Interfacing Independent Mind and ESP in STEM Education: Exploiting Discovery-Oriented Approach to Learning

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Abstract

As Mohan (1986) rightly argues, While the need for coordinating the learning of language and subject matter is generally recognized, just how this should be accomplished remains a problem and is one of particular concern for university ESL/EFL programs. In view of this vital pedagogical concern, skills-integrated content courses have been designed and experimented by many universities and individual academicians. In content-based curriculum the basic organizational unit is a theme or topic, rather than the more customary grammatical patterns or language functions. The main goal of this, as Bycina (1982) explains, is to provide meaningful contexts for language learning instead of focusing on language as an object of study. At the foundation of this approach is the Krashen's (1984) notion that acquisition is best promoted when language is presented in comprehensible and interesting communicative contexts (p. 25). In a more crystalized view of English for STEM education, this paper revisits the concept of thinking and pedagogy of English for Specific Purposes (ESP) and emphasizes on the use of independent mind to promote focused ESP for the students of the Scientific Disciplines of Science, Technology, Engineering, and Mathematics (STEM). In the backdrop of the context of STEM education, we have developed a tripartite discussion in the paper focused on the primacy of independent mind and thinking skills; the need to facilitate language development in a contextualized, integrated, interactive framework; and the ways and means to exploit the richness of authentic scientific materials and discussion-led innovative tasks and activities to promote active ESP in STEM education.

Keywords: content-based language instruction, discovery-oriented approach, English for specific purposes, independent mind, STEM education, thinking skills

1. Introduction

This paper falls in the research territory of ESP and establishes its niche by identifying a gap in the pedagogy of ESP for the students of STEM disciplines. We argue in favor of a desired need for a shift towards a discovery-oriented approach to ESP and thereby attempt to occupy this as a niche by outlining the nature and purpose of this re-search-oriented discussion of the vital pedagogical issues under examination. Taking the desired focus and direction, we explore, examine and demonstrate an integrated-interactive and more focused pedagogy of ESP for the students of STEM disciplines.

According to Master's (1991) explanation, working with academic content in a real context in a language class is known as content-based language instruction (CBI), which is extensively used in ESP classes. Our concern and focus in this paper is on adopting a more focused CBI in ESP in general and for the purposes of STEM language instruction in particular. It is a common knowledge that scientific disciplines of STEM are, by nature, discovery-oriented. General methodology of scientific disciplines, to use Krishnaswami, Verma, and Nagarjan's (1992) view, involves the process of controlled observation; hypothesis formation; analysis; generalization; prediction; testing by further observation; and confirmation, modification, or rejection of the hypothesis (p. 2). Needless the say that the success of this methodology primarily depends on the adequate levels of an individual's thinking skills. And, we would stress on the need to tap deeper levels of students' thinking here through Osho's (2015) philosophical approach to deep thinking. To Osho (2015), thinking means a moving mind. Thinking means that if there is problem you should not try to find the answer in your memory, as the answer will be 'old' and 'stale' (p. 75). To illustrate, when life creates a question, put memory aside and don't allow your memory to speak. Tell your memory to excuse you. And once your memory

becomes totally silent, your consciousness will explore its own answer based on the strong foundations of one's independent thinking. Students need to develop this kind of independent thinking in ESP courses for STEM disciplines.

In view of the discovery-oriented experimental nature of scientific disciplines, the language education also needs to be discovery-oriented and critical. ESP courses need to be presented in comprehensible and interesting communicative contexts and need to be oriented towards promoting independent thinking skills. However, the ESP courses offered for ESL/EFL students lack this focused aspect and approach. In the backdrop of this vital pedagogical problem and issue of concern and thereby emerging rationale and motivation based on the research in the field of ESP in general and STEM ESP in particular, this paper aims to demonstrate how independent thinking skills could be developed using authentic materials from scientific contexts in order to strengthen reflective language skills of STEM students. The main objectives of this paper are focused on the discussion and demonstration of (a) the primacy of independent mind and thinking skills in STEM education, (b) the need to teach language in a contextualized, integrated, and interactive framework, and (c) how to exploit the richness of authentic scientific materials to design discussion-based, integrated and interactive tasks and activities for developing reflective English language and thinking skills for the students in STEM education. After this, what follows in the paper is the crystalized discussion and demonstration of how ESL/EFL pedagogy can be made discovery-oriented, comprehensible, and interesting for the students of STEM disciplines and achieve the desired educational goals and outcomes.

2. The Primacy of Independent Mind

The general methodology of Science primarily depends on adequate levels of students' thinking skills. Thinking, as Osho (2015) argues, is a moving mind. Here, thinking is not referred to a thinking which is developed based on borrowed and accumulated knowledge and thoughts but the thinking which gives birth to one's own thinking, i.e. the thinking which gives birth to one's own consciousness (pp. 70-79). Such an approach to ESP in STEM education will not only promote higher levels of critical and creative thinking skills but also transform STEM education and deliver desired pedagogical outcomes.

3. Centrality of Integrated Interactive Framework

The use of integrated-interactive pedagogical framework is central to the development of not only language skills but also thinking skills. Good reasons to certainly do that are many. According to Hinkel (2006), people in meaningful communication employ incremental language skills not in isolation but in tandem (p. 113). As Harmer (2016) argues, the use of language skills is multilayered and therefore it would make no sense to teach and learn each skill in isolation and we also need to replicate the natural process of skill-mixing in order to provide maximum learning opportunities for different students in the classes (p. 297-98). To illustrate Harmer's argument, speaking activity is bound to involve listening and speaking and it may also involve taking or making notes and writing. Furthermore, students involved in collaborative tasks and activities will be speaking, listening, writing and reading almost simultaneously (p. 299). Ellis (2004) calls it a natural developmental route in the theory of second language acquisition. These arguments of Hinkel, Harmer, and Ellis are linked with, and lend support to, River's (2000) premise that "Communication essentially derives from interaction" (p. xiii). Rivers argues that students achieve facility in using a language when they focus their attention on conveying and receiving authentic messages that contain information of interest to the speaker and listener in a situation of importance to both (p. 4). These vital pedagogical ideas and arguments strengthen the Vygotskian (1978) pedagogical premise that knowledge is co-constructed when individuals are engaged with one another in the learning process and also lend support to the use of authentic materials, collaborative tasks and activities and reflective approach and practices.

4. How to Exploit Authentic Materials and Design Interactive ESP Tasks and Activities

This section, the core of this paper, exemplifies and discusses (a) How to set the context of an STEM ESP lesson; (b) How to design and conduct reflection-oriented interactive tasks and activities; (c) How to integrate all the four language skills of listening, speaking, reading, and writing; (d) How to bring in heightened level of awareness and consciousness in discovery-oriented discussions, reflections, and meaningful argumentations, and (e) How to channelize and culminate the exchange of ideas and argumentations in the form of an organized writing.

4.1 Setting the Context of a STEM ESP Lesson: An Example

In order to set the context and tone and tenor of the proposed lesson, the following warm up activity is planned and developed.

Warm-up Activity

Image 1

grasshopper

versus

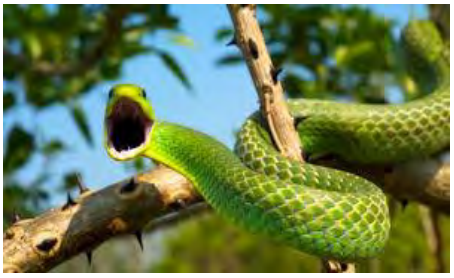

Image 2

snake

4.1.1 Task 1:

Look at the two creatures, observe their body size, known strengths and weaknesses from your knowledge and experience and answer the following questions.

(i) Who will win if there is a fight between the grasshopper and the snake? Why do you think so? Justify your reason.

(ii) Based on your experience-based reason, can you form a hypothesis about the outcome of a fight/tussle/bout/conflict between the known stronger and weaker?

4.1.2 Task 2:

Watch the following video from the link ***https://www.youtube.com/watch?v=9-Xd7H8-6_I*** in which a snake is creeping towards the grasshopper to swallow it but the grasshopper resists and this encounter develops into a fierce fight between the grasshopper and the snake. At the end of the video, examine if your reasoned out answer to Task 1 was correct or not.

4.1.3 Task 3:

Would you like to change your hypothesis that the powerful and stronger always wins and weaker loses?

Having carefully watched and observed the fight between the weaker grasshopper and stronger snake, can you reflect upon the following and analyze the situation you witnessed in the video?

(a) Why did the snake get defeated miserably and eventually lost its life?

(b) How did grasshopper defeat the snake and kill it and victoriously survive?

(c) Now, can you generalize and predict the outcome of the fight between the weaker and the stronger? or Do you need to test it by further observation and then confirm or modify or reject the initial hypothesis you had before watching the video?

4.1.4 Task 4: Further Activity

Here, at this stage, students may be asked to explore Discovery Channel videos from you tube, let's say 6 videos of fights between certain weaker and stronger animals and analyze them in the same way as done in the above case.

4.1.5 Reflection:

Upon reflecting upon the above activities, one can conclude that (a) the tasks are discovery-oriented, and (b) they are based on the strengths of argument(s) of the learners. This process can be used in the teaching and practice lessons of ESP in STEM classrooms.

Let us explore some further enhanced pedagogic scope and possibilities. To develop an integrated and interactive writing lesson for STEM disciplines, we can select a scientific process, e.g. photosynthesis, hydrolysis, atomic fission, volcanic eruption, genetic modification of food, fruits, and vegetables, etc.

Relevant reading texts could be found out from Wikipedia or Science books and journals on these topics. Students can be asked to explore relevant and authentic online materials, read the texts relevant to any chosen topic, answer comprehension questions, solve grammar and vocabulary exercises based on the text. Finally, an argumentative topic can be carved out from the scope for arguments available in the texts based on the risks, concerns, controversies, etc.

Then, the students can be involved in arguing for or against it. After oral arguments, students can be involved in writing a reflective argumentative essay.

Let us see a model lesson on the shortlisted topic of *Genetic Modification of Foods*.

4.1.6 Task 5: Reflective argumentation on Genetically Modified Food

Warm-up: Ask questions about the importance of food in human life, availability of fresh food, over-dependence on cold-storage food and then move on to genetically modified food—exploit prior knowledge of students.

Ask the question: **Can you form a hypothesis for or against the use of genetically modified food?**

Then, students can be divided in groups and given a topic and asked to explore the relevant text(s) using online sources and read in the group and discuss. Someone in each group can be nominated to make notes from the discussion within the group. Then notes can be organized in a textual form and shared with other groups. The themes to explore in each group can be the following:

(a) What are genetically modified foods?

(b) How are genetically modified foods created?

(c) How does genetic modification affect many of the products we consume on a daily basis?

(d) Is genetically modified food good for the countries which produce it?

(e) Is genetically modified food helpful or harmful for the consumers?

(f) What are the regulatory provisions related to ensuring health and safety of human beings from genetically engineered foods?

(g) Are there patents for different genetically modified foods? What are the regulatory measures in cases of violations?

(h) Is it ethical to interfere in the natural process of growing foods, vegetables, and fruits?

Based on the readings of the texts explored on the above topics and having shared them with each other in and outside of groups, the group leaders can be invited in turns to share their thoughts on the advantages and disadvantages of genetically modified foods.

Moving from the readings of the explored texts and sharing that information up to discussing the advantages and disadvantages, the students may be asked to move towards research on the topic under discussion and read the abstract from a research conducted by Barwa & Anilakumar (2013) entitled, "*Genetically modified foods: Safety, risks and public concern*", which can be made available from ***https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3791249/.*** After reading this abstract from the journal published by Springer, students can be asked to download the full paper, read it in the class or at home, as applicable, and make notes in order to attempt and answer the following tasks and activities linked with ESP writing in STEM disciplines.

4.1.7 Reflection-oriented tasks and activities linked with STEM Writing

Now, based on the readings, discussions, note making and note taking and reading of the full journal article, the students can be involved in expressing their opinions on the questions of concern such as (a) What are the risks of "tampering with the Mother Nature"?; (b)What effects will this have on the environment?; and (c)What are the health concerns that consumers should be aware of?

After the above discussion, students can be involved in writing a reflective argumentative essay on the following topic. ***Is genetic modification technology really beneficial for humanity? Argue for or against it.*** But before doing this, students need to be briefly prepared for argumentative writing. And, the first obvious question, at this juncture, would be to ask why do we need to argue? And the answer to this is that we need to argue in order to (a) take a sound personal position on issues of concern and controversy; (b) be assertive and to stand up for your ideas; (c) reinforce the value or truth of your ideas to other people; (d) consider different points of view; (e) present pros and cons of an argumentative issue; (f) rule out alternatives and suggest a logical solution; and (g) convince/persuade an opposing audience to adopt new beliefs or behavior.

The next question in a row to answer would logically be: How can one argue effectively? And the answer is that we can argue effectively by (a) constructing a strong argument; (b) giving good reasons and examples; (c) quoting authority on the subject; (d) listening to other's argument carefully; (e) giving concession to other's argument(s) and respecting their opinion; and (f) refuting counter argument(s) by presenting stronger, authentic and convincing reasons.

At this stage, desirably, introducing the language and structure used for argumentative and scientific writing would be beneficial.

(A) The following cohesive devices needed for effective argumentative writing may be elicited, introduced and practiced:

(i) The use of in addition, furthermore, moreover to show addition;

(ii) The use of while, whereas to show contrast;

(iii) The use of however, nevertheless to show contrast;

(iv) The use of although, even though to show concession;

(v) The use of clauses to show concession such as the following: 'Your argument has some merit on the surface but…', 'I appreciate your point, but….', 'To be honest, your argument isn't completely baseless; however, …', 'Your reason reflects a genuine concern on the matter, but…'

(B) We can also highlight here that students should focus on using the vocabulary of scientific register, i.e. required technical and sub-technical vocabulary and the use of passive voice that predominates in scientific writing, e.g. Genetically modified food is created by altering its DNA.

(C) The Structure of an Argumentative Essay: A typical structure of an argumentative essay includes the following components: (a) Introduction: Hook, Supporting Sentences, Thesis Statement; (b) Body Paragraph 1: (reason 1), Supporting Sentences, Details, Examples; Body Paragraph 2: Topic Sentence (reason 2), Supporting Sentences, Details, Examples; Body Paragraph 3: (reason 3), Supporting Sentences, Details, Examples; (c) Conclusion: Restate the Thesis + Final Comment by stating a recommendation/prediction/solution.

At this stage the students are ready for handling and completing the reflective argumentative task on the given topic, i.e. "Is genetic modification technology really beneficial for humanity? Argue for or against it". Further, the students can be involved in reviewing peer's first draft of the essay and revise it. The final draft of the essay can be marked by the course instructor and returned to students with feedback for further improvement, as needed.

4.1.8 Scaffolding and Further Consolidation:

For exploiting further scope for scaffolding and consolidation of the above argumentative writing in STEM ESP, a related independent task-based extension activity can be explored. In the context of the present lesson, another related and thought-provoking task-based activity may be proposed to students to explore, study and present it in the form of a reflective argumentative essay/report on one of the following topics and submit it to the course instructor in the form of an assignment.

4.1.9 Topic for the Extension Activity:

(a) Can the focus in future shift from genetically modified foods to genetically modified human beings?

(b) What would be the consequences of this shift?

(c) What would be its advantages and disadvantages?

(d) Should it be allowed or prohibited based on the foundations of science versus the foundations of socio-cultural ethics?

4.1.10 Think and Link Activity:

At the end of the lesson, it is an opportune time to involve the students in a 'think and link' activity by asking the following self-reflection questions.

(i) Is this lesson on writing sufficiently contextualized in STEM discipline(s)?

(ii) Would you consider this lesson a discovery-oriented lesson?

(iii) Do you think that you will be able to make your reading and writing interactive based on this lesson?

(iv) Do you think your independent thinking skills will considerably develop based on the learning opportunities provided and exploited in this lesson?

Thus, an elaborate cycle of practice and production of discovery-oriented reflective and argumentative thinking skills can be covered in the ESP lessons of STEM disciplines. Creative and innovative teachers can design and use many such integrated interactive lessons.

5. Conclusion

In this paper, we have revisited the ESP pedagogy in STEM disciplines and attempted to reroute the learning and teaching practice in alignment with the nature of scientific disciplines. Through a discovery-oriented approach to ESP in STEM disciplines and its effective management, we have provided meaningful scientific contexts for language learning instead of focusing on language as an object of study and thereby facilitated an enhanced scope for students' cognitive engagement and sustainable development of English language skills through an integrated and interactive framework of teaching and learning. This has been effected by exploiting the richness of authentic materials tapping on the students' independent mind and higher order thinking skills by promoting the use of language in comprehensible and interesting communicative contexts from the students' STEM discipline. The pedagogical framework developed in this paper; applied on a number of tasks and activities in a couple of EFL classes; and the positive results being seen on the students' performance underlines the need for interfacing the independent mind of the students and the teachers to facilitate discovery-oriented active ESP in the context of STEM education. Such an approach will not only provide the students and the teachers with stimulating learning/teaching experience in ESP classrooms but also enhance their performance and cognitive achievements in the ESP classes of STEM disciplines.

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