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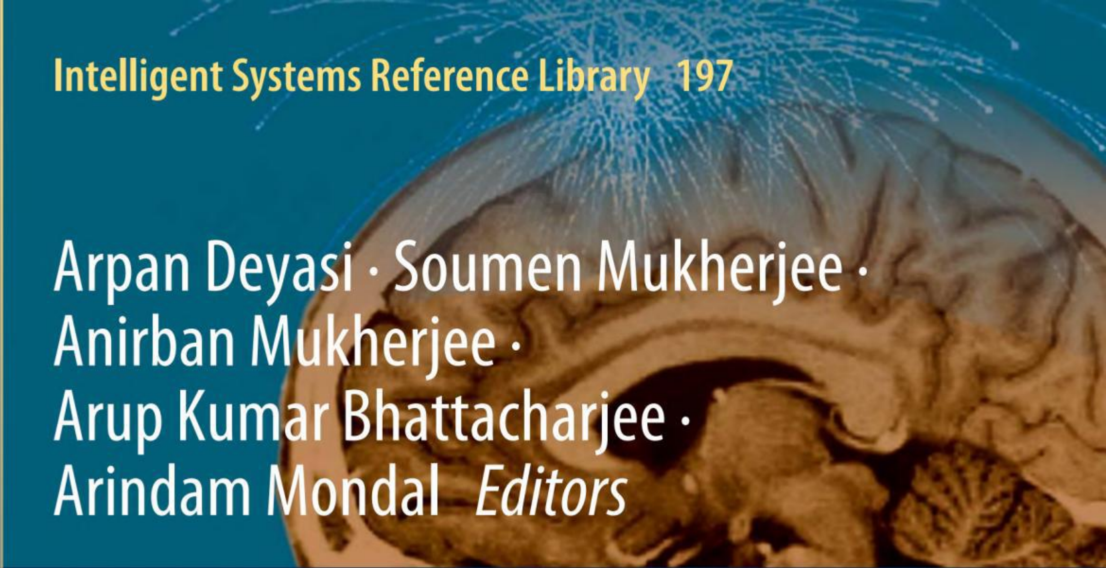

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Computational Intelligence in Digital Pedagogy

Springer

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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 currculum 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

Table 1.2 Performance for the papers when authentic 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%	46.32	58.25	35.78	47.24	45.12	23.59	15.23	13.54	9.04	4.12	33.57	42.57	45.21	48.12
80 – 89%	23.1	26.2	20.71	25.34	32.12	33.33	9.52	11.23	21.65	22.34	28.7	35.16	25.36	28.87
70 – 79%	19.98	7.14	15.74	9.65	8.58	19.56	26.38	24.34	27.18	26.17	20.14	8.9	14.32	9.25
60 – 69%	4.2	3.25	14.51	7.58	3.21	10.7	34.87	28.5	30.2	38.28	4.89	7.41	2.34	6.3
below 60%	2.1	2.65	5.47	3.7	2.3	11.2	5.8	9.78	4.89	3.73	7.54	2.43	7.12	1.34

Table 1.3 Summary of the data obtained after regression analysis for flipped learning

Performance parameters	Chemistry	Physics	Mathematics	English language for communication	Programming language	Basic electronics engg	Mechanics
P-value	0.17133	0.037712	0.040468	0.841592	0.391982	0.038087	0.051898
R-Value	0.516544	0.808944	0.01331	0.015559	0.24914	0.807736	0.766049

Table 1.4 Summary of the data obtained after regression analysis for authentic learning

Performance parameters	Chemistry	Physics	Mathematics	English language for communication	Programming language	Basic electronics engg	Mechanics
P-value	0.014467	0.007663	0.120221	0.00133	0.005146	0.029309	0.00546
R-Value	0.897102	0.932131	0.607378	0.978673	0.947784	0.837428	0.945704

for all the seven subjects as given in the tables, and three most significant factors are evaluated. Those are [*i*] Significance-*F*, *R*-value and *P*-value.

From the above analysis, it is found that if we incorporate flipped learning, grade is severely deteriorated in physics, mathematics, basic electronics engg and mechanics, which is established from the *P*-value. This is one significant determination form regression analysis, satisfied the dataset shown in Table 1.1. For physics and electronics, this is predicted and previously also reported for another different dataset [24]; here, the same is observed from the *R*-value. Henceforth, flipped learning model is not applicable to the analytical subjects, but can surely be applicable for programming language, English and chemistry.

Consequently, if we adopt authentic learning method, it is found that except the mathematics, it provides significant improvement for all other subjects and negative impact on programming language (combined with Table 1.2). Henceforth, for computer language teaching, flipped learning is the most suitable technique, whereas for core science and engineering papers, authentic learning pedagogy proves its supremacy. A few tables obtained from regression analysis are given below for both the pedagogical techniques (Tables 1.5, 1.6, 1.7 and 1.8).

After performance evaluation of the first year of students, we have computed the attendance variation w.r.t the year 2015. Corresponding variations of result and placements are also tabulated. Data are shown in tabular format in Table 1.9.

From the analysis, it is found that flipped learning is not the best alternative considering different socioeconomic scenario of learners, but in some cases, it works fine. But authentic learning, when proper instructional guidance is provided, works better for all the sections of people. Corresponding outcome is reflected in results and placement scenario.

1.5.2 Quality Analysis

Next we have carried out comparative analysis of feedback for both the cases and compared with existing data. Results are shown in Table 1.10. Graphical representation of the data is given in Fig. 1.1, separately for three classes. It may be presumed that different reference levels are considered for making the classes. Figure 1.1a represents the 'delighted' students, Fig. 1.1b speaks for 'confused' students, and Fig. 1.1c indicates data for 'boring' students.

Now the authenticity of the result can be analyzed by *t*-test. So we have performed *t*-test for all three datasets, and results are summarized in Table 1.11. From the results, both *t*-stat and *P*-value are obtained.

Henceforth, it is justified from the *t*-test that authentic learning is enjoyable for students across all subjects compared to flipped learning (dataset is taken considering the overall experience). This pedagogy can significantly improve the quality of students by engaging more students and can be justified from the *P*-value for delighted students as well as from the *P*-value of boring students. Since *P*-value indicates significant changes, henceforth it is significant or both increment and reduction. A few tables from the *t*-test are given below (Tables 1.12, 1.13 and 1.14):

Table 1.5 Regression analysis for performance in programming language under flipped learning

Summary output								
Regression statistics								
Multiple *R*	0.492326349							
R-square	0.242385234							
Adjusted *R*-square	−0.010153022							
Standard error	10.54058215							
Observations	5							
ANOVA								
	Df	***SS***	***MS***	***F***	***Significance-F***			
Regression	1	106.63706	106.63706	0.9597961	0.399485126			
Residual	3	333.31162	111.10387					
Total	4	439.94868						
	Coefficients	***Standard error***	***t-stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	28.15521775	9.6000771	2.9328116	0.0608623	−2.39651215	58.70 6948	−2.3965122	58.70694765
X variable 1	−0.440495578	0.4496267	−0.9796918	0.3994851	−1.871408304	0.9904171	−1.8714083	0.990417149

Table 1.6 Regression analysis for performance in basic electronics engineering under flipped learning

Summary output								
Regression statistics								
Multiple *R*	0.8987412							
R-square	0.8077357							
Adjusted *R*-square	0.7436476							
Standard error	11.454615							
Observations	5							
ANOVA								
	Df	***SS***	***MS***	***F***	***Significance-F***			
Regression	1	1653.6849	1653.6849	12.603518	0.0380868			
Residual	3	393.6246	131.2082					
Total	4	2047.3095						
	Coefficients	***Standard error***	***t-stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	−38.927389	17.355486	−2.2429444	0.110659	−94.160291	16.305512	−94.160291	16.305512
X variable 1	2.9753052	0.838 0803	3.550 1433	0.038 0868	0.3081596	5.6424508	0.3081596	5.6424508

Table 1.7 Regression analysis for performance in physics under authentic learning

Summary output								
Regression statistics								
Multiple *R*	0.965469							
R-square	0.932131							
Adjusted *R*-square	0.909508							
Standard error	3.352424							
Observations	5							
ANOVA								
	Df	***SS***	***MS***	***F***	***Significance-F***			
Regression	1	463.068	463.068	41.20283	0.007663			
Residual	3	33.71623	11.23874					
Total	4	496.7843						
	Coefficients	***Standard error***	***t-stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	7.233332	2.301503	3.142874	0.051549	−0.09108	14.55774	−0.09108	14.55774
X variable 1	0.59933	0.093369	6.418943	0.007663	0.302188	0.896472	0.302188	0.896472

Table 1.8 Regression analysis for performance in chemistry under authentic learning

Summary output								
Regression statistics								
Multiple *R*	0.947155							
R-square	0.897102							
Adjusted *R*-square	0.862803							
Standard error	6.596643							
Observations	5							
ANOVA								
	Df	***SS***	***MS***	***F***	***Significance-F***			
Regression	1	1138.158	1138.158	26.15511	0.014467			
Residual	3	130.5471	43.5157					
Total	4	1268.705						
	Coefficients	***Standard error***	***t-stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	5.263826	4.008107	1.313295	0.280498	−7.49176	18.01941	−7.49176	18.01941
X variable 1	0.711672	0.139156	5.114206	0.014467	0.268816	1.154528	0.268816	1.154528

Table 1.9 Comparative study of attendance, result and placement attributes

Attribute	2015	2016 (For authentic/active learning [24])	2017 (For authentic/active learning [24])	2016 (For flipped learning)	2017 (For flipped learning)
Student's attendance (Grade = 5)	30	44	52	52	49
Student's result (Grade = 10)	43	60	75	58	53
Student's placement (Grade = 10)	75	88	89	80	78

Table 1.10 Comparative analysis of student's feedback under flipped mode

Parameters	Flipped learning [24]			Authentic learning		
	Delighted	Confused	Boring	Delighted	Confused	Boring
Quality of content	76	9	11	85	10	4
Delivery	74	14	10	88	6	5
Clarification of concepts	69	15	12	76	13	9
Teaching the subject matter	73	13	12	79	13	7
Overall experience	71	14	12	76	15	6

1.6 Conclusion

Data suggest that both authentic learning and flipped learning are excellent pedagogical techniques for improvement of performance. However, different socioeconomic and environmental conditions are responsible for its effective implementation. From the statistical analysis, it is found out that significance performance improvement is done when authentic learning is invoked for science as well as for core engineering papers, whereas humanities and computer engineering learning can be boosted if flipped learning is considered. Therefore, authentic learning gets the preference and that enhances the active participation of students, justified from the *t*-test results.

Apart from statistical data, it may be considered that infrastructural requirement for flipped learning technique is a source of major concern and that is why authentic learning or active learning becomes popular irrespective of sections and categories. Different aspects are considered for learner's feedback where appreciation is better received for authentic learning. Though these data on which preliminary investigation is carried out, can't provide conclusive results, and therefore a large dataset is required for a prolonged period for further conclusion, a reflection can be obtained from the

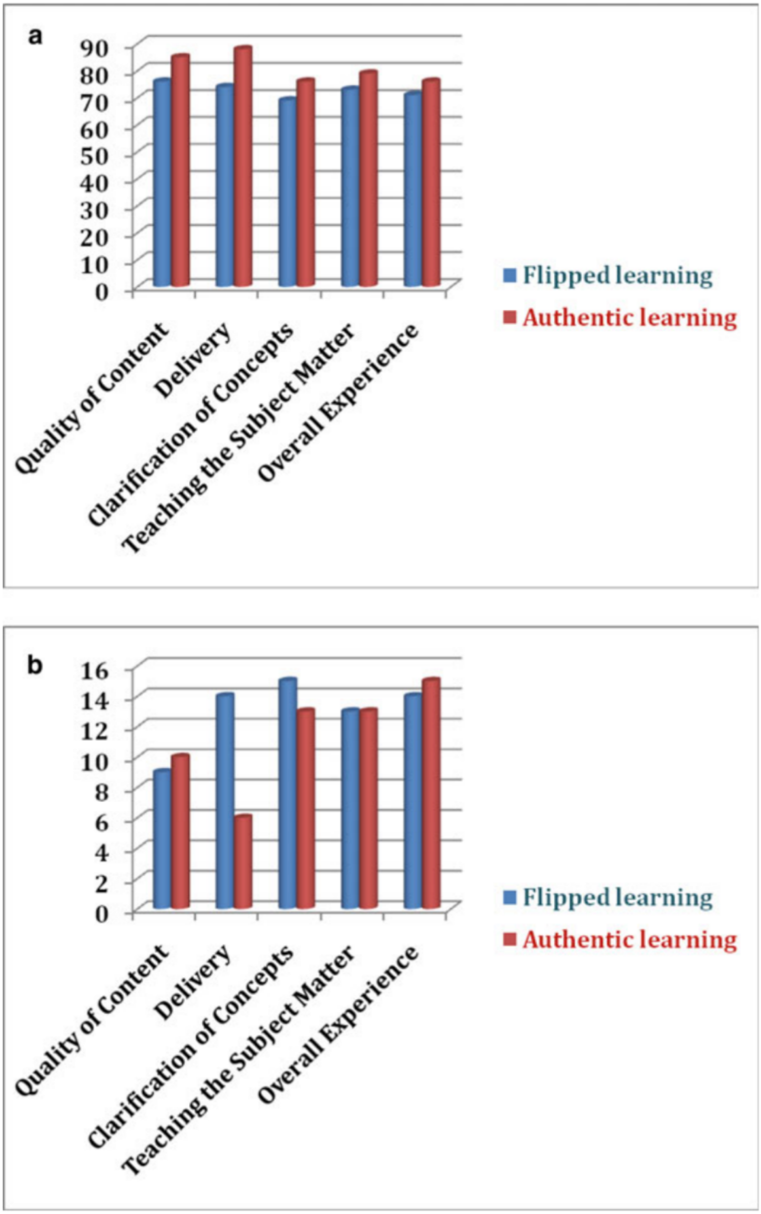

Fig. 1.1 **a** Bar diagram for 'delighted' students. **b** Bar diagram for 'confused' students. **c** Bar diagram for 'boring' students

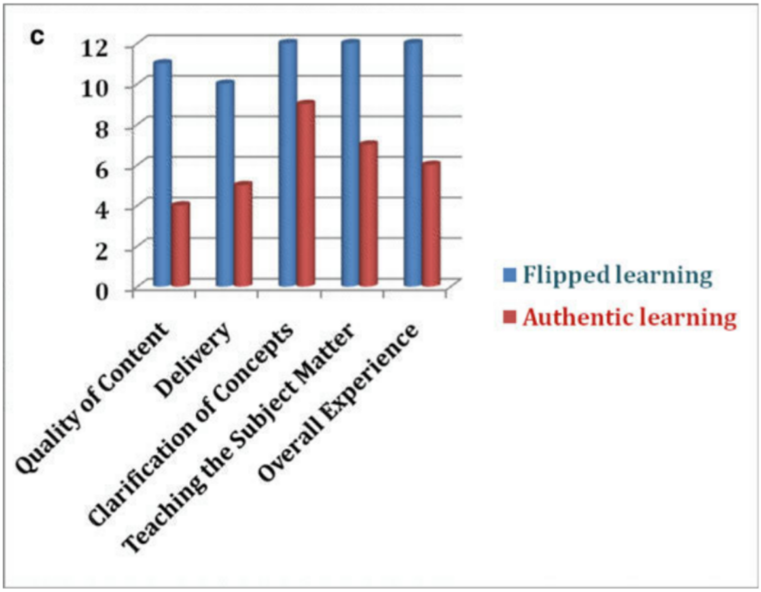

Fig. 1.1 (continued)

Table 1.11 Results obtained from t-test for the data given in Table 1.10

	t-stat	P-value
Delighted	-2.62448	**0.039349**
Confused	1.1163113	0.306989
Boring	4.800266	**0.003**

Table 1.12 t-test result for 'delighted' students

	76	*85*
Mean	71.75	79.75
Variance	4.9166667	32.25
Observations	4	4
Pooled variance	18.583333	
Hypothesized mean difference	0	
Df	6	
t-stat.	−2.624479	
$P(T \leq t)$ one-tail	0.0196747	
t Critical one-tail	1.9431803	
$P(T \leq t)$ two-tail	0.0393494	
t Critical two-tail	2.4469118	

Table 1.13 *t*-test result for 'confused' students

	9	*10*
Mean	14	11.75
Variance	0.6666667	15.5833333
Observations	4	4
Pooled variance	8.125	
Hypothesized mean difference	0	
Df	6	
t-stat.	1.1163126	
$P(T \leq t)$ one-tail	0.1534943	
t Critical one-tail	1.9431803	
$P(T \leq t)$ two-tail	0.3069886	
t Critical two-tail	2.4469118	

Table 1.14 *t*-test result for 'boring' students

	11	*4*
Mean	11.5	6.75
Variance	1	2.91666667
Observations	4	4
Pooled variance	1.9583333	
Hypothesized mean difference	0	
Df	6	
t-stat	4.800266	
$P(T \leq \mathrm{t})$ one-tail	0.0015	
t Critical one-tail	1.9431803	
$P(T \leq t)$ two-tail	0.0029999	
t Critical two-tail	2.4469118	

findings as represented in this chapter. Only first year of engineering students is considered for evaluation purpose, and implementation in higher-order classes is required for further verification and validation.

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Chapter 2
A Set of Empirical Models to Evaluate E-learning Web Sites and Their Comparison

Soumili Dey, Suchandra Datta, Anal Acharya, and Debabrata Datta

Abstract With the advancement of network technologies, Internet users including students and researchers have switched to online learning options or simply e-learning modules due to wide range of advantages. Many educational Web sites have come up with various online courses or e-learning software to facilitate e-learning. However, without proper guidance, students might face problems in selecting an appropriate e-learning platform as they might not be well informed about the quality of the e-learning software. Such a well-designed evaluator of e-learning software would not only help to find the best-fit e-learning software, but also to resolve information overloading problem. Hence, evaluating and recommending appropriate e-learning software becomes a vital concern. In this research work, an e-learning software evaluator has been designed not only for evaluating but also ranking the e-learning educational Web sites. This article uses analytical hierarchical process (AHP) and principal component analysis (PCA) to evaluate e-learning software. The results of these were then compared parametrically.

Keywords MCDM · AHP · PCA · E-learning evaluator

2.1 Introduction

The exponential growth of computer networks resulting in the birth of the ubiquitous World Wide Web has led to the growth and expansion of e-learning. E-learning refers to acquiring knowledge or skill pertaining to a particular topic from materials accessible through some communication networks, notably the Internet and viewed on some electronic devices. E-learning radically changes traditional learning scenarios in the sense that everyone has access to information irrespective of previous formal education, independent of location, cost-effective solution to learning and flexibility of accessing the material. Using this method of learning, it is possible for students

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multiple criterion can also solve real-life problem which are characterized by interdependent criteria exhibiting feedback-like effects. A new hybrid dynamic multiple-criteria decision making (HDMCDM) was proposed to solve interdependent and feedback situations in field of economics and business. It improves interrelationships among criteria to achieve aspiration levels. Some techniques are offered to integrate performance in super-additive/non-additive value function situation. A comprehensive study on how gaining knowledge has changed in this digital age shows that information and communication technology has provided with a new improved framework for teaching and learning purpose [6]. It highlights the use of digital media like journals, Web sites, blogs, educational videos that are of use to teachers and students alike, facilitated with infrastructure to support online learning. It focuses on the numerous initiatives taken to introduce good quality online educational programs at higher education levels, thus bringing in a need to rank the numerous sites to help new learners to choose sites that would help them to learn effectively.

Adequate digital access and how it affects the learning capability of the students should also be quantified [7]. The paper investigated the performance gains of students from digital pedagogy. The findings are to be focused on, so that teachers can facilitate the process while avoiding any pitfalls. The study found that the creation of material as understood by students and made available on digital platform greatly enhanced their learning procedure. It formulated four important principles, namely knowledge comes from research and practice, achievement issues addressed by digital pedagogy, evaluating the effectiveness of innovations improves practice and attention to systemic change.

AHP has been studied extensively and is used in almost every application related with MCDM. It has been seen that instead of using AHP alone, it has been used with combined mathematical tools such as mathematical programming, quality function deployment (QFD), meta-heuristics, SWOT analysis, and data envelopment analysis (DEA) and was proved to be better. The analysis of application of integrated AHP has answered three questions: which integrated AHP was more widely used, which area the integrated AHP were prevalently applied to, and was there any inadequacy of the approaches. If such inadequacy existed, then what were the possible improvements and future works. AHP had also found its application in enhancing strengths, weaknesses, opportunities, and threats (SWOT) analysis. The SWOT analysis is a generally used tool which examines strengths and weaknesses of organization or industry together with opportunities and threats of the marketplace environment. AHP approach achieves pairwise comparisons among factors or criteria in order to prioritize them at each level of the hierarchy using the eigenvalue calculation. AHP is mainly used for prioritizing and comparing the SWOT factors [8]. AHP has also been applicable in economic, social, political, and technological areas. AHP is not only useful in decision making but also in planning, conflict resolution, and forecasting. The main mathematical models on which economics has based its quantitative thinking up to now are utility theory which uses interval scales and linear programming. The axiomatic foundation of utility theory uses gambles or lotteries to elicit judgments about utilities from decision makers. However, AHP offers economists a substantially different approach to deal with economic problems through ratio scales. AHP offers psychologists, sociologists, and political scientists the methodology that they have sought for some time to quantify and derive measurements for intangibles. AHP also helped providing people in the physical and engineering sciences with a quantitative method to link hard measurement to human values. In such a process, one needs to interpret what the measurements mean.

The applicability of PCA as a ranking tool has been investigated in numerous research papers over the years. PCA has been used to rank World Universities, and the results are compared to QS world ranking results [9]. Performance indicators are selected depending on the QS World University rankings, covering aspects of research, teaching, employability, and internationalization. The variables are academic reputation as measured through a global survey, employer reputation, student-to-faculty ratio, citations-per-faculty, international faculty ratio, and international student ratio. QS World University rankings are the publication of the rankings of world universities by Quaquarelli Symonds. It is the only international ranking that has received International Ranking Expert Group approval.

In contrast to QSWUR which assigns weights to the selected variables on an individual basis, PCA strives to assign weights as a whole depending on their collective contribution. It essentially investigates the correlation between the variables. These values were standardized by converting the numerical value of the ranks to corresponding percentages. The principal components are calculated, and sum of each principal component multiplied with its variability gives the final value of the rank. The higher the value of the rank, the better is the rank. There is some difference between the ranks given by PCA and those given by QS. The discrepancy arises due to the fact that PCA extracts the principal components at first, thereby establishing a relative scale of weights which is not predetermined.

PCA has also been used for ranking sports related data, namely player ranking for cricket players [10]. The batting variables used are runs, batting average, batting strike rate, fours, sixes, and a new variable that was constructed combining the number of centuries with the number of fifties in an innings. The histograms for the variables were investigated, and a matrix plot of the variables revealed some correlations between the variables. High values of the variables mark the better performance of a player with respect to only that variable, but their joint contribution to performance is to be calculated. A similar treatment is made of the batting variables. Players are ranked then using the usual method for PCA, and a discrepancy with the ranking obtained from Ramakrishnan method is noted. It maybe attributed to the fact that PCA takes into consideration more variables than the other method.

In [11], further applications of PCA are investigated but in a different context. An attempt is made to propose an information quality framework for ranking e-learning sites, but PCA is used to rank or find the relative importance between the factors under consideration. Using linear regression, the relative importance of each dimension inside the quality factors is calculated. To measure the reliability of the research results, Cronbach's coefficient alpha is considered where the minimum accepted value can be extended to 0.6 [12, 13]. To further improve the reliability, data items which showed very little corrected correlation were removed. The results show that there are three information quality factors in e-learning systems since the

2.3.3 Proposed Model Using AHP

AHP or analytical hierarchical process is one of the MCDM or multi-criteria decision-making methods that were developed by Thomas L. Satty. A complicated problem is decomposed into a multilevel hierarchical structure with respect to the objective, criteria, and alternatives and hence expressing the general decision operation. Pairwise comparisons are performed to derive relative importance of the variable in each level of the hierarchy and/or appraise the alternatives in the lowest level of the hierarchy in order to make the best decision among alternatives. When subjectivity exists and where a problem can solved by organizing the decision criteria and the subcriterion in a hierarchical way, AHP becomes an effective decision-making method [19].

The three main operations in AHP, includes hierarchy construction, priority analysis, and consistency verification. The hierarchy construction step involves breaking down complex multiple criteria decision problems into its component parts of which every possible attributes are arranged into multiple hierarchical levels [20]. The priority analysis step involves a construction of several pairwise comparison matrixes. The pairwise comparison matrix is a manual interface with users or the decision makers which contains almost precise form of quantified weights of the comparisons of the criteria in a pairwise fashion. Since the comparisons are carried out through personal or subjective judgments, some degree of inconsistency may arise while constructing the comparison matrixes. To guarantee the judgments are consistent, the final operation called consistency verification is regarded as one of the most advantages of the AHP. It is incorporated in order to measure the degree of consistency among the pairwise comparisons by computing the consistency ratio. If the consistency ratio exceeds a certain limit, then decision makers should review and revise the pairwise comparisons. Once all pairwise comparisons are carried out at every level, and are proved to be consistent, the judgments can then be synthesized to find out the priority ranking of each criterion and its attributes. The ranking procedure would enable the users to choose the most appropriate e-learning software.

AHP is used to determine relative priorities on absolute scales from both discrete and continuous paired comparisons in multilevel hierarchic structures. The prioritization mechanism is accomplished by assigning a number from a comparison scale (see Table 2.1) developed by Saaty [21] to represent the relative importance of the criteria. Pairwise comparisons matrices of these factors provide the means for calculation of importance [19] (Table 2.2).

In the proposed model, we break down the complex multi-criteria decision-making problem into a hierarchy of interrelated decision elements. Here, selecting the appropriate alternatives or educational Web site is the decision to be made, and multiple criteria are the parameters considered for selecting the Web site (Fig. 2.1).

In the next step, we create the pairwise comparison matrix which comprises of the comparisons of the criteria and the available alternatives. The construction of the matrix is done by determining the relative importance of the criteria. In each level, the criteria are compared pairwise according to their levels of influence and based

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lockdown phase in India ushered in the boom of digital pedagogy, and it opened the lock gates of AI-based **Virtual Lab** for Higher Technical Education in India.

In a general English language teaching course, faculty members often emphasize on teaching the basic four skills namely **Listening, Speaking, Reading** and **Writing (LSRW)**. Digital pedagogy of Technical English Communication focuses on presentation skill and digitally controlled practice sessions of roughly tuned input/receptive skill activities or communicative activities that centre round the issue of **real-life problem solving**. Different student grouping models may be used for ensuring group dynamics and team work in digital framework based on AI-based Web tools.

If the technical English communication faculty members have the scope of using a large variety of digital techniques and SBA[27], then the former can apply their honest effort for upgrading lesson plan to cope up with the requisite standard of digital pedagogy.

In a digitized learning environment, Technical English Communication learner may feel positive about learning Technical English Communication in digital mode. They can finish their digital learning activities and take part in digitized evaluation process at their own pace and own urge. The technical students do never feel good about Humanities and Social Science classes as well as Law and Management classes due to theoretical approach followed in classroom situation under traditional pedagogy. As a result of DCA[28] or SBA that are enjoyable, the technical students of higher education will learn useful communication nuances of English for technical communication within the scheduled period of time that they could never learn before in a traditional setting.

Finally, we must not forget to boot that **Digital Pedagogy** will work effectively only if the control of operation is in the hands of a well-trained English faculty who is well-trained in both traditional and digital pedagogy and who is in possession of teaching sub skills as displayed in Fig. 13.2. To exemplify the statement, we may share the analogy of ‘leaving the students with e-study materials and not guiding them how to extract those for solving real life problems’ will have the same effect as ‘supplying the digital tools to the students without specifying the outcomes and providing training of effective handling of these Web tools’. English can be taught most effectively as technical English communication by using SBA and DCA. Digital tech-savvy learners of higher Technical Education need to be continuously monitored with the digital tools, and proper measures are to be taken by using control tools for effective application of digital pedagogy (Fig. 13.10).

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[27] Software-Based Activities.

[28] Digitized Communicative Activities.

of new-age industries as well as academics. Several bodies are formed worldwide to combat with this requirement, and different outlines are proposed [2–5], which ultimately produced Washington Accord [6] and is now widely accepted across different countries due to its overall established significance. In the juncture of changing educational scenario for input–output-based system to outcome oriented system though the introduction of pedagogy following Washington Accord, data analysis becomes an integral part for evaluation for the students and corresponding upgradation of curricula. Because of large volume data generated in every academic semester, it is not possible to analyze it manually, and in this context, different soft computing and machine learning approaches become essential to analyze, synthesize, and evaluate data. Outcome obtained for every student can be classified for different categories which are related with course outcome, program outcome and moreover, can be mapped with institutional vision and mission. Thus, implication of modern data analysis approaches is extremely crucial in this point of view, and also relevant in present day context.

14.1.1 Digital Pedagogy: Significance in Present Education Scenario

Pedagogy is now become the essential part of education system, replacing the conventional input–output-based techniques, where sophisticated technical tools and inventive schemes are intermixed with the obtained data for further upgradation to produce better quality of human resources. It is a truly a scientific approach where didactics is revolutionarized by introduction of technology. Teaching methodologies are changed through introduction of active/flipped/blended/adaptive/authentic learning methods for producing better outcome. As per the guideline of Washington Accord, every student has to satisfy the program outcome as dictated before initiation of the course, at least partially in each of them. Therefore, strategic principle has to be adopted at the beginning of each course where the planning or more precisely, program educational objective, will critically depend on the geographical, financial, and socio-economical class of the students they have received [7]. In this context, analysis of data should be considered as a very important part of redefining program outcome and also of objective [8].

Pedagogy is a modern science where engineering didactics is conceptualized by introduction of technology through proper amalgamation of experimental, computational, and self-learning methodologies in information-based teaching for producing better outcome. With introduction of appropriate pedagogical technique, it has been observed in different published reports that outcome and moreover, acceptance of the students are increasing in both academia as well as industrial sectors [9]. There exists the relevance of pedagogy, and when it is perplexed with digital mode [10], learners will be provided added flexibility where they can set their time and pace to adopt the

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