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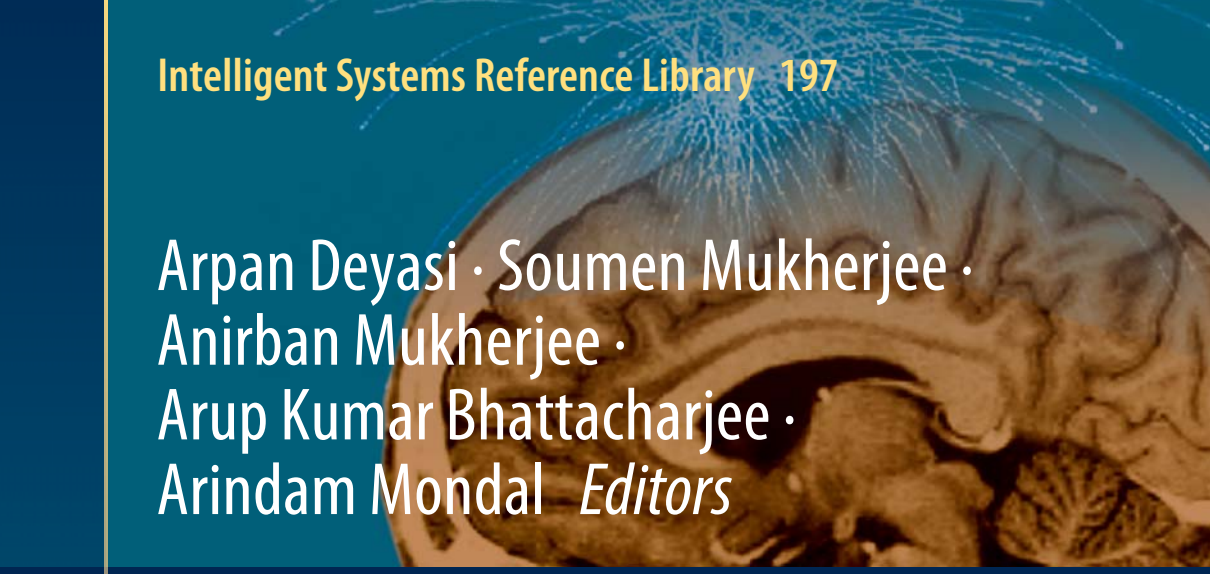

Arpan Deyasi · Soumen Mukherjee · Anirban Mukherjee · Arup Kumar Bhattacharjee · Arindam Mondal *Editors*

Computational Intelligence in Digital Pedagogy

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Anirban Mukherjee dedicates to
his mother Sunanda, wife Attreyee and son Ritam

Arpan Deyasi dedicates to
The teachers who ignites the passion for teaching

Soumen Mukherjee dedicates to
his father, mother, wife Koyal and eight-year-old son Aarush

Arup Kumar Bhattacharjee dedicates to
his parents, Sandhya and Mrityunjoy Bhattacharjee,
for always being there with him

Arindam Mondal dedicates to
his mother, wife and son for always loving and supporting him

Foreword

"If the mountain will not come to Muhammad, then Muhammad must go to the mountain," Francis Bacon writes in his essays in the year 1625. Quoting this, Swami Vivekananda introduces Maharaja of Mysore to a new idea in a letter written to him in the year 1894 that *"If the poor boy cannot come to education, education must go to him."* Not leaving at that Vivekananda also suggests a technique though rudimentary yet befitting its time. In the wake of Digital Revolution, taking the education to the doorstep of one and all with ease is a dream coming true for every educationalist.

Education with adroit promptness has at all times incorporated the then-emerging technologies in appropriate measure for its promotion and propagation. We are now in the era of data science, during which time it has become both trend and trade for a mass of apparently insignificant data to be subjected to the lens of algorithmic scrutiny in the hope of revealing meaningful insights into the past, present and/or future. The seemingly unobjective targets that have suffered so long with subjective bias are now, with improved precision, being rendered as estimable and thereby actionable metric. Such a reality is presented before us by a plethora of tools and techniques that have been developed over a period of time under the umbrella of soft computing which in its ever-evolving state is being broadly addressed as computational intelligence.

Computational intelligence has found application in every line of business that can promise to quantify facts and figures. Digital pedagogy being one such has been chosen as the theme of this compilation in which a lot of practitioners and researchers in the field of education have contributed their thought-provoking articles, their findings that can change the way we are practicing pedagogy, and their suggestions for the improvement of practices in vogue keeping intact the principle and philosophy of pedagogy. The time is opportune for such a publication to reach the eager educator to benefit.

I am sure that this much-awaited compilation will be widely received by educators at large and that it ushers in its trail a demand and compulsion to produce another comprehensive sequel under this theme.

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Preface

In modern science and engineering, didactics is primarily shaped and conceptualized by introduction of technology, where information-based teaching is integrated with experimental, computational and self-learning methodologies for producing better learning outcome. Among the different pedagogic methods, active learning, flipped learning, blended learning and adaptive learning are now the choices of researchers and practitioners with encouraging flexibility and scope offered by the digital media and technology. With the continuous development of new computing technologies like machine learning, deep learning, big data, data science along with the growing computing capacities of intelligent machines, new scopes and challenges are opening up for teaching–learning in higher education segment, precisely in engineering or technical education.

With national and international regulatory guideline of measurable program outcome, course outcome and program educational objectives in an ecosystem of outcome-based technical education (OBTE), it is now a challenge for the higher education institutes, administrators, educators and teaching staffs to continuously measure, monitor, analyze and redefine the outcomes and its parameters. Here comes the importance of digital pedagogy aided by computational intelligence. Intelligent capturing, analysis and interpretation of large amount of primary and secondary data lead to predictive outcome and also suggest necessary modifications in the rubrics and target outcomes. Evaluation being a major part of pedagogy, intelligent assessment of subjective and objective responses can be developed in online/offline mode that will necessitate imminent change in pedagogic strategies from the traditional ones to digital-based strategies; the later should include interactive teaching dashboard, online interactive course content (MOOC) with embedded assessment and polling mechanism, response-sensitive intelligent tutoring, etc.

Good use of AI across digital pedagogic platforms can make teaching–learning more independent of human factor (teacher/student quality), time and place and at the same time more impactful and enjoyable for the learners. Providing access to the digital media and learning tools (even to the extent of mobile apps) to the students would allow them to keep pace with innovations in learning technologies,

learn according to their own pace and understanding level and have instantaneous feedback and evaluation.

This book is a collection of fourteen chapters that depict some of the very recent unpublished research works, survey and case studies in the field of digital pedagogy and some very intriguing discussions, thoughts and analysis of perceived changes in the pedagogic strategies in technical education system. Examples of pedagogical possibilities that are both new and currently practiced across a range of teaching contexts are featured in the book. The chapters have been carefully selected out of several submissions following a rigorous review, revision and editing process. It is indeed encouraging for the editors to bring out this collection under Springer Nature edited series *Intelligent Systems Reference Library (ISRL)*, and the book is expected to evoke interest of researchers of different backgrounds owing to its cross-platform characteristics. An overview of the chapters of the book is given as follows:

The chapter titled *Authentic Pedagogy: A Project-oriented Teaching–Learning Method based on Critical Thinking* discusses at length a new pedagogical concept known as authentic learning which is an instructional learning strategy based on development of tangible prototypes through project-oriented activities. This strategy helps the learners develop solutions of real-world problems following agile methodology. The authors have shown the efficacy of the method by experimenting it with a group of learners and also compared the results with flipped learning method in technical pedagogy domain.

In the chapter titled *A Set of Empirical Models to Evaluate E-learning Websites and their Comparison*, design of an e-learning software evaluator has been proposed that will not only evaluate but also rank the different e-learning educational websites that are frequently referred by students and researchers. Students very often face problems in selecting an appropriate e-learning platform as they might not be well informed about the quality of the online courses and the e-learning software. The authors have proposed analytical hierarchical process (AHP) and Principal Component Analysis (PCA).

The chapter titled *Multimedia-based Learning Tools and Its Scope, Applications for Virtual Learning Environment* depicts the impact of multimedia-based interactive teaching material in the understanding of the content. The authors have shown with statistical analysis how multimedia and image processing tools are inevitable in web-based learning systems for online interactive self-learning which may well turn out to be the basic mode of learning for the future generation.

In modern teaching–learning as well as in academic administration, social media is gradually gaining in importance for its versatility of information dissemination and opinion exchange. In the chapter titled *Social Network Analysis in Education: A Study*, the authors have reported their unique research on how to detect useful data from massive databases of educational data in social media by applying some data mining algorithm. Such data is extracted to understand and measure the performance of student and is also helpful to study students' thinking pattern, weakness, focus, etc. For the academic administrators, such media-data mining technique helps them take important decisions by detecting a trend of opinion.

In the chapter titled *Personalization in Education using Recommendation System: An Overview*, the authors have presented the concept and benefit of e-learning recommender system, the primary aim of which is to assist users searching for e-learning content of their choice to cope with data overload of large pool of available materials. The authors have discussed five categories of basic recommender systems presently in practice and also compared pros and cons of some of the existing systems. Finally, while outlining few challenges of recommendation engine like gray-sheep problem, cold start problem, etc., a new recommendation framework has been proposed in this chapter which is expected to cope with some of these challenges.

The authors of the chapter titled *Automation of Attainment Calculation in Outcome-Based Technical Education (OBTE)* targeted an intelligent system to determine the attainment of outcome of a course automatically based on the classified student data and course rubrics. In view of national and international education policy, OBTE is fast becoming a mandatory standard. In this automated processing, huge academic data for calculation of attainment can help reduce manual involvement and ensure quality of information generated. A machine learning approach has been adopted to design the prototype system.

The chapter titled *Quality Issues in Teaching–Learning Process* deals with the quality issues mainly in the field of technical education system which is gradually transforming from traditional system to digital system but still facing the challenges of VUCA, i.e., volatility, uncertainty, complexity and ambiguity of LT process. In the context of digital pedagogy, the author discusses different ICT-based LT methodology including flipped teaching, collaborative learning, active learning and presented through a case study how digital pedagogy can promote independent learning among students.

There has been a paradigm shift in the scope and pedagogy of English language teaching in technical education domain in last ten years or so with introduction of language laboratory in the technical institutions in India. The learners are facilitated to master the fundamental English communication skills through digital pedagogy techniques aided by multimedia-infused visual, aural, audio-visual and verbal communication devices. The author presents the findings of an interesting research on the justification, advantage and future scope of trending pedagogy specific to English language laboratory in the chapter titled *Digital English Language Laboratory: Roles, Challenges and Scopes for the Future Development in India*.

The chapter titled *Overview and Future Scope of SWAYAM in the World of MOOCS: A Comparative Study with Reference to Major International MOOCS* presents a comparative study of SWAYAM, an online digital resource platform sponsored and developed by MHRD, Govt. of India, with respect to other international MOOCS to understand the future viability, sustainability and further scope of the same as SWAYAM is a benchmark standard of digital pedagogy in India. The study analyzes the effectiveness of SWAYAM courses on certain parameters and also proposes how intelligent tutoring features like augmented reality, simulated environment, virtual assistant and predictive guidance can be embedded in the

SWAYAM courses to make it more user-friendly and effective for personalized learning experience.

Blending of Traditional System and Digital Pedagogy: An Indian Perspective is another chapter that presents a study on changing scenario of teaching–learning in India and explores blending of digitized facilities in traditional system. At first, it gives a brief survey on blended learning. Then it presents two teaching–learning models incorporating digital technology—one is the Intelligent School Network for Research (ISNR) and the other is the Intelligent Feedback System for Classrooms (IFSC). It shows how formative assessment of learners can be done using intelligent data analysis.

In the chapter titled *Application of Internet of Things in Digital Pedagogy*, a novel application of IoT in digital pedagogy is presented by the authors. It describes how learners can access resources in a smart learning environment using IoT applications in their mobiles. A system is proposed that enables students to connect and interact with the augmented objects in their learning space to collect information which in turn improves their collaborative learning outcome. The system is validated by a experiment using control group and experimental group of students of engineering.

The authors of the chapter titled *An Innovative Step for Enhancement in Students Result and Teaching–Learning Process Using Educational Technology* have clearly explained the formative and summative assessment techniques of traditional pedagogy in higher education domain and in this context highlighted the possible application of AI and machine learning techniques in student's result analysis. Finally, the authors have presented statistical results of a case study that compared the learning outcomes of a traditional classroom and online digital classroom of computer science and engineering.

Digital Pedagogical Paradigm in Language Lab-based English Teaching for Higher Technical Education is another chapter of the book that deals with smart teaching of communicative English. It presents a digital pedagogical model that specifies how to handle digital language laboratory to develop communicative competence of UG engineering students. The authors elaborate how instead of using digital language laboratory as an alternative of smart classroom, specific strategies, dynamic lesson plans, interactive assessment techniques and software/hardware tools and facilities should be adopted or availed by English language teachers so as to fulfill the learning outcomes as per global accreditation norms.

In the chapter titled *A Novel Outcome Evaluation Model Blended with Computational Intelligence and Digital Pedagogy for UG Engineering Education*, a novel model is proposed which exhibits the importance of computational intelligence applied over input academic data of a higher education institution so as to achieve the benchmark criteria in program outcome. Novelty of the proposed model also lies in the fact that it considers any change of pedagogical techniques for benefit of the students, if necessary. The authors have indicated use of different soft computing, machine learning techniques including SVM, ANN, text mining, fuzzy logic, clustering and classification in different phase of data analysis to get the desired output.

The book does not claim to cover all possible applications of computational intelligence in educational technology but serves as an valuable pointer to the vast opportunity that exists in leveraging technological advancements in disseminating knowledge and skill to the digital age students and most seamlessly integrate digital pedagogy strategies in the day-to-day teaching–learning process so as to make it more effortless and enjoyable. The research works or ideas presented in the book are scalable in future and might become more relevant and valuable in near future when the AI wave is going to hit the higher education sector in an overwhelming manner.

It is needless to mention that the effort of the editors to bring out this volume would not have been successful without the valuable contribution and cooperation rendered by the authors. The editors take this opportunity to express their thanks to Springer Nature, to provide the scope to edit such a concise and quality volume on a theme on which not many titles are available. The editors would also like to express their heartfelt thanks to Mr. Maniarasan Gandhi, the Project Coordinator, and Mr. Aninda Bose, Senior Editor, Springer, for their encouragement and support right from the proposal phase. We are overwhelmed to receive the blessings of Swami Dhyanagamyananda, Head, Department of Computer Science, Ramakrishna Mission Vivekananda Educational and Research Institute, Belur, through his illuminating *Foreword* that speaks about the relevance of this compilation. Last but not least, the editors gratefully acknowledge the contribution of the reviewers who have shared their valuable expertise and time in meticulously reviewing the chapters included or excluded in this volume.

We sincerely hope that the proposed book would come to the benefit of researchers and administrators in education sectors. Since the book contains several methodologies of teaching and assessment using digital platform, it is likely to help the faculty members in colleges and also the teachers of schools to implement it in their day-to-day academics. Towards outcome-based course planning and assessment, this book can also be useful as it provides important pointers to application of soft computing techniques in data analysis and interpretation.

We invite any suggestion and criticism of this treatise from the readers with an open mind. This will help us to better shape the future volumes of this title. We also invite innovative research ideas or proposals or case study report or pointers to new avenues in pedagogy domain that can be explored. You can mail your ideas to the *School of Digital Pedagogy*, *RCCIIT, Kolkata* (at sdp.rcciit@gmail.com)—an initiative of the editors to foster research and practice in intelligent educational technology.

Kolkata, India

Arpan Deyasi
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Arup Kumar Bhattacharjee
Arindam Mondal

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Arpan Deyasi is presently working as an Assistant Professor in the Department of Electronics and Communication Engineering in RCC Institute of Information Technology, Kolkata, India. He has 13 years of professional experience in academics and industry. He received B.Sc. (Hons.), B.Tech., M.Tech. degree from the University of Calcutta. He is working in the area of semiconductor nanostructure and semiconductor photonics, and also on pedagogic principles. He has published more than 150 peer-reviewed research papers including book chapters, and a few edited volumes under the banner of CRC Press, IGI Global, etc. His major teaching subjects are solid state device, electromagnetics, photonics and pedagogical studies in P.G. courses. He is reviewer of a few journals of repute and some prestigious conferences in India and abroad. He has delivered a few talks and conducted hands-on sessions on nanolelectronics, photonics and electromagnetics in various FDP's, workshops and seminars. He is the Editor of various conference proceedings and edited volumes. He is a member of IEEE Electron Device Society, IE(I), OSI, IETE, ISTE, ACM, etc.

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Chapter 1
Authentic Pedagogy: A Project-Oriented Teaching–Learning Method Based on Critical Thinking

Arpan Deyasi, Swapan Bhattacharyya, Pampa Debnath, and Angsuman Sarkar

Abstract Authentic learning is a typical organized and systematic learning strategy which helps the learners to develop solutions in real-world problems guided by proper instructional approaches. Development of tangible prototypes is the primary target that can be achieved through instructional learning begins form classroom and laboratory sessions, which ultimately blossoms through project-oriented activities, following agile methodology. Results obtained after implementing the proposed technique over more than hundred learners depict that proper metacognition of learned concepts along with implementation of thinking skills through project-oriented activities can improve the potentiality of students in future industry/academia sectors. Results are also partially dependent with availability of infrastructural resources and socio-humanitarian factors, but a far better compared to the data obtained when flipped learning method is invoked. Learning outcome speaks clearly in favor of implementing the technique in a wider domain and student community, precisely in engineering teaching–learning method.

Keywords Traditional approach · Transfer of learning · Authentic learning · Pedagogy · Critical thinking · Project-oriented analysis

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1.1 Introduction

In Indian academic structure, college holds the transition phase between student and professional. The transition phase is significant in terms of both academic and industry perspective. It gives the flavor of real-life applications in prototype format where mode of learning becomes changes compared to school life. In general, traditional learning systems are till days followed in most of the undergraduate level institutions which follows the input–output-based system, i.e., the traditional pedagogical approach. Students are considered as passive learner which does not give the flavor of profound mastery through assimilation of content, but a superficial idea thanks to the total marks-oriented evaluation process. This type of education is alternatively called as content-driven education which basically follows a linear learning model and is not at all suitable to meet the demand of the present century, as per the reports published by Washington accord. Though curriculum has revised by different expert bodies in different levels of education of different subjects, but owing to the adaptation of same process, outcome remains almost indifferent. However, changes are slowly incorporating in this so-called process-driven education system by adopting outcome-based method, precisely in the technological education sector where application of the knowledge learned in the lecture theater speaks about quality of the learners [1–3]. Henceforth, in this chapter, our discussion will be mostly limited in the engineering education, and the impact of outcome-based method [4] compared to the conservative method.

Several methods are already discussed and published by different educationists in the last few years for incorporating the outcome-based system, and works are also extended in medical domain also where real-time work deals with life of human and animals [5]. Among the methods, flipped leaning [6], active learning [7], authentic learning [8] and blended learning [9] are the choice of teachers because of their novelties. Among them, a little bit focus is nowadays shifted into authentic learning where all the students are engaged in problem-solving irrespective of dimensions with the help of critical thinking. The problems are selected in such a way that only textbooks and conventional working formulae are not at all sufficient to reach the conclusion. It has also given some comfort zone to the teachers as it is completely structured in terms of providing instructions, and all the end results are properly collected in an organized fashion into portfolios. It is a mapping of classroom with the real world through the problem-oriented assignments, but completely controlled by instructions. Therefore, this type of learning can be considered as a series of well thought-out activities.

Concept of authentic learning is not very old; actually, it evolves with changing approaches of instructions inside the classroom [10]. Simultaneously, different cognitive processes are also discussed [11] for the sake of various learning methods. Basically, authentic pedagogy helps the learners to solve equivalent real-life problems in the four walls of classroom under instructional mode which is a shift of paradigm [12] from the well-known marks-oriented approach. The prototypes developed can be made a demonstrable product which helps a similarity analysis with the actual

product available or required in the demand situation. Role of teacher is converted from dictator to facilitator, also to become a project manager. Learning can be made from environment, but not in a whimsical fashion, but under the structured guidance.

In authentic learning (AL), not only concepts are utilized, but the knowledge is blended with the practical experience to ultimately produce a feasible outcome. The design or the prototypes may not always be experimental, but simulation works are equally accepted provided it is made under the environmental constraints. In this context, student's perspective becomes critically important [13] for successful implementation of the method. Different ways of support are also provided to the learner to achieve the goal, which can be shared with local as well as maybe with global community. Careful approach is made from teacher's point of view to implement optimal learning which is effectively utilized to produce meaningful tasks through regular practice and that involves multi-sensory activities.

Not only outcome is mattered, but quality of the method to achieve it becomes critically important and meaningful. The process should be ethical as per the norms and that is checked. Through several unit level tests and assignments, a productive skill set is generated by reiterative manner [14] within a pre-defined timeline. In this context, it is the demand of teacher from learner side that he/she should introduce the self-aggravated inquest methods to make the product, useful for at last a specific community.

A learner-side approach is different from the traditional approach in the form of role reversal. In the earlier age, authoritative figure is considered as teacher and students are forced to play the passive role. However, in all modern pedagogical methods, prominence is given to the learner as well in AL also [15]. Here, the concept of authority is lost, and a shared mode of responsibility is invoked for both the parties. Learning is given predominance over teaching. This happens as instructor is converted to facilitator, so learners are forced to take additional burden coming out from the passive shell. Role of the facilitator is more complex as all the learners do not possess the equivalent background, equal interests of all the subjects and equal foundation at the school level. Therefore, form the faculty's point of view, a deeper understanding is required. In active learning, teacher cannot impose restrictions [16], but in authentic learning, restrictions are transported in a submissive way through instructions of doing work. It is a sort of negotiation type of work. Each single module of a particular course in any academic curriculum that can be described in the classroom should have blended with authentic experience [17], the way the students can be familiar and quickly adopted. This is the objective of meaningful learning, where knowledge can be transferred from ceremonial education to practice. Help can only be provided from the facilitator side when it is desired.

The learning environment should be facilitative for AL, i.e., it should be supportive for all category of students as far as practicable where reflective questions are given weight. In order to do that, tasks should be organized in a careful manner where critical hypothetical situations are incorporated. This will permit the learners to think and to respond. The first is important in terms of cognitive skill, whereas the second one supports psychomotor action. A transfer between these two skills required organized debate and dialogue. Task should not be conventional, rather

challenging, and performance should be assessed both in formative and summative manner. Henceforth, in such situation, learner will take responsibility of learning [18] with the facilitation. Here comes the importance of modern teaching pedagogies, where authentic learning becomes vital due to its structured format. Critical thinking helps to take on the role of professionals with the proper transferability of knowledge. The tools and study materials are not exactly in the textbook format, but web-based contents are given more acceptance than the traditional resources of knowledge. In this context, one point can be emphasized that the role of textbook remains the same and may never be replaced, but accessing multiple data through browsing becomes a rather adopted method simultaneously which helps to solve real-life equivalent problems. Role of collaborative work in this context [19] becomes important to develop the process of critical thinking in the multidisciplinary environment.

In this present chapter, sample survey is carried out on few students where authentic pedagogy is implemented. Results are shown as is available on a few subjects and also compared with the data obtained using flipped learning technology. Though the set of students on which the modified curriculum are imposed are different than the students who have undergone the conventional teaching methodology, they belong to the same curriculum, and the same set of courses are considered. At the end, project-based work is invoked through instructional guidance, and results clearly support this pedagogic technique. Statistical analysis has been performed to test the null hypothesis, and result in certain cases speaks in favor of the choice of pedagogic method. The work has similarity with the management information system (MIS) using agile methodology and therefore established the need of this dyadic in present-day technical curriculum.

1.2 Comparative Studies Between Pedagogic Principles

Till date, a group of academicians proposed in favor of implementation of flipped learning replacing traditional input–output-based system owing to its uniqueness of giving learners more space, as well as it is a learner-centric approach [20, 21]. Flipped learning involves creating a classroom at home where a learner can proceed in h(is/er) own pace at own time [6], and the assignments are solved in the next day class. This is a reverse classroom strategy and is obviously gaining attention and popularity among students [22] in various countries, as well as parts of Indian educational institutions also. However, it is heavily dependent on the availability of digital resources and also of continuous communication along with infrastructural demand. Web-based learning environment is the need of present generation for students [23], and therefore, flipped learning becomes the choicest pedagogical technique nowadays. However, recent study shows that the technique generates poor results for a few subjects compared to that obtained from traditional teaching–learning approach [24], whereas for other subjects, it generates comparatively better result. A deeper inspection reveals that for physics or mathematics-oriented subjects in engineering education, flipped learning is miserably failure [44].

Implementation of active learning, as an alternative of flipped learning, is more feasible due to the requirement of less number of infrastructural resources. It does not require continuous uninterrupted Internet connections in the student's home and is a more systematic and pragmatic approach [25]. In this methodology, students practice complex group problems through Think-Pair-Share mode [26], and outcome is finally justified by project-based learning [27]. Project work gets the maximum importance where all the learning of theoretical and laboratory classes are tested, and its impact is measured by human performance and behavior [28]. Noticeable differences in terms of outcome at every major and minor aspect are observed [24]. From present Indian context, implementation of active learning is much financially justified than flipped learning methodology.

A combination of the abovementioned learning technologies is called blended learning, where focus is made on removal of mental barrier between learners and facilitators [24]. Lecture classes are converted into assignment-based, and emphasis is given on discussion forum [29, 30]. Findings after application of this methodology are also available in different literatures for graduate and undergraduate level of students [22, 25, 31, 32]. Results on Indian students are also reported very recently [24].

Authentic learning is very close to blended learning with very little disparity. It is primarily dependent on instructional guideline, and systematic progress is made. Proper instructional approach is applied on different set of learners, and measurable differences are recorded for its further use. Active learning is basically a subclass of authentic learning, which is project-oriented, but that has to be performed within the given instructions. This constraint is far practicable, but it is found that it produces comparatively better results than other pedagogical procedures returned. In this technique, the instructor has the opportunity to tune the performance and therefore gets some indication of student understanding of the material presented during the lecture itself. In the next section, a comparative study is presented between two different sets of students where flipped learning pedagogy and authentic learning technique are independently applied. Both the sets of students are from undergraduate technical level, and different types of courses are taken for the experiment purpose. Results and corresponding methodology become critically important, whenever applied to a large database in real world.

1.3 Procedure of Authentic Learning

Education of students either in school level or in degree courses is a really complex and difficult task which has to be performed relentlessly by teachers within a predefined time frame. Highly skilled and qualified teachers provide explicit instructions to train the students, as per the demand of the educational institutions and also of society. Professionals are bit more mature, and therefore, they can adopt various ways of learning [33] to develop skill, attitude and knowledge (information). The age of science and technology serves the data to all classes of people more easily,

and therefore, representing new information is not essential, but representing in the new mode becomes vital. The importance of right pedagogical approaches comes here and plays a vital role in shaping and nurturing young minds. Learners can get their required meta-cognitive and procedural knowledge about the outside world form the teaching–learning process and be measured as outcome of the course [33]. Professional courses are nowadays designed in such a way that it can develop the logical thinking process based on the accumulated concepts, and these concepts, whenever utilized for the benefit of mankind, may be termed as practical education. At that point, need of the education is succeeded. School level courses deal with natural science and elementary science, but these learning are mostly devoid of practical aspects, though curriculum is design for learner-centric perspective. Teaching–learning for these elementary science levels consists of classroom lecture, discussions, tutorials, laboratory classes, projects, seminars and field works. The pedagogic principle adopted at this juncture becomes the key player for outcome measurement.

The most popular teaching method is the lecture method where instructor can simulate and create interest among learners, and the people on the other side of the table can express their opinions or can create it. This is basically utilized to promote the learning. Through proper instruction, it can impart meaningful information and thereby develop critical thinking [34]. This method is popular in all the places across world, and it will remain popular as expected [35]. Through this method, a large number of audiences can be set into a particular tune, thereby saving time and helps to save financial crunch. Existing academic limitations can be overcome by lecture. However, different learners need different methods of inputs and time consumption also, and therefore, tutorials can play a vital role. This tutorial method deals with small no. of group size, so this is a suitable addition with the lectures [36]. A proper combination of lecture and tutorial can clear the concepts and prepare the learner for the next level, i.e., for implementation.

Lecturing is the choicest method in a large size class, and scarcity of human resources makes the demand. However, once the phase is over, hands-on experience plays the vital role, which is termed as laboratory class. Also in semester system, this method is the most suitable to cover a large size audience [34]. In the laboratory sessions, where implementation and design have the sole objectives, learners can get the space and infrastructural opportunities so that the learned concepts can take shape. Now this procedure looks almost similar to active learning [37]. However, a small difference exists between these two. Activity learning consists of different activities performed immediately after theoretical learning [29]. However, role of instructional guideline is not a major factor in the activity guideline is not a major factor is the activity guideline [38]. But in case of authentic learning, laboratory classes are based on instructional guideline initially. The implementation phase consists of design-oriented problem, i.e., the project-based activities have the flexibility, where outcome is the only fundamental criterion. The varieties of activities are not primary in authentic learning, but care is taken in such a way that optimal number of activities is enough to learn and assimilate the concepts learned in theoretical classes. Group

discussions and seminar presentations are the two popular activities for literature-type courses, where proper instructional guideline makes the learner to understand the real-world problems better.

Project-based activity is the implementation phase where learner can be accommodated with real-world problems and will try to solve that [39]. Activities that must be followed are designed specifically for students to use it at home and in the society for promoting knowledge and can be used in many places and in solving different environmental complications. However, choice of problem is partially controlled at the initial phase through instructional guideline. So the term 'authentic' is justified, and more precisely, the development life cycle of the project almost follows the agile methodology [40]. This completes the total procedure of authentic learning, quite contrary to flipped learning, and almost similar to activity learning. In the next section, vis-a-vis comparative study is performed between different pedagogic procedures.

1.4 Incorporation of Statistical Analysis

For authentication of the findings obtained through different pedagogical techniques, we have introduced a few statistical analyses. A few related works are already published in various literatures where multiple linear regression methods are invoked [41, 42]. It is considered as one of the major statistical techniques for predicting student's performance and therefore can safely be chosen for understanding the impact of pedagogy on learning outcome. Also the quality parameters at the end play a pivotal role in selecting the right mode of pedagogy where significance value becomes critically important. Under this situation, *t*-test can be considered as a tool for performance measurement. A few works are reported earlier involving *t*-test [43]. Therefore, we have also incorporated his method. Results of both the methods are summarized properly in the next section along with the detailed tables obtained. Important findings are properly highlighted, and significance of the results is discussed. Key features from the analysis are critically mentioned in the conclusion section with an overall comparative study between two pedagogic principles, and pros and cons of both of them are mentioned.

1.5 Results and Discussions

Two different sets of students are considered for performance analysis in consecutive two years. One group is subjected to flipped learning, whereas other group is undergone authentic learning technique. All the learning subjects are kept same under the same curriculum so that comparison can be justified. Results are also compared with the data obtained from active learning technique, wherever possible. Also the

feedback data are compared as the effectiveness of teaching, which can be utilized to monitor the progress and the modification of applied technique in the next cycle.

1.5.1 Performance

The first analysis tarts with the performance of students in the first year of UG course, and data are taken consecutively for two years. Comparative study is performed with the students' undergone flipped learning techniques. Table 1.1 deals with the attendance for flipped learning, whereas Table 1.2 consists of the data for authentic learning. Significant positive changes are given in blue color, whereas negative changes are indicated by red color (above 70%).

A closer inspection between two tables shows that flipped learning technique becomes effective in humanities discipline or where mathematical/physical application is less. It is also successful for programming-oriented papers. However, for physics and electronics engg-related papers, flipped learning failed miserably. This statement can more be justified once we will move toward the result analysis. Henceforth, flipped learning methodology can be applied from case-to-case basis.

Once the performance is obtained, we have carried regression analysis on the available dataset to analyze the effect of both the pedagogic principles on their grades in classes for specific subjects. The summarized results obtained after regression analysis are organized in Table 1.3 and Table 1.4, respectively. /result is computed

Table 1.1 Performance for the papers when flipped learning is invoked

	Chemistry		Physics		Mathematics		English language for communication		Programming language		Basic electronics engg		Mechanics	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Above 90%	9.47	13.28	57.49	32.18	57.11	13.59	7.28	23.1	8.04	30.12	55.49	30.28	55.32	29.12
80 – 89%	19.47	24.52	25.09	21.46	26.41	33.33	7.9	35.34	17.09	29.58	27.23	20.42	26.38	18.08
70 – 79%	29.47	22.19	13.94	18.39	11.2	9.56	29.73	35.27	25.13	20.12	14.52	17.98	12.34	15.85
60 – 69%	9.47	18.28	3.14	10.34	0.5	20.7	45.53	4.32	35.18	8.25	2.02	11.28	3.57	16.31
below 60%	25.79	21.32	0.33	17.16	0.1	21.2	3.33	0.35	14.37	4.93	0.45	18.97	0.65	18.79