

What is ‘Student-Centered’ Electromagnetic Instruction?

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Abstract:

This article discusses the meaning of the term ‘student-centered teaching’ with reference to literature. A review of activities suggested in the literature for aiding electromagnetic education is also undertaken in this background.

Introduction:

The Zen teachers emphasized *experiential* rather than theoretical knowledge [1]. In the Guru-Sishya tradition of Hinduism, knowledge was imparted by mentoring through a ‘developing relationship between the guru and the disciple’ [2]. J.C. Maxwell [3] wanted to *help* students in ‘understanding Faraday’s modes of thought and expression.’ More recently, a scholar, emphasizing the need for a class where students participate in discussions, had poetically said [4]:

‘Let’s encourage discussion

And let all join the fray’

There are several fine undergraduate texts, where one can see the great dedication of the authors in attempting to take the concepts across to students (and teachers).

Thus the student, in principle, has always in a sense been at the centre of the traditional educational system. However, there has been ‘evidence of the low status of undergraduate education at research universities for the past half century’ as ‘an appropriate balance between research and undergraduate teaching ... does not now exist’ at several institutions [5]. In this background, and reflecting certain changed circumstances, that include ‘the changing demographics of the student population and the more consumer/client-centered culture in today’s society,’ [6] more recently, there has been much talk in the educational literature about teaching increasingly and explicitly becoming ‘student-centered.’ In this

article, a brief, non-exhaustive review is presented on the term ‘student centered instruction.’ Some of the educational approaches that have been employed in electromagnetic teaching are also considered.

What is student-centered teaching?:

There are various ways in which student-centered learning is defined [7]. According to Lea *et al.* [7], student-centered learning includes ‘reliance upon active rather than passive learning, an emphasis on deep learning and understanding, increased responsibility and accountability on the part of the student, and increased sense of autonomy in the learner, an interdependence between the teacher and learner, mutual respect within the learner-teacher relationship, and a reflexive approach to the learning and teaching process on the part of both teacher and learner.’

Essentially in line with the above, Smith and MacGregor [8] suggest that an environment that fosters student centered instruction should be such as to motivate students by ‘getting them more actively engaged,’ stimulate both students and teachers and facilitate learning ‘in concert with others.’

Thus it has been acknowledged (re-emphasized?) that effective learning requires active involvement in the learning process by the students and that healthy interaction between the instructor and the students are necessary in order to arouse the natural curiosity in the students [8, 9]. Besides, this could stimulate both teachers and the students. Going a step further, Felder *et al.* [10] opine that a comfortable social environment in the class can have a profound positive impact on the quality of teaching-learning. ‘If the students believe that an instructor is concerned about them and has a strong desire for them to learn the course material, the effects on their motivation to learn and their attitudes toward the course, the subject and the instructor can be profound.’ A profitable discussion on ethics and values, which is also a desired attribute of the modern engineer, obviously can flourish only under such an environment.

While a university’s guide [11] too considers the student-centered learning to be ‘a highly social process requiring continuous development of relationship and communication between the teacher and the students,’ it adds that this type of learning needs ‘formative’ rather than ‘summative’ assessment– the *process* by which students develop their

understanding needs to be assessed, and not just the knowledge acquired by them; curricula should be developed around the *processes* through which learning is to be developed. Thus student-centered learning entails the development of higher order thinking and information skills that entails ‘intellectual curiosity, openness to alternative ideas, and acceptance of responsibility for one’s own learning’ [12].

According to McKeachie [13], a student-centered class will have a high degree of one or more of the following attributes: ‘student participation in goal setting, emphasis upon affective goals, student participation and student interaction, instructor acceptance of inaccurate statements, group cohesiveness, ability to determine its own fate and amount of time devoted to discussing personal experiences and problems.’

In a broad sense, student-centered teaching aims to work towards [14]:

- ‘a climate of trust in which curiosity and the natural desire to learn can be nourished and enhanced;
- a participatory mode of decision-making in all aspects of learning in which students, teachers and administrators have their part;
- helping students to achieve results they appreciate and consider worthwhile, to build their self-esteem and confidence;
- uncovering the excitement in intellectual and emotional discovery, which leads students to become life-long learners;
- developing in teachers the attitudes that research has shown to be most effective in facilitating learning;
- helping teachers to grow as persons finding rich satisfaction in their interactions with learners.’

It is desired that a modern engineering graduate who has gone through his education in a student-centered environment is a ‘good communicator, collaborator, team leader, and policy consultant...and..is... flexible enough to venture into new inter-disciplinary areas’ [15]. These words of Chang echo the fundamental objective of modern education.

Educational activities for ‘student-centered’ EM teaching:

Outlining that factors such as the shift from industrial to a knowledge-based society, increased globalization and the dominance of market forces in general and in educational field in particular, have started having significant effects on the delivery of education and that the result of these effects is the evolution of themes for higher education that include learner-centeredness and life-long learning, Gupta et al. [16] suggest that simulators can be successfully employed to partly address some of these challenges, but cautions that ‘the experience with simulators does not replace the insight or the precise details that are obtained by a mathematical analysis.’

Addressing the complexity of the technical challenges facing the modern engineer, Felsen and Sevgi [17] suggest, ‘requires a broad range of innovative, multi-disciplinary, physics-based, problem-matched analytical and computational skills that are not adequately covered’ in the present engineering curricula. The authors also point out that an interdisciplinary exposure is required for modern engineers. Given this complexity, assimilation of electromagnetic concepts by students ‘can be greatly enhanced by appropriate, interactive, computer examples’ [18]. In addition, the use of multimedia-based educational tools in teaching ‘provides motivation, increases learning rate, contributes to retention, and even helps in managing large classes where the role of the teacher is expected to change from information provider to a coaching-type guide and facilitator.’ This also helps in developing conceptual understanding of the subject [19]. In this paper, efforts by several academics to develop web-based courses are outlined.

It has been suggested that the integration of appropriate historical content into electromagnetic teaching could facilitate teaching-in-context and could in turn have significant influence on learning and understanding, apart from possibly motivating the students to contemplate about innovation, creativity and ethics [20, 21, 22]. Surveys with students and professors have tended to support these ideas [23, 24, 25].

Recognizing that ‘understanding the mathematical constructs of EM is a major task for most engineering students,’ Anderson and Mina [26] suggest an approach that ‘focuses on the teaching of the governing physics of electromagnetism and decouples the advanced mathematics from the physics of the subject.’ Spending more time with electromagnetic concepts, the authors believe, will create an educational environment in which ‘the student

will be able to thrive in a subject that has long been dreaded.’ It may be noted that the discussion in [20-25] is in a sense in line with the approach discussed in [26].

Furse [27] has tried several methods that include working in small-groups to promote active learning in students.

In an interesting recent article, Gupta [28] considers ways of enhancing the transfer of learning. He has noted the following:

- Transfer of learning is more easily accomplished for conceptual knowledge than for problem-solving skills;
- Knowledge transfer significantly benefits from a broad and rich knowledge base;
- The use of physical, rather than essentially mathematical, problems enhance knowledge transfer as solving physical problems demand deployment of additional knowledge by the student;

As opportunities available to the instructor to enhance knowledge transfer, Gupta further suggests an emphasis on ‘fundamental, rather than the superficial, characteristics and features’ of learning exercises, use of generic rather than specific vocabulary when appropriate, establishing connections with other subjects and an organized delivery of teaching. He also recommends that the students be taught how to organize received information so that long-term retention is facilitated.

Consolidating the key points from above, it is possible to have a suggested mapping of the role of a teacher in student-centered instruction with appropriate educational activities as follows:

Role	Activities
Inculcating knowledge of fundamentals	Lectures; Emphasis of concepts
Developing higher-order thinking skills	Emphasizing that there may always be uncertainty about scientific (and all) knowledge; Discussing thoughts on being open to ideas; Encouraging independent learning; open-ended problems; Interdisciplinary knowledge; Communication skill
Creating a comfortable social environment	Nourishing a friendly class environment; Encouraging student-staff and student-student discussions
Helping with connecting information learned	Use of simulation tools; Discussion of practical applications
Providing group-learning settings	Where possible, forming small groups to discuss problems
Helping contemplation on innovation	Historical development of science; Simulation exercises
Having active student participation in decision making	Staff-student consultation in academic affairs
Assessment	Formative and continuous

Conclusion:

In this short article, a review of the definitions that have been proposed on ‘student-centered instruction’ was done. Some of the EM education-related articles were reviewed in this background. Consolidating the discussions, a possible mapping of a teacher’s role in student-centered instruction with activities was presented.

It has been pointed out that the approach of student-centered teaching has certain problems such as its focus on individual student and the extent of resource requirement for large classes [6] and that student-centered teaching and learning has not transferred into practice, though the term is ‘used very commonly in the literature and in University policy statements.’ However, the approach, which may have inevitable limitations [29], presents

interesting possibilities for making teaching and learning enjoyable to teachers and the students alike.

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