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RESEARCH ARTICLE

Project based Engineering Graphics Instruction in a Content and Language Integrated Flipped Classroom

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Abstract

Objectives: To enhance the first-year engineering students' conceptual understanding of Basic Engineering Graphics. **Methods:** The mixed research was observational and unpaired; it was done during January 2020, as an interdisciplinary collaborative project between the departments of English and Mechanical Engineering. It involved two English language teachers, two mechanical engineering teachers, and seventy-first year B.Tech students of Dr. MGR Educational and Research Institute, Chennai. A pilot survey helped teachers understand students' difficulties in learning Engineering Graphics; so different approaches like the bilingual, content and language integrated learning and the project-based content instruction with videos and Flipped learning through mobile assistance were introduced. Students watched videos on isometric projections and drawings in their mobile phones. They checked their understanding of them with the text book reading in peer company. The classrooms were utilised for peer discussions and teachers' clarifications. **Findings:** The project as a group activity offered scope for peer interaction that the students were cognitively stimulated for better understanding of isometric projections. A post evaluation of the drawings, presentation by the students and a post interview found the bilingual and Content and Language Integrated Learning approach has stimulated the cognition of the net-generation learners while exploiting their interest in the mobile phones through flipped classroom. The process of learning exemplified the principle of cooperative learning among students and the cooperative work of teachers of different disciplines (i.e.) subject and language teachers. **Novelty/Applications:** Teaching engineering graphics with the assistance of language teachers and in a flipped classroom was a novel approach.

Keywords: Engineering graphics; isometric projections; content and language integrated learning; Flipped learning

1 Introduction

Computer Aided Engineering Drawing (CAED), Computer Aided Machine Drawing (CAMD) and CAD, or computer-aided design and drafting (CADD) which encompass 2D or 3D CAD programs such as AutoCAD or AutoCAD LT software are indispensable digital tools to train the digital native students in engineering graphics for their professional success. Engineering drawings depict products in their orthographic, sectional, isometric views etc., for which 2D and 3D software are used globally. Hence, designers or students cannot escape from 2D/3D engineering drawing, especially when conventional drawing is involved. The cognitive understanding of the concepts of engineering graphics and design decide students' proficiency in them. Therefore, CAD users must comprehend and be knowledgeable in conventional drawing [(1)]. Drawing with the traditional tools is a necessity and fundamental for the learners' kinesic movements in coordination with their mental activity. Considering the complexity, the students face in learning Basic Engineering Graphics in first year engineering undergraduate program, the departments of English and Mechanical Engineering mooted an interdisciplinary project to enhance the first-year engineering students' conceptual understanding of Basic Engineering Graphics through a project-based engineering graphics instruction in a content and language-integrated-flipped classroom. The success of the project in motivating the students to understand the concept and draw the isometric projection is deliberated in this article.

2 Literature Review

There remains a mismatch between engineering professors' teaching style and engineering students' learning to style that results in poor performance of engineering students in engineering programs [(2)]. Students are unable to communicate graphically, apply spatial visual reasoning, read and interpret graphical text in subjects like Engineering Graphics and Design (EGD) [(3–5)]. What [(6)] and UGC in India advocate, is a curriculum that includes active learning activities framework which is flexible enough to suit different learning processes and needs of the students while including problem solving and project-oriented tasks, because they are associated with helping students to develop a robust understanding of technical drawing while making connections between the theoretical design principles, and apply their learning to real life problems. Further, team project ensures collaboration in groups. As it is a central way of learning in modern communities, project-centred methodology helps students' understanding; refines their critical thinking skills and understanding of the others' viewpoints [(6)].

Of late, higher education institutions have been trying to provide students with both hard skills, namely cognitive knowledge, professional skills [(7)] and soft skills, such as problem-solving and teamwork [(8)]. But, as long as traditional teacher centric teaching methodologies continue, the learning outcomes like students' content knowledge, conceptual understanding, and course achievement cannot be realized. [(9,10)]. In contrast, project-based learning (PjBL) — a learning process in which students are engaged in working on authentic projects and the development of products, can engage students in knowledge construction by having them accomplish meaningful projects and develop real-world products [(11,12)]. PjBL, motivates students with driving questions with a focus on learning goals, participation in educational activities, collaboration among students, the use of scaffolding technologies, and the creation of tangible artifacts. This process of creating new knowledge allows students to test and achieve their ideas in the way they want, which promotes their innovation competence [(13)].

The digital native students' interest and their speed in operating mobile phones is exploited for language, literature and content learning. It is a 'New Learning' [(14)] also called Flipped learning or flipped classrooms — a novel teaching learning pedagogy which uses smart phones; shifts direct learning out of the huge gathering and learning space into an individual learning space with the help of technology, with a focus on collaboration while maximizing one-to-one interaction among peers. It is a productive classroom teaching as the locution "flip" means to turn topsy-turvy or turn over or swap, the teachers utilise the classroom to plunge into in-depth understanding of the subject. As such, it allows the teachers to use them to assist content and language integrated teaching in a formal classroom and make learning lively and interesting through discussions over videos watched repeatedly by the students at their own convenience and proximity to their peer groups [(15)], [(16)]. Content Based Instructions and Content and Language Integrated Learning share core principles like people learn a second language more successfully when they use the language as a means of understanding content; content matter is not only about acquiring knowledge and skills but learners creating their own knowledge and understanding and developing skills i.e. personalized learning. [(17)] observe in a content and language integrated classroom, the learners are cognitively challenged yet linguistically supported; the teachers need to start with visuals or real objects and brainstorm existing knowledge of the learners and elicit answers for the questions raised to have a feedback on their understanding. Better still the teachers start with presentation which introduces concepts and language and start with linear text which introduces the ideas ; may use the language that the learner is comfortable (mother tongue) to understand the content. Once the classroom process begins it gives opportunity to test whether the desired outcome is reached or not. Eliciting questions apart, success criteria can be preparing a presentation which acts on several levels, clarifying content, the presentation conventions, and the quality expectations. The students can do

the presentation either in groups or pairs depending upon the time allotted for the delivery of the content as per the Lesson Delivery Plan of the subject. Whether in groups or pairs, the process offers immense opportunity to the students to discuss and check their learning and find vocabulary and structure to express what is understood. As such, the presentations made by the learners to explain the concepts may well be used for evaluating the learners' understanding[18].

3 Research Methodology

The seventy students of first year Engineering students of Dr. MGR Educational and Research Institute were the research participants in an observational and unpaired and mixed research that observed students' behaviour before and after the introduction of different approaches in the engineering graphics-teaching learning-process. The research was carried in the month of January 2020.

The overall perception of students about the engineering graphics class, received as feedback for the Customised Questionnaire (Appendix 1) was negative (78%) that the researchers felt the need for change in the teaching approach and methodology. Since the questionnaire identified the students by their mother tongue (Table 1) rouping was done on the basis of students' mother tongue that the use of bilingual methodology would help each group of five members discuss among themselves in their mother tongue for understanding the concept and retain. There were two mechanical engineering faculty: one knowing Tamil, Telugu & English and the other knowing Hindi & English to facilitate learning through mother tongue and English. Two faculty members from the department of English identified keywords, content obligatory words and syntax for assisting the subject teachers and monitoring the group interaction.

Table 1. Mother tongue of the students

MOTHER TONGUE OF THE STUDENTS					
Tamil	Telugu	Malayalam	Hindi	Bengali	Assamese
27	20	3	15	3	2

The Isometric Projection in Engineering Drawing was segregated into its component structures. An inventory was made regarding the vocabulary requirement and the instruments used in the process. The first session was the brain storming session to help the learners to be cognitively alert to recollect and recognise required vocabulary. Then their knowledge of the drawing instruments was checked. The language teachers who were bilingual could explain the content teacher's versions in English and in the first language or regional language. The application of isometric drawings and projections were discussed with the handouts of the industries in which the beautiful images of the machinery parts were available. Then a video presentation gave the model to draw isometric projection. After the video presentation, clarification session followed to assess the learners' comprehension.

The linear text introduced the ideas of Engineering Graphics[19]. Isometric projections of the machinery were handy, and they were studied and used as materials (Figure 1); further, the projects were the 3dimensional images that the students researched in google search. Then the materials were downloaded in their mobiles to learn at the convenience of their home. The link for YouTube video on the isometric projections drawing was also given. The point here in was, that the students could view the video repeatedly in peer company and discuss in the language they were comfortable with. The teacher elicited questions to get the feedback on students' understanding of the isometric projections. The students' interest in the mobile phone was successfully exploited and the learning was flipped. After the discussion, the students drew the isometric projection. The members of any group drew the same isometric projection as a group project. Each drawing was evaluated. The cumulative marks of all the members of a group were considered as their group mark. Not only was the individual submission evaluated but the presentation of the individual members also. After the process, in an unstructured interview, the students' perception of the basic engineering graph as a subject was inquired.

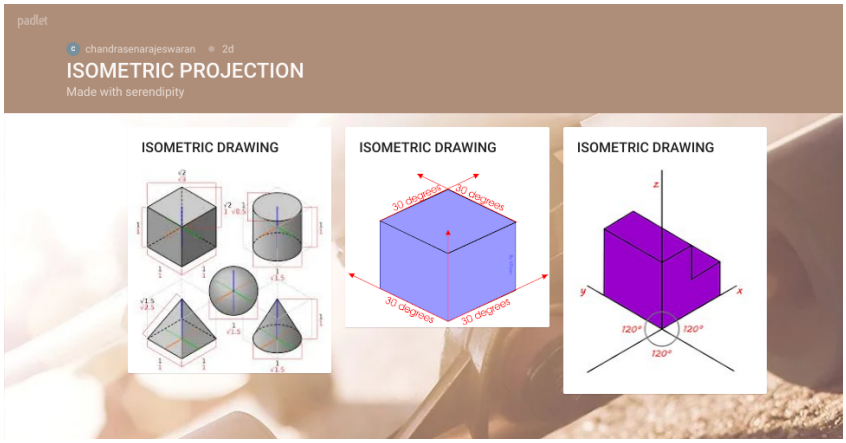

Fig 1. Isometric projection

4 Results

After the change in the teaching process, the students submitted the isometric projection drawings as a project and presented how they drew the diagram. The evaluation gave the following result:

Out of seventy students 65 students passed and only 5 students failed, that too marginally. The marks obtained by the students was as follows. (Table 2)

Table 2. Marks obtained by the students

Marks Obtained by students				
Range				
41-50	51-60	61-70	71-80	81-90
5	10	28	17	10

Range of Class Test Marks after the Innovative Teaching (Figure 2)

41-50 = 5 students (5 Tamil)
51-60 = 10 students 5 Hindi + 4 Tamil + 1 Telugu
61-70 = 28 students (10 Tamil +13 Telugu + 3 Malayalam + 2 Assamese)
71-80 = 17 students (2 Bengali + 5 Tamil + 6 Hindi + 4 Telugu)
81-90 = 10 students (3 Tamil + 1 Bengali + 4 Hindi + 2 Telugu)

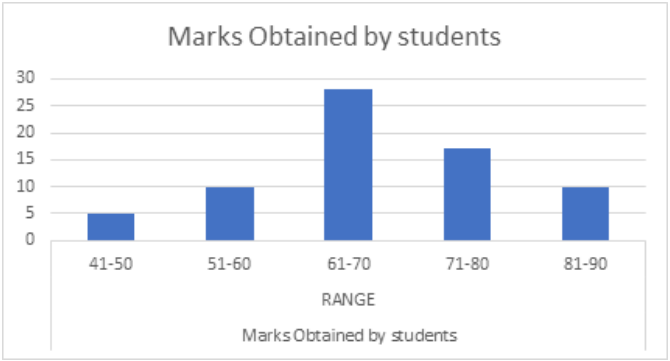

Fig 2. Marks obtained by the students

5 Findings and Discussion

The teaching approach — the team project –developing students' cognitive understanding of technical drawing proves [20] and [21]. PjBL's utility in knowledge construction, namely information sharing, disagreement detection, negotiation of meaning, modification of new ideas, and enabling students to make connections between the theoretical design principles, building complexity and applying their learning to real life problems was evident as in [22]. Projects gave the students a context to discuss and analyse individual weakness and the ways to supplement them in the group. Research has also shown supporting learner autonomy during learning tasks is fostering the students to be innovative as observed by [23]. Within a short period, flipped learning has helped students learn rudimentary knowledge through short videos at home and come to the classroom environment to understand the situations and correct their mistakes in the context of use as informed by [24].

The research participants researched in group using the resources like text book and visual for information and group presentation: oral and written; as the individual members presented, the groups owned the responsibility for shared knowledge. The present classroom experience substantiates the views of [17]. Both, gifted and academically handicapped students have built positive relationships that could develop their social, psychological and cognitive experiences while helping them build team based organizational structure. Content and Language Integrated Learning approach with its social-cognitive perspective has introduced students to bilingual explanations and "modelling examples". The classroom observation confirmed the students' motivation and interest in the use of video for defining and describing the isometric projections and drawing with specific reference to angles and so on. This finding resonates with [25] and [26]. Observational learning of cognitive tasks requires the students to externalize their cognitive actions, like thinking aloud, or writing down the actions, or, asking students to speak and write the definition, advantages and disadvantages to help them to scaffold their speaking and writing ability. The rehearsals helped the students to present the concept and process of drawing IMP. These positive outcomes are in line with the observation of [17].

Among the fourteen groups ten groups drew the Isometric Projection to the satisfaction of the subject teachers; all the groups answered the teacher elicited questions on the definition of Isometric Projection. Group reports or assignments are considered to be problematic because they involve merging diverse skills and personalities with the hope that they will collaborate towards a common goal of learning [27,28]. Grouping the class of seventy into fourteen groups did not pose any problem. Though certain members presented well and their individual score was good, because of the other members' insufficient contribution to the success of the group, very badly reflected in the accrued group marks. Grouping in a heterogeneous class is not a problem, but group assessment is [29]. When individual members' marks were accrued to make group mark, 2 groups failed because all the team members were either not able or not willing to contribute equally to the team's success. The positive aspect of the research is that the two Assamese students could pass in the range of 61-70; it shows that the genuine efforts of the teachers will bear fruit with the willing cooperation of the students.

The pair of teachers from Mechanical Engineering department and English Department of Dr MGR Educational and Research Institute could work closely with each other and to act as 'critical friends' to give constructive feedback for future engagements of this sort. As matured and participatory learners, the students said the particular topic was given more importance and more time than allotted to other topics. When their enjoyment in learning isometric projection was reiterated, they agreed the time spent was for a valid purpose.

6 Conclusion

The perspective of engineering drawing with its focus on angle of 30° and so on and how it looks from the top view as well as from the front view has been difficult for the first-year engineering students. This kind of specific drawing needs the best ways in executing as well as teaching or in providing guidance. Because, it is very much evident that the 21st century generation (Engineering Student Community) have a greater inclination towards smart learning and is highly interested to learn things from animations, software's and through practical models, the teaching should be free from chalk and talk and the Instructor choice of teaching tools should get modified, without forgetting the base for Engineering Drawing [30]. After all, the essence of higher education is not the acquisition of a set of skills and the ability to use them mechanically, but the formation of an engineer's special structure of thinking and knowledge base in a whole range of sciences that allow him to creatively approach the task assigned to him, just copy, but get the best possible solution [31].

Limitation

Since the research was done in a deemed to be university in Chennai, with a limited number of students the results obtained may not be generalized.

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