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A new systematic approach of teaching and learning of forensic science for interdisciplinary students: A step towards renovating the forensic education system

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ABSTRACT

The new pedagogical approach of teaching and learning provides better deliverables by the teachers and better understanding and student engagement. In this order, a course was designed on Forensic Science for undergrad students from interdisciplinary background. Six pedagogies were used in this course with the aim to develop creativity, critical and logical thinking, practical learning, social accountability and research aptitude among the students. The main reasons for selecting these students were to avoid influencing the learning outcome due to their prior knowledge and observing the actual impact of the pedagogical learning. The suggested approach may be helpful in reducing the theoretical and practical gap in forensic science education. Besides, this teaching and learning approach may open a new avenue of forensic research and may result in a paradigm shift.

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1. Introduction

Forensic science is the amalgamation of different branches of science, arts, commerce, law, and engineering by which the linkage with the crime scene, victim, and the culprit is possible. As a subject, forensic science evolved to investigate the crime scene, detect & examine the clues, and identify the perpetrator using various scientific methods and justice principles. That is why Forensic science is one of the most captivating subjects that can very easily entice students. However, teaching this subject is not an easy task. Globally, students are influenced by various TV shows and movies like CSI, FBI Files, and CID. Hence, it becomes difficult for a teacher/instructor to satiate students' queries only through the traditional teaching pedagogies.

Moreover, it is challenging to provide basic and applied knowledge about the topic within the limited period (lecture as well as semester) through the traditional teaching pedagogies, including classroom lecture, chalk-talk, "flipped" learning and experiential learning [1–3]. Therefore, integration of new techniques or pedagogy of teaching and learning along with existing pedagogies are essentially required in the field of forensic science education. These new pedagogies of teaching and learning may enhance the knowledge, creative & critical thinking and logical research aptitude among the students, which is indispensable for the deep understanding of the subject.

Forensic science education in India is in a sound and developing stage, but class-room teaching and learning are more towards the conventional teaching and learning that is lecture-based, where students cannot be sufficiently engaged and are mostly teacher-driven. Conventional teaching and learning (one-sided teaching and learning) sometimes become monotonous and boring, making it difficult for students to understand specific topics explicitly. However, if different active teaching and learning approaches are introduced into the classroom, it will not be monotonous or dull, and students will learn the difficult topics more efficiently and more engagingly.

From the Indian perspective, the Forensic science curriculum has been designed in ways where teacher/instructors cannot introduce new teaching and learning pedagogies because of the vast amount of course content and limited time of deliverable. Moreover, except for the practical classes, there is limited scope in the curriculum for the project or problem-based learning pedagogy. Perhaps this could be one reason why forensic science is still not an entirely research-driven course in India. It is necessary to revamp the forensic science curriculum and make it more practical,

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research and experiment oriented rather than only theoretical. Forensic science could be the best example of an interdisciplinary subject that can easily collaborate between different subject branches for conducting interdisciplinary research. Additionally, these new pedagogies may also be helpful in continuously engaging the students and provide effective learning.

A course was designed for non-scientific background undergrad students to enhance the awareness of forensic science. The idea to teach this course in such a unique mode brings interdisciplinary learning, multiple skills, and application of theory to abide by undergraduates' education. Moreover, it focused on using different pedagogies in facilitating learning among students who do not have prior knowledge about the subject. With this study's help, an attempt was made to estimate the effect of using a combination of different pedagogies in reducing the theoretical and practical gap for a particular subject, continuous student engagement and skill development.

2. Course design

The course was designed as a short-term course of 15 days duration. Each day, the course instructor gave 3-h instruction or lecture followed by a 5-h duration designated for learning skills and activities involving different pedagogies. The class size was 20, which has been kept constant since the beginning of the course in 2016. The curriculum was designed for the learners to identify the evidence (Fingerprint, footprint, forged document, bloodstains, etc.) often found at the crime scene and establish their significance to establish their link with the crime, perpetrator &/or victim. The course was divided into six modules. The learning objectives of these modules are given below:

Module 1- It is an introductory module in which learners get acquainted with the definition, basic principles, and forensic science application. They also get information about the role of forensic science in crime investigation. They also get to know about various state and central forensic science laboratories in India.

Module 2- In the second module of the course, learners get informed about fingerprints, which are among the most common clues at the crime scene. Here, they learn about different fingerprint pattern types, classification (10-digit primary), and latent fingerprint development (Powder and Chemical). In this module, learners also get acquainted with the fingerprint matching procedure.

Module 3- In the third module, learners learn about footprints, footwear/shoeprints, gait pattern and gait pattern analysis. They also acquire knowledge about the preservation methods and their role/significance in the investigation process.

Module 4- In the fourth module, the learners are informed about the various types of forgeries. With the help of flags of forgeries, they also learn to detect whether a document/signature is forged or genuine. Additionally, they also learn about various security features present in Indian currency and get acquainted with how they can differentiate between genuine and counterfeit currency notes.

Modules 5- In the fifth module of the course, the learners know about detecting bloodstains, different bloodstain patterns, and their analysis and interpretation.

Module 6- The last is an evaluation module. In this module, the learners are taught the crime scene investigation procedure (Seven "S" steps). It also includes how to search, identify, preserve, package and forward the evidence to the lab for examination purpose.

3. Pedagogies used

Different teaching-learning pedagogies were used for these six modules (Fig. 1). These pedagogies are -

1. Inquiry (Interaction/Discussion) based Learning Pedagogy
2. Observation-based Learning Pedagogy
3. Experiment-based Learning Pedagogy
4. Problem-based Learning Pedagogy
5. Case-based Learning Pedagogy
6. Project-based Learning Pedagogy

3.1. Inquiry (Interaction/discussion) based learning pedagogy

Inquiry (Interaction/Discussion) based Learning Pedagogy is one of the most challenging but rewarding. In this pedagogy, the lecture starts in a pre-determined way, but once either the instructor or any student raises a question, the discussion starts taking its path. Something new usually comes out linked to another known topic or leads to a new topic. It is evident that this pedagogy enhances the ability to think profoundly and articulates new ideas in the students [4]. This pedagogy was used in all the modules during lecture sessions to get an idea of what the student understood about the topic(s) covered. This pedagogy is constructive to develop critical thinking, way of expression and communication skills among the students.

3.2. Observation-based learning pedagogy

Observation-based learning is the part of experiential learning pedagogy in which the 'learning by doing' approach helps grow observational skills. Furthermore, this also enhances the students' level of patience, which plays a vital role in the investigation procedure. This pedagogy was used in all the modules of this course. Students were acquainted with a new definition of Forensic (shown in Fig. 2). This pedagogy was also used in other modules through the learning activities like fingerprint pattern recognition, matching/verification of finger/footprint, and the detection of genuine or forged document/currency, enhancing/developing the students' observation skill. Correct and precise observation skills are helpful in forensic investigation procedure, but they would also help the students a long way in both career and life.

3.3. Experiment-based learning pedagogy

Experiment-based learning pedagogy is also derived from experiential learning pedagogy, which provides hands-on experience to the students on laboratory equipment/instruments [4,5]. This pedagogy explains the advantages and limitations of laboratory experiments, equipment/instruments, and students. This pedagogy enables students to test hypotheses and observe how well the concept and procedure work under laboratory conditions. It also empowers students to design and conduct experiments. This pedagogy was used throughout all modules except module one, a bit theoretical and conceptual rather than experimental. This pedagogy has been used in module 2 (latent fingerprint development using powder/chemical methods), in module 3 (Gait pattern analysis), in module 4 (deciphering the indented or secret writing), in module 5 (height of blood droplet and angle of impact estimation) and module 6 (during laboratory testing of various clues obtained from the mock crime scene). This is trial and error-based pedagogy with the help of which students learned by doing various experiments.

3.4. Problem-based learning pedagogy

Problem-based learning (PBL) pedagogy is student-centric. With this pedagogy's help, students learn about a topic by solving a problem found in questioned material. This pedagogy does not

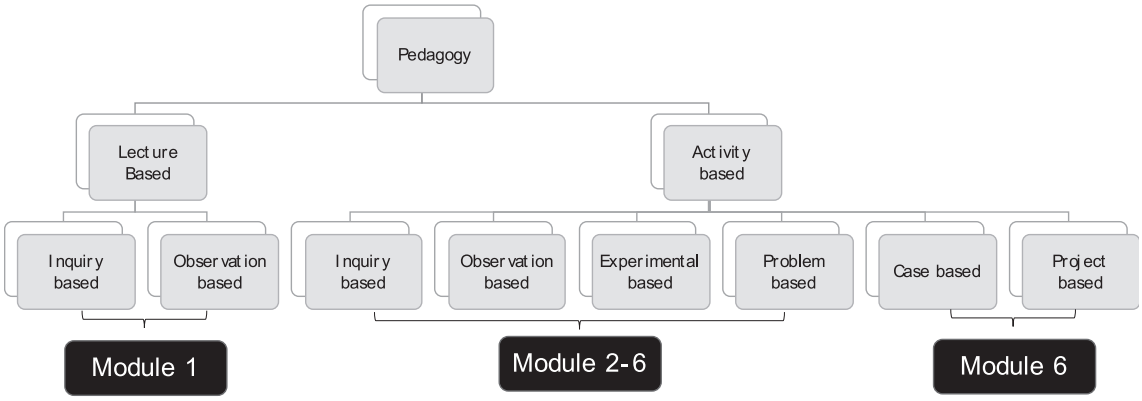


Fig. 1. Block diagram of different pedagogies used in the different modules of the designed course.

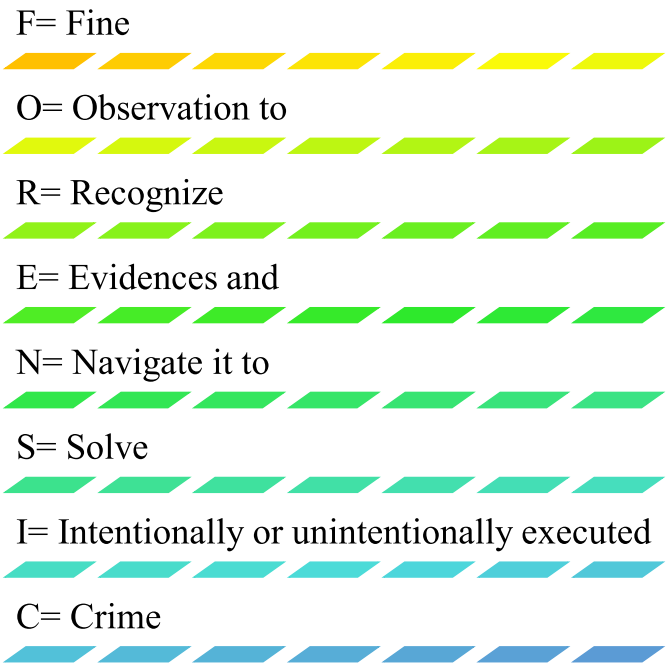


Fig. 2. New meaning of term "FORENSIC" developed in the designed course.

focus on solving a problem with a defined solution. Instead, it allows developing other desirable skills and qualities, including gaining knowledge, enhancing group activity (collaboration and communication), and enhancing curiosity [4]. In the course, this pedagogy has been used in module 2 (identification of unknown fingerprints, fingerprint classification); in module 3 (height estimation of a person through step and stride length in Gait pattern), in module 4 (signature verification, handwriting similarities) and module 5 (direction of blood droplet estimation, identification of the origin of blood source). This pedagogy was helpful to assess the knowledge and various skills such as critical and logical thinking, observation and experiment handling of the students.

3.5. Case-based learning pedagogy

Case-based learning pedagogy is also a kind of problem-based learning pedagogy. Case-based learning provides more flexibility to the students rather than problem-based learning pedagogy. Case-based learning pedagogy develops critical, logical and analytical thinking skills in the learners and also evolves the insightful judgmental skill in them, which comes to them from reading and group discussion. This pedagogy can play a vital role in understanding the complex and interdisciplinary topics that do not have pre-decided solutions or where evaluation and analysis are required, and conclusive remarks come through result interpretation and alternative explanations [4,5]. In this course, module 6 was based on this pedagogy. Before implementing this pedagogy, the students were briefed about the crime scene investigation procedure. Before making a mock crime scene, the students discussed and streamlined their stories and relevant clues. Once the discussion was done, they have constructed a mock crime scene and handed it over to the other group for investigation purposes.

3.6. Project-based learning pedagogy

Project-based learning pedagogy provides long term engagement to the students in which they explore and examine targeted sets of questions, challenges and problems throughout the project. This type of pedagogy can provide more autonomy, ownership and responsibility to the learners in terms of design and implementation. Projects are usually based on real-world problems and are long term engagement for the learners. To avoid losing its prime objective, the instructor needs to careful design and monitor the stages/phases [4,5]. In this course, this pedagogy has been used in module 6. The investigating group students have used this pedagogy during the investigation process, analysis/examinations of clues and result interpretation. This pedagogy was introduced to assess almost all the skills and knowledge that learners grasped from different course modules.

4. Result and discussion

Integration of active learning pedagogy approaches into the course provides more knowledge to understand complex topics [4,5]. The literature mentions that flipped classroom and project-based learning are the best learning approaches to improve students' performance [3,6–9]. Keeping this in mind herein, this course attempted to implicate some more learning approaches that could also enhance students' performance and more knowledge and engagement.

On the first day of the course, students expected that they would do some detective kind of things. Students did not have any previous background in forensic and were not even aware of any scientific terminology. Hence, in the first session, the instructor took an interactive approach and began the course via storytelling mode. This interactive approach was followed through with graphic

representation. For example, they were shown a new meaning of the term 'FORENSIC' that was self-explanatory and provided glimpses of the course in a few lines (Fig. 2). In summation, "*Forensic is a fine observation to recognize evidence and navigate it to solve intentionally or unintentionally executed crime*." By this definition, students quickly understood how observation skills play a vital role in recognizing the evidence relevant to intentionally or unintentionally executed crime. The instructor soon observed that this interactive approach converted into the discussion and inquiry mode of learning. Once the inquiry mode of learning started, students reached their comfort zone and became highly competitive, and everyone tried to give their best.

However, after three sessions, students started losing focus, which led to the introduction of observation-based pedagogy. This is an active learning pedagogy, wherein the students took their own/others finger impression using stamp-pad ink and learnt how to take plain and rolled fingerprint on paper and then attempted to identify the type of pattern (Arch, Whorl, Loop). Once pattern recognition activity has been completed in the next session, they moved to learn how to classify these fingerprint impressions based on pattern characteristics [10,11]. First, they classified their fingerprint impression, and after that classified unknown fingerprint impressions using ten-digit primary classifications. Here, they also learnt how to take fingerprint impressions on a fingerprint chart.

In the sixth to seventh sessions, they learned about developing latent/invisible fingerprint impression via powder and chemical method using experiment-based learning pedagogy. In these sessions, they learnt how to select fingerprint powder (in contrast to the background on which latent fingerprint impression was present) to visualize the invisible fingerprint impression [11]. They also learnt to visualize fresh fingerprint impression on porous surfaces using the Ninhydrin chemical method and aged fingerprint impression by the physical developer method [10,12]. Moreover, students also learnt to preserve the developed fingerprint impressions using photography and tape lifting methods.

In the 8th session, the learners got acquainted with some specific fingerprint characteristics (Minutia), which play a vital role in matching and verification [13,14]. Observation-based learning pedagogy has been used to identify the specific characteristics in fingerprint impressions. After that, problem-based learning pedagogy was used in which unknown prints were given to the students for identification, matching and verification. Moreover, they interpreted their findings with a logical explanation. In this manner, critical thinking also became a part of this active learning exercise.

In the 9th session, another evidence was introduced to the learners, i.e., footprints/footwear impressions. In this session, students get acquainted with step length (distance between two successive placements of the opposite foot) and stride length (distance between two successive placements of the same foot) and how these two terms could play a vital role in gait pattern analysis and its forensic significance [15].

In the 10th session, blood pattern analysis was taught. Instead of using actual blood, students used simulated blood (red colour paint, beetroot juice etc.) for blood pattern analysis. In this session, experiment-based and problem-based learning pedagogies were used. The learners calculated the 'angle of impact' of blood droplet on various surfaces and 'height of fall' from different heights [16]. They got acquainted with various types of blood spatter like low, medium and high-velocity [17].

In the 11th session, the course moved towards document analysis. In this session, three different pedagogies were included to provide more knowledge and understanding to the learners. In this module, learners were taught about various types of forgery (alteration or obliteration or duplication) and its detection methods (non-destructive or destructive) [18]. Experiment based learning pedagogy was used to detect forgery while results were interpreted using observation-based pedagogy. "Signature and handwriting comparison & verification" activity was performed using observation-based pedagogy. Concurrently, secret and indented writing had been decoded using experiment-based pedagogy. Students also learned differentiation among various inks of ball pen and gel pen in this session using paper and thin layer chromatography methods. This ink analysis helps in the detection of various types of forgeries.

In the 12th session, the "security features" of currency note were discussed by the instructor. These features help distinguish genuine and counterfeit currency. The examination & identification of currency notes was performed using experiment-based and observation-based pedagogy. Security features were identified using oblique, transmitted and UV light sources. After completion of these activities, in the same session, unknown forged signatures, altered documents, secret and indented writings samples were given to the learners for examination and identification purpose. This part of the session was fully based on problem-based learning pedagogy. This pedagogy was the best way to evaluate the knowledge and skill of students.

In the 13th session, students got information about the 7 seven steps of the crime scene investigation procedure. In short, these steps are known as 7S steps (shown in Fig. 3).

Before creating the mock crime scene in session 14th & 15th, discussion on crime scene investigation procedure formed a background for learners. The mock crime scene investigation was taught using case and project-based learning pedagogy. It helped them to create and investigate the crime scene themselves. The class was divided into two teams. In the 14th session, Team A used their creativity and prepared a mock crime scene with various evidence; those are linked to each other to form a story. After that, team B investigated the mock crime scene prepared by team A using project-based learning pedagogy. Learners carefully investigated the mock crime scene, collected and examined the evidence found at the mock crime scene and finally made a report and interpreted the mystery. There was a role-reversal in the 15th session, with Team B creating the mock crime scene using case-based learning pedagogy and Team A investigated the mock crime scene using a project-based learning pedagogy approach. After completing this exercise, both teams submitted their investigation reports. This task helped to develop critical and logical thinking among the learners.

With the help of different pedagogical approaches in this course, an attempt was made to develop various skills such as the ability of deep thinking & articulating new ideas (using inquiry-based learning approach); concentration and patience level enhancement (using observation-based learning); ability to design and conducting experiments (using experiment-based learning); developing team spirit and prior knowledgeability (using problem-based learning); critical and analytical thinking ability (using case-based learning) and finally develop result interpretation skills (using project-based learning). These abilities develop the students' research aptitude that may help motivate them towards the research field [4].

4.1. Student feedback on different teaching-learning pedagogy

The instructor is teaching this course since 2016 and till now had taught four batches (20–30 students/batch). The former two batches were taught using the conventional approach, and later two batches were taught using the innovative approach, wherein significant changes were observed in students' approach to learning. Meanwhile, in one batch the same topic was taught with both conventional as well as the active learning based innovative

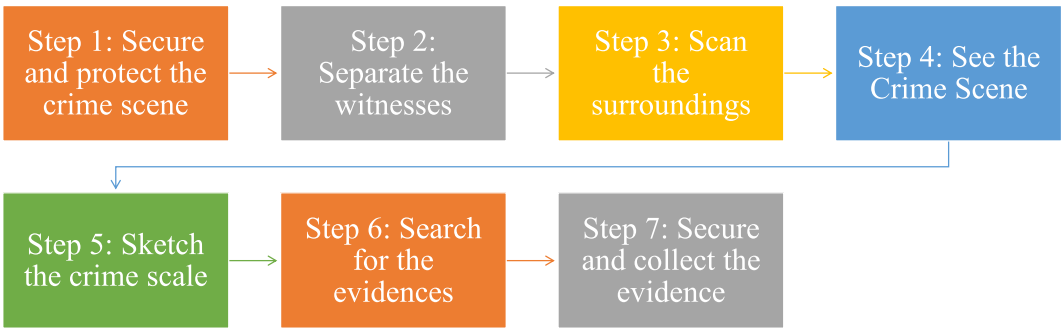


Fig. 3. 7 steps of crime scene investigation procedure.

approach. It was found that students were better engaged in the active learning approach. The learning and understanding about the topics were as well. For example, when they were taught about ridge characteristics (minutiae) then rather than the conventional approach, when students' saw these characteristics in their fingerprints, then they understood better.

Problem and observation-based questions were given to the students after both type of classes and it was found that if 30% students performed well after lecture-based approach of teaching then 80% of students performed well after active mode of teaching and learning. Similar types of problem and observation-based questions (e.g., fingerprint pattern identification and comparison with given reference sample) were assigned to the students after both approaches of teaching. It was found that after the lecture-based approach, only 6 students were able to successfully identify and compare them with reference sample and accurately interpret the results while similar questions had been accurately interpreted (identification and comparison of fingerprint) by 16 students after using active teaching and learning approach. Here, the term 'performed well' refers to the students who successfully identified the pattern accurately, compared it with the reference sample and correctly interpreted the results for matching/not matching of the questioned fingerprint.

Student feedback has been taken in this study to understand which pedagogy is most impactful. In this survey, all 20 students had given their feedback. Four different parameters (ease in understanding, concept clarity, engagement and developing skills) were used to evaluate it. Results shown in Fig. 4 indicated that all pedagogy used in this study were having their importance. Inquiry- and observation-based pedagogy were more impactful than others in providing concept clarity.

Meanwhile, case- and project-based pedagogy were practical in terms of ease of understanding the topics. Also, problem- and project-based pedagogy were most prominent to develop critical thinking and logical thinking skills. This feedback has exhibited that all pedagogies are equally essential, but their selection should be based on the topics.

5. Challenges

Although all the pedagogies worked well into the course, it was hard to decide how much prior knowledge would be required for students before using any learning pedagogies. Besides, the sequential arrangements of the learning pedagogies were also another challenge which is a debatable issue. Some teachers start with project-based learning and incorporate all other various types of pedagogies into it, while others do the opposite. In the present course, if the instructor started with project-based learning pedagogy and tried to assimilate rest all pedagogies into it, it would be difficult to know how many students understood the topic and how many developed the skill related to it. However, when the instructor started with different pedagogies and reached project-based learning pedagogies, time management was entirely disorganized because some skills took more time than stipulated time frames. Therefore, it was hard to manage two things simultaneously- 1) completing the course in the stipulated time frame and 2) student's understanding and the development of skills. In this situation, it is suggested to reduce the course content but not compromise students' understanding of the topic and skill development.

Student's engagement was another challenge because some students were quick learners while some were slow. Therefore,

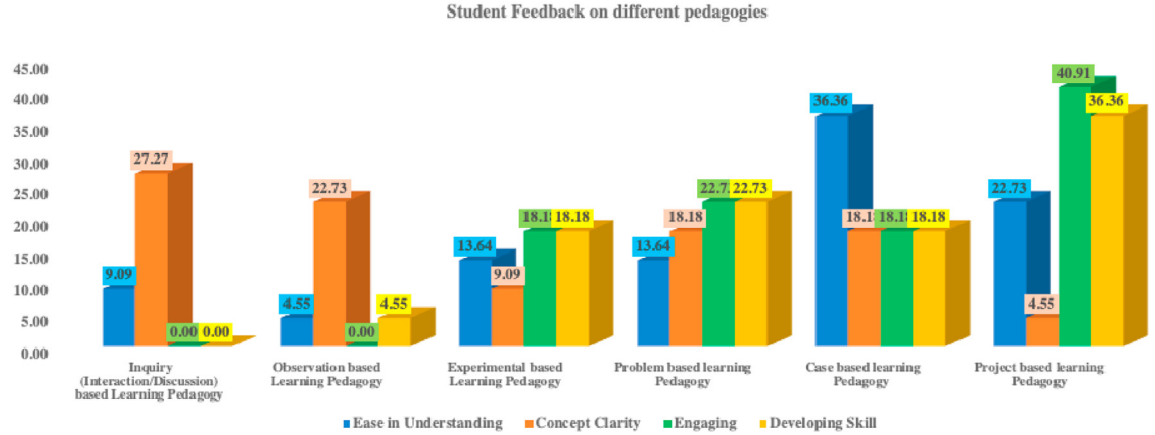


Fig. 4. Graphical representation of Students' feedback on different pedagogies used in the designed course.

their engagement times differed. Quick learners were easily distracted from the activities, and slow learners took more than the stipulated time. To resolve this issue, the 'peer tutor was the perfect activity. In this activity, quick learners helped the slow learner. Both were engaged in the activities and were able to finish the activities within the given time frame.

Written assignments were another challenge because of the easy availability of material on digital platforms. Therefore, project/problem-based assignments were given to the students in this course rather than a written assignment. With this type of assignments, students' learning and skill developing abilities were quickly evaluated.

6. Conclusion

With this article's help, an attempt was made to elucidate that it is high time to revamp the teaching-learning procedure and make them more skill and activity-oriented. Various teaching-learning pedagogies are available, and many more can be created through which teachers can deliver difficult topics with ease. This new teaching-learning approach provides a better understanding of the topics/course and develops the curiosity, skill, critical and innovative thinking in the learners that motivate them towards the research. This paper may help many other trainers/teachers develop their courses with similar patterns by using different teaching-learning pedagogies and shifting the education system's paradigm towards a new direction.

Declaration of competing interest

None.

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