story, can be used to incorporate various ethical values into the education material to reach a higher level of successful teaching according to the criteria in Bloom's Taxonomy in both affective and cognitive domains [41]. It should be noted that, for the case study investigated in the current work, the proposed method was implemented in the class, and the students were asked to participate in the discussions either individually or in groups of 3-4 members. To better navigate the learners, in brainstorming sessions that the lecturer encourages and moderates, the lecturer divides the audience into smaller groups for targeted research and to better understand concepts as they progress toward a solution until one joint solution is collectively found. As previously mentioned, the teacher should navigate the learners using targeted questions or providing guiding hints. For instance, the students were asked to answer several questions while each of the slides was displayed, including: 1. In your opinion, what is considered the challenge? 2. If you were in a similar position, how would you solve this problem? 3. What do you think will happen next? The remaining slides were displayed after the students' answers were collected for the prior slides and the teacher provided the necessary information based on the learning objective in the lesson plan. As the slideshow is played, the students read the conversations and are encouraged to use their imagination and creativity to personify the story's characters, increasing their participation and consideration. Moreover, at the end of each section, the teacher will ask the students to further develop the storyline for future sections or improve the previous slides and storyline based on their creativity and the acquired knowledge regarding the teaching topic. This part can be done as either individual or group homework whatever the teacher prefers. The teacher may check the provided answers and select the best ones to be presented in the next section. At the start of each section, a certain amount of time should be allocated to review the best answers and discuss the related scientific concepts. Here the students should be encouraged to create content and prepare their answers based on their abilities and creativity.

B. VERIFICATION OF EFFECTIVENESS AND ATTRACTIVENESS

One of the primary goals of teaching during a course is to transfer the necessary knowledge to the learners successfully.

FIGURE 12. At the end of a course full of learning, thought, and adventure, the main character of the story looks hopefully into the future, and the story ends with a bright image and hope for a better future.

Therefore, several exams and tests are usually designed and taken during a course to evaluate the level of learning. In order to investigate the effectiveness of the proposed teaching method and to check whether there was any improvement with respect to the previous conventional teaching methods, here, 48 students in 4 classes of 12 people were selected as samples. For two classes (I, and II) the conventional teaching method was applied, while in the other two (III, and IV), the proposed teaching method was implemented during the course of the experiment. The final grades of these classes were compared to see how effective is the currently proposed storytelling teaching technique.

Moreover, it is emphasized repeatedly in the literature that there is a strong correlation between learning efficiency and the emotional conditions of the learners. This means that the more learners enjoy the learning process, the more efficient and successful the teaching process will be. Therefore, the attractiveness of this teaching method was also assessed throughout this study.

To investigate the attractiveness of the method, the feedback from the students (24 students in classes III and IV), as well as the teaching experience of teacher and teacher assistants was analyzed. Primarily, these feedback and experiences were received qualitatively and analyzed based on their keywords, to define the learning experience and the challenges regarding the implementation of this method during the course of the experiments and future employment.

Besides primary qualitative feedback received during the study course, to assess the effectiveness and attractiveness of the proposed method more thoroughly, the students developed and filled out a questionnaire at the end of the course (Table 3). Ten questions in four dimensions of the learning experience (focusing on students' participation, excitement, and focus), knowledge acquisition (focusing on transfer difficulty, transfer speed, and knowledge retainment), usability (focusing on educational field and level), and overall evaluation (attractiveness and effectiveness) were designed for the questionnaire.

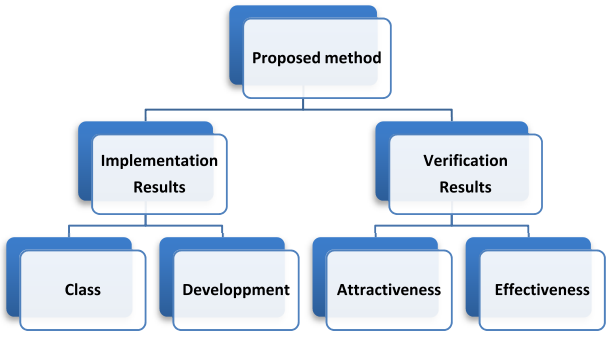


FIGURE 13. Result categories: implementation and evaluation.

Descriptive answers were provided for each question using a five-point Likert scale. The descriptive scores then correspond to the following numerical perceptions: 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

The validity of the questionnaire has been confirmed by experienced professors and experts. Also, the reliability of the questionnaire has been evaluated using Cronbach's alpha test. A Cronbach's alpha coefficient value of more than 0.7 for the questionnaire approves its reliability. The statistical analysis of the provided answers was carried out using IBM SPSS Statistics 27 software. In the next section, the outcomes of the discussions presented in this section will be introduced.

III. RESULTS

In this section, the results related to the two categories discussed in Section II are presented. The categorization of these items is shown in Figure 13. The results in the implementation section consist of two parts. Initially, the results obtained in the class are introduced. In the subsequent step towards expanding this approach, after implementation in the class, further results of executing the proposed method are presented. The evaluation of the proposed method also includes two parts. Firstly, the satisfaction of the students is discussed, followed by the effectiveness of the method in their learning.

A. IMPLEMENTATION RESULTS

Based on the explanations in the methodology section, the proposed teaching technique could be easily adapted for other lesson plans with proper justifications. Here the implementation results of this technique for the case study are presented.

1) CLASS RESULTS

The class outcomes are analyzed from two perspectives: the students' learning experience and the teachers' instructional experience. Each perspective highlights the advantages and disadvantages of implementing this storytelling-based method, providing insights that can help refine and enhance its application in the future. This dual analysis offers a comprehensive understanding of the method's impact, capturing both student engagement and instructional effectiveness.

TABLE 3. Prepared questionnaire for the end-of-course survey.

Dimension	Criterion	Q #	Question
Learning Experience	Student Participation	Q1	Applying the presented method leads to more student participation.
	Student Excitement	Q2	Applying the presented method excites students to further study the related topic besides the curriculum.
	Student Focus	Q3	Applying the presented method makes students more focused on the teaching content.
Knowledge Acquisition	Transfer Difficulty	Q4	Applying the presented method makes students receive educational concepts more easily.
	Transfer Speed	Q5	Applying the presented method makes students receive educational concepts faster.
	Knowledge Retainment	Q6	Applying the presented method makes students remember educational concepts faster.
Usability	Educational Field	Q7	This method can be applied to all engineering topics.
	Educational Level	Q8	This method can be applied to high schoolers, undergraduate, and graduate students.
Overall Evaluation	Overall Attractiveness	Q9	In general, applying the presented method is more attractive than the conventional methods.
	Overall Effectiveness	Q10	In general, applying the presented method is more effective than the conventional methods.

Considering the students' points of view, for each slide, the students' answers were collected, and those solutions were written down and navigated throughout the teaching course. Finally, a new vision for the application of renewable energy was given to the students upon displaying the last slide. In this section, some examples of students' answers to a few questions are introduced. Although there were lots of answers, just a few were selected and presented in Table 4.

This method implementation's achievements can be different according to the type of its audience. For example, introducing and providing basic information about renewable energy in schools can be one of the primary target goals of this method. Among the most prominent achievements of this project, we can mention the establishment of a tangible correlation between different teaching topics. For example, in the case study carried out in the current article, the teaching of electrical topics is related to each slide. In this way, the teaching topics in the lesson plan can be taught by showing each slide and by guiding the learners to consider the keywords in the answers and discussions (Bolded in Table 2).

For example, in the first slide, the rapid discharge of the battery due to low temperature was mentioned, so after a group discussion among students to find different methods of recharging the battery, this topic can be taught at more profound levels by introducing batteries, how they work, different types of batteries and their lifespans. It is also possible to check the characteristics of battery discharge in relation to temperature. Finally, it is possible to examine the solutions that increase the battery life according to the battery manufacturing technology. Other examples that can be mentioned for teaching the various topics of each slide are the description of the power bank, solar panel, wind turbine, power electronic elements required for direct or indirect use of the solar panels, and how to connect them to the grid, types of inverters, environmental conditions which affect the operation of solar panels and wind turbines, biomass, dynamo, and other topics.

From the teachers' perspective, preparing lesson plans for each section of the storytelling-based method requires significant time for strategy development and content creation. Additionally, the active participation of students during implementation can lead to deviations from the planned lessons. Therefore, teachers need to not only prepare precise lesson plans but also skillfully guide student discussions to align with the predefined storyline. Moreover, the instructors must be prepared to adapt the story in response to student feedback and participation, which can lead to deviations from the original lesson plan. This requires adaptability, flexibility, and quick thinking.

Furthermore, digital storytelling demands proficiency in information technology, graphic design, and subject matter expertise, presenting challenges for both educators and students. The more teachers and students are comfortable with these tools, the better the teaching and learning experience. Same as other teaching methods, this method effectivity can also be influenced by resource availability and institutional support. The implementation of this method through the course of the experiment and feedback from the teachers emphasized the fact that access to necessary resources, such as software and multimedia tools, may be limited. Thus, universities need to provide adequate support and training for instructors to implement this method successfully. This also includes administrative backing, professional development opportunities, and possibly adjustments to curriculum standards.

Despite these challenges, this method offers substantial benefits to the learners, such as engaging students, facilitating

knowledge transfer, and increasing interest in learning—particularly in engineering courses that involve abstract and complex concepts. Consequently, teachers must invest considerable time and effort initially to achieve successful educational outcomes and experiences.

2) DEVELOPMENT RESULTS

Additionally, following multiple implementations throughout the course, the method was reversed, whereby students were tasked with creating slides on specific topics and developing a lesson plan or presentation using the introduced methods as homework or an exercise. For instance, considering some of the waste left in nature, one of the groups presented their story regarding the concepts of waste management, waste to energy, and recycling [18].

Moreover, several other topics and themes including wide using observation of nature in renewable energy [3], using comic stories theme for simulating the power of a hybrid car in MATLAB [20], the introduction of different renewable energy resources, and hybrid vehicles as family members [5], using images of class members to define the challenge and behavior of PV panels [34], the snowball effect on polymer electrolyte fuel cells [35], were also provided by using and implementing this method. Additionally, using Virtual Reality and Augmented Reality, several educational spaces and videos were developed. This shows that the proposed method in the current study is applicable, and its impacts on deep learning as well as motivating students to understand the new subjects on a deeper level by correlating their everyday life as well as their different perspectives for learning could be helpful.

B. ATTRACTIVENESS AND EFFECTIVENESS RESULTS

In this section, the results regarding the attractiveness and effectiveness of the proposed method are presented. Attractiveness: Primarily, the attractiveness of the method was evaluated on the feedback from other students. For instance, some of the students' feedback and comments in the class have been collected in free format and presented as follows:

1. Usually, explaining the different methods of producing electricity from renewable energy sources in slides that are limited to only scientific text makes the class boring and monotonous. But this series created an **uplifting and memorable** class because it is a story and the presence of photos.

2. This set of slides and the way of expressing the contents in the storyline created a **new idea** for studying and looking around and I think it will help me to be more **creative**.

3. Expressing the methods of generating electricity from renewable energy sources, within a nature-theme story, is a beautiful reference to the concept of environmentally friendly development methods of electricity generation, and besides technical aspects, it also emphasizes the **ethical concepts**.

4. The method is an interesting idea for learning and teaching. The creation of a storyline results in **lasting educational** content. Moreover, this can be boosted by adding animations to the story.

5. The set of slides is very **attractive and useful**, and if the dialogues are expressed in dubbed form, the set will be more attractive and informative.

6. This collection and teaching method is **suitable and attractive** for students, but it is not complete, and it is better to continue the story in other environments such as ''forest, desert, and sea'' and the methods of electricity generation in those environments are also expressed.

7. The beautiful introduction to renewable energy conveyed to me the sense that these energies (as well as the learning contents) are as strong, **sustainable, and everlasting** as mountains!

8. The learning experience was **memorable and fun**. I wish the generator of your life keeps running and in your path of progress, your battery never runs out of charge.

According to the primary students' opinions, it can be seen that the idea of this teaching method was attractive to them, and they are satisfied with the manner in which the contents are presented. In general, students found the storytelling-based teaching method inspiring and engaging. Working on this project also improved students' creativity, and made them perceive a bigger picture regarding the teaching topics. Additionally, students noted that the method sparked new ideas and creativity in their work, and a few suggestions to add other subjects to the collection as well as to animate and dub the story have been proposed. These ideas were mostly then followed by students themselves and completed as previously mentioned in the development results section.

Besides the primary feedback received during the study, the analysis results regarding the feedback from the questionnaire in Table 3 are also presented here. First, the dataset was analyzed to check whether they were distributed normally or not. Either the Kolmogorov-Smirnov test or the Shapiro–Wilk test could be applied in this regard. However, it should be noted that the Shapiro–Wilk test is more suitable for small populations or sample sizes like the current study (<50), whereas the Kolmogorov–Smirnov test is usually utilized for large samples (≥ 50). Here both tests were analyzed, and the results are presented in Table 6. For the Kolmogorov–Smirnov test, if the recorded data perfectly match a normal distribution, the value of the Kolmogorov–Smirnov statistic will be 0. Moreover, for the Shapiro-Wilk test, if the Sig. value is higher than 0.05, the data is normal. While for Sig. the value below 0.05, the data meaningfully diverge from a normal distribution. Therefore, based on the presented results in Table 6, the distribution is not normal. Therefore, for further analysis, the non-parametric Wilcoxon signed-rank test was performed (Table 7).

The Wilcoxon signed-rank test deals with median analysis. Based on the results in Table 7, it can be implied that due to the absence of a significant error level for each question (except questions 7 and 8), the null hypothesis is rejected, and as a result, the received data medians are different from 3,

TABLE 4. Some of the answers including free perceptions and scientific points expressed by students for each slide (Figure).

Few Provided Answers	Slide (Fig.) #
✓ When camping in nature, the behaviors and equipment should be in such ways that lead to the **least damage to the environment**. ✓ Based on previous experience, **cold affects the efficiency of batteries** and can cause premature discharge of batteries. The reason for this incident may be related to the chemical reactions of the materials inside the battery.	1
✓ The higher the altitude, the **lower the ambient temperature** and the higher the snowfall probability. ✓ The clear air and proximity to the sun in mountainous regions lead to **more sun exposure** and some skin damage. ✓ Considering the possible dangers in the mountains, including **harsh**, traveling alone to these areas is dangerous, and it is better to do so in a group.	2
✓ **Renewable energy** sources are abundant in nature. Nevertheless, these resources may not be visible at first glance despite their abundance. ✓ To exploit all the available energy sources, **research and experiments** must be done to find sources and ways of exploiting them. ✓ Humans **need** energy. Energy **production** is possible in any situation, but it requires the use of special **tools** and familiarity with different energy sources. ✓ To obtain energy, at least one energy source is needed. As the story's main character has struggled to find new **sources of energy**. ✓ The reduction of energy sources and the destructive consequences of fossil energy consumption have led governments to **use new energies**.	3
✓ Renewable energy sources are **available** and do not have the **limitations** of fossil fuels. Thus, renewable energy sources can be the ultimate solution for energy supply after depleting fossil energy. ✓ Energy in nature is available in renewable and non-renewable categories. However, renewable energy sources are **environmentally friendly**. ✓ During **energy crises**, attention to renewable resources always increases.	4
✓ One of the **traditional ways** of generating electricity is using water vapor. ✓ To generate electricity, a **heat source**, a mechanical system, and a dynamo can be used.	5
✓ A belt or shaft is required for the **dynamo** to work. The exploitation of fossil fuels is expensive and requires a lot of tools. ✓ The use of traditional energy production systems **harms the environment**. Creating a **fire** in nature may cause a big fire.	6
✓ **Wind** is one of the renewable sources of energy production. In windy areas, it is possible to produce electrical energy using wind turbines. The wind is a **widespread and ubiquitous** source of energy. ✓ When discussing the use of renewable energies, wind turbines fall in the category of some of the primary ways of exploiting these resources and reveal the level of attention and use of these **turbines** at the global level. ✓ **Continuous and high wind speeds** in an area make it suitable for establishing a wind farm.	7
✓ **Higher altitudes and mountainous areas** are suitable for installing wind turbines. The wind makes the turbine rotate, and by using the generator, electricity can be generated from this rotation. ✓ Wind turbines need a **dynamo or generator** to produce electricity. ✓ Wind turbines have **different sizes**; here, the small size is considered for low usage.	8
✓ The sun is one of the sources of renewable energy. **Solar energy** is the most widely available renewable energy source. ✓ The **radiant and thermal energy** of the sun is a suitable source for energy production, but it is **not available** during some hours of the day. ✓ **Small** and local power plants as well as **large-scale** ones can be installed to use solar energy.	9
✓ In addition to **thermal** energy, one can get energy from the sun using solar **photovoltaic** panels. ✓ It is necessary to carry energy production tools in remote areas. **Small portable photovoltaic panels** can be installed on the bag and used as a charger.	10
✓ When energy sources are not available, or it is not possible to use them, using **stored energy** is a suitable solution. ✓ When traveling to remote areas, you should carry **energy reserves**. ✓ **Power banks** are devices used to charge electronic equipment. **Batteries** are only energy storage devices and do not have the power to produce energy. ✓ To **charge** a battery, one must use a source that has a **higher voltage** than that battery.	11
✓ One of the most important **advantages** of renewable energy is protecting the environment and lower pollution. ✓ The development of different renewable energy systems requires considering various **social, environmental, and technical aspects**. ✓ To achieve the **sustainable development** goals, **long-term planning** is needed.	12

which indicates that the students provide a meaningful opinion concerning the questions. Therefore, their answers to these questions can be assessed to check the effectiveness and attractiveness of the proposed method. For questions 7 and 8, since the teachers should design the lesson plan, the learners might not clearly have the knowledge to see through the whole course content (Q7 and Q8). Previous experiences indicate that by carefully modifying and preparing the contents and considering the framework presented in the methodology, the proposed model can also be presented for all engineering topics and different teaching levels, including high scholars, undergraduate, and graduate students. The usability of

TABLE 5. Summary of some of the developed answers and homework provided by the students based on the proposed storytelling method.

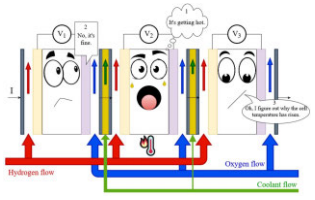
Ref.	Main Subject	Sample Slide
[3]	- Renewable Energy - Observation of Nature	
[20]	- Hybrid car in MATLAB - Comic stories	
[5]	- Hybrid vehicles - Family members	
[35]	- Fuel cells - Visual abstract	
[18]	- Waste to Power systems - Storytelling in the mountains	
[34]	- Challenge and behavior of PV panels - Images of class members	
[33]	- System faults - Development challenges	

TABLE 6. Normality test analysis results for the answers received from the learners to the questionnaire in Table 3.

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Q1	.358	24	.000	.637	24	.000
Q2	.278	24	.000	.817	24	.001
Q3	.295	24	.000	.694	24	.000
Q4	.333	24	.000	.781	24	.000
Q5	.288	24	.000	.607	24	.000
Q6	.399	24	.000	.706	24	.000
Q7	.326	24	.000	.825	24	.001
Q8	.330	24	.000	.791	24	.000
Q9	.305	24	.000	.769	24	.000
Q10	.311	24	.000	.787	24	.000

a. Lilliefors Significance Correction

TABLE 7. Hypothesis and the results of the Wilcoxon signed-rank test analysis for the answers to the questionnaire in Table 3.

Null Hypothesis	Test	Sig.[a,b]	Decision
Median of Q1 equals 3.	One-Sample Wilcoxon Signed Rank Test	.000	Reject the null hypothesis
Median of Q2 equals 3.	One-Sample Wilcoxon Signed Rank Test	.003	Reject the null hypothesis
Median of Q3 equals 3.	One-Sample Wilcoxon Signed Rank Test	.000	Reject the null hypothesis
Median of Q4 equals 3.	One-Sample Wilcoxon Signed Rank Test	.034	Reject the null hypothesis
Median of Q5 equals 3.	One-Sample Wilcoxon Signed Rank Test	.000	Reject the null hypothesis
Median of Q6 equals 3.	One-Sample Wilcoxon Signed Rank Test	.015	Reject the null hypothesis
Median of Q7 equals 3.	One-Sample Wilcoxon Signed Rank Test	.106	Retain the null hypothesis
Median of Q8 equals 3.	One-Sample Wilcoxon Signed Rank Test	.118	Retain the null hypothesis
Median of Q9 equals 3.	One-Sample Wilcoxon Signed Rank Test	.002	Reject the null hypothesis
Median of Q10 equals 3.	One-Sample Wilcoxon Signed Rank Test	.013	Reject the null hypothesis

[a] Significance level is .050.
[b] Asymptotic significance is displayed.

this method can also be confirmed through the developed results (presented in previous sections) which covered a wide range of educational fields and levels. Figure 14 and Table 8 represent the analysis of the feedback received from the questionnaires. Moreover, Cronbach's alpha coefficient value of 0.865 approves the reliability of the questionnaire.

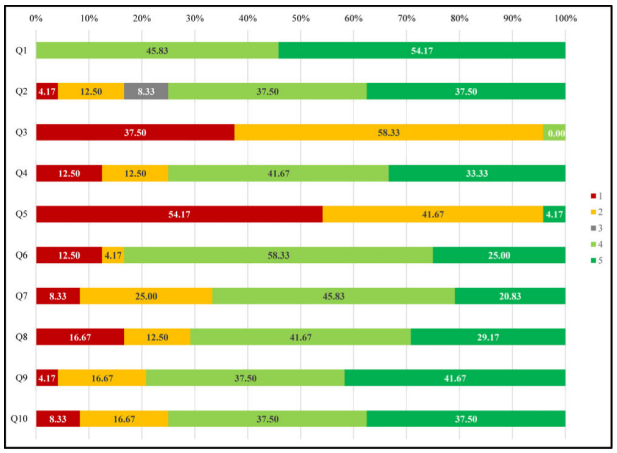


FIGURE 14. Frequency of the answers given to the questions related to the questionnaire in Table 3.

TABLE 8. Frequency of the answers given to the questions related to the questionnaire in Table 3.

	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	Mean	SD
Q1	0.00	0.00	0.00	45.83	54.17	4.54	0.50
Q2	4.17	12.50	8.33	37.50	37.50	3.92	1.15
Q3	37.50	58.33	0.00	4.17	0.00	1.71	0.68
Q4	12.50	12.50	0.00	41.67	33.33	3.71	1.37
Q5	54.17	41.67	0.00	0.00	4.17	1.58	0.86
Q6	12.50	4.17	0.00	58.33	25.00	3.79	1.22
Q7	8.33	25.00	0.00	45.83	20.83	3.46	1.29
Q8	16.67	12.50	0.00	41.67	29.17	3.54	1.44
Q9	4.17	16.67	0.00	37.50	41.67	3.96	1.21
Q10	8.33	16.67	0.00	37.50	37.50	3.79	1.32

Considering the learning experience dimension, the results indicate that all the learners believed that the proposed method led to more student participation (Q1). Besides, it can be seen that most of the students confirmed that after implementing this method during the class, they were more excited to study the related topic further regarding the teaching contents (Q2). Nevertheless, since the method relies on discussions and brainstorming, there is always the possibility of digressing from the main topic (Q3). Such digressions may lead to slower knowledge transfer from the perspective of the knowledge acquisition dimension (Q5). However, the majority of learners considered the proposed method more effective when considering other knowledge acquisition criteria (speed and retainment). This means that the proposed method leads the students to more easily receive (Q4) and faster remembrance (Q6) of the teaching content. Finally, the feedback from the learners indicated that compared to conventional teaching methods, the proposed method is more attractive and efficient. Table 8 also provides the mean for each question as well as the standard deviation.

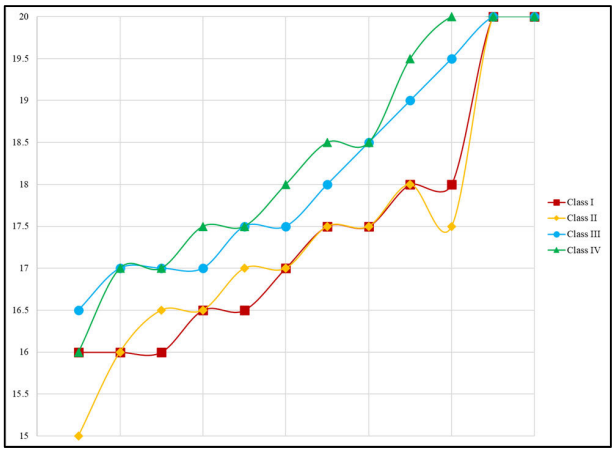


FIGURE 15. Final grades of the students in different classes.

TABLE 9. Analysis of the final grades of the students in different classes.

	Class I	Class II	Class III	Class IV
Mean	17.42	17.38	18.13	18.29
Variance	1.826	1.964	1.422	1.686
SD	1.351	1.401	1.192	1.298

In order to evaluate the effectiveness of the proposed method implementation, besides the level of satisfaction reported by the learners, the learning level of the participants was also evaluated by a standard exam at the end of the course for all the classes (I, II, III, and IV). The results are presented in Figure 15 and Table 9.

As can be seen, for the participants in classes III and IV in which the proposed method was applied, the average grades of the learner on the final standard exam were around 1 point (out of 20) higher than the other classes (I and II) where conventional teaching methods were applied. Moreover, comparing the variances and standard deviations of the grades shows that for the classes in which the conventional method is applied, there is a bigger gap in the level of learning between the participants. These results indicate that throughout the proposed method, the transfer of information and educating procedure have been carried out more uniformly, and there is less level difference between students.

IV. CONCLUSION

Numerous studies have been conducted over the last few years suggesting that to improve the quality of learning, conventional or old-fashioned teaching methods must be reformed and, sometimes, even required to undergo extensive changes. Furthermore, due to the fact that each student is unique, a variety of teaching techniques must be incorporated during teaching procedures in order to ensure the success of the lesson.

Hence, the present study intends to introduce an improved teaching method that is based on storytelling and aims at

tapping into the creativity of students. The introduced method was proposed to be implemented for various levels of learners, including high scholars, undergraduates, and graduates, to teach different scientific topics.

To assess the degree of achievement and success of educational goals of the proposed method with respect to the conventional ones, a case study implementation for teaching renewable energy topics during a one-year course and for 48 students in 4 classes of 12 people was carried out.

Through the lesson plan preparation process, Bloom's Taxonomy of educational objectives as well as the affective domains of Bloom's taxonomy were followed to track the trend of each student's performance. Bloom's technique has been used to quantify the amount of knowledge that learners have gained both psychologically and scientifically.

To check the effectiveness and attractiveness of the proposed method, the feedback received within validated and reliable (Cronbach's alpha coefficient value of 0.865) questionnaires from the learners were statistically analyzed. The Normality tests, including Kolmogorov-Smirnov and Shapiro–Wilk showed a meaningful divergence from a normal distribution. Therefore, for further analysis, the non-parametric Wilcoxon signed-rank test was performed.

The results indicate a clear preference of students regarding the implementation of the proposed method and definite higher attractiveness (79.17%) and effectiveness (75%) in comparison to the previous conventional teaching. Besides, it led to more student participation and, therefore, easy receiving, as well as longer and faster remembering of teaching contents, while exiting learners for further follow-ups and deeper pursuit of the related topics.

Besides the learner perspective, the final grades evaluation of students confirms better and more uniform knowledge transfer by applying the proposed method. Likewise, other education criteria in Bloom's Taxonomy in both affective and cognitive domains can be improved by using this method. Nevertheless, to define and prepare this method for various courses, further preparation might be needed, and larger group studies could be helpful to detail the challenges and thus improve the method implementation.

In line with future works, different plans can be presented on forests, seas, and other environments, according to the challenges and energies present in these environments. It is obvious that the proposed idea and methods can also be used to introduce other topics apart from renewable energy.

Moreover, future research should address the challenges of implementing storytelling-based teaching methods in university courses. Key areas for exploration include developing streamlined processes to reduce preparation time, identifying strategies to keep student discussions aligned with the storyline, and enhancing digital proficiency for educators and students. Studies should also examine the impact of institutional support, such as resource availability and professional development opportunities, on the successful adoption of this method. Longitudinal studies could further assess the long-term benefits and drawbacks, providing insights for improving the method's efficacy and enhancing educational outcomes in complex fields like engineering.

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MOHAMMAD AFKAR received the B.Sc. and M.Sc. degrees in electrical engineering and renewable energy engineering from Shahid Beheshti University, Tehran, Iran, in 2014 and 2020, respectively. He is currently with the Laboratory of Renewable Energies Engineering (REDSBU), Shahid Beheshti University. His research interests include power electronics, control and converters for fuel cell (FC) and photovoltaic (PV) systems, and education engineering.

ASLAN GHOLAMI received the Ph.D. degree in mechanical engineering. He is currently an Assistant Professor at Shahid Beheshti University. His primary research endeavors focus on renewable energy systems, as well as innovative education. It's an exciting area of research as he and his colleagues explore new technologies and methods to create sustainable energy solutions for the future and are passionate to dedicate their time and expertise to nurturing the next generation of engineers, fostering an environment of learning and growth to drive progress in this field.

ROGHAYEH GAVAGSAZ-GHOACHANI received the M.Sc. degree in electrical engineering from Institut National Polytechnique de Lorraine (INPL), Nancy, France, in 2007, and the Ph.D. degree in electrical engineering from Université de Lorraine, France, in 2012. She is currently with the Department of Renewable Energies Engineering, Shahid Beheshti University, Tehran, Iran. She is also a Researcher with the ''Groupe de Recherche en Energie Electrique de Nancy'' (GREEN), and the ''Laboratoire d'Energétique et de Mécanique Théorique et Appliquée'' (LEMTA), Université de Lorraine. Her current research interests include stability study, control of power electronics systems, renewable energy, and education engineering.

MATHEEPOT PHATTANASAK (Senior Member, IEEE) received the B.Sc. and M.E. degrees in electrical engineering from the King Mongkut's Institute of Technology North Bangkok (KMITNB), Bangkok, Thailand, in 1996 and 2004, respectively, and the Ph.D. degree in electrical engineering from Université de Lorraine, Vandœuvre-lès-Nancy, France, in 2012. He is currently a Full Professor with the Department of Teacher Training in Electrical Engineering (TE), KMUTNB. His current research interests include power electronics and their controllers.

SERGE PIERFEDERICI received the Engineering degree in electrical engineering from Ecole Nationale Supérieure d'Electricité et Mécanique, Nancy, France, in 1994, and the Ph.D. degree in electrical engineering from Institut National Polytechnique de Lorraine, Nancy, in 1998. Since 2009, he has been a Full Professor with the University of Lorraine, Nancy. He has authored and coauthored more than 200 articles which are published in international peer-reviewed journals. His research interests include the stability study of distributed power systems, modeling, control of power electronic systems, and distributed control of multisources and multicarrier microgrids. He was a recipient of several IEEE awards. He serves on the editorial boards for the international peer-reviewed journals.