Teaching Domain-Specific English to Engineering Students through SPRE Model-Based Projects

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Abstract—The authors present the adaptation of the *Situation-Problem-Response-Evaluation* (SPRE) critical thinking framework, originally developed by Dr. Hannigan [10], to a wide range of engineering projects in the English language course for undergraduates. Each student in a SPRE team acts in accordance with an assigned role and lives through the same stages, such as finding and processing information, selecting and evaluating sources, problem solving, presenting their position in the 'panel' discussion' and report writing as the final stage. Thus, the language is practiced in all four modalities and in the professional context. The authors share their experience in introducing professional English through projects ranging from wide- scope inter-domain problem-solving tasks to narrow - scope problems drawn from a particular subject area. They suggest supplementing this scheme with an initial stage, where students draft and redraft their proposals for further research after getting peer-and teacher feedback. This stage enables students to identify the research gap and narrow down the 'problem' or the aim of the project. SPRE projects meet the request for professional English (ESP) from the university subject departments.

Keywords—Critical thinking, the English language, task-based learning, engineering projects, SPRE model

1 Introduction

In the new paradigm of education, the focus shifts from knowledge acquisition through a teacher's instructions to ensuring that students master the process of learning. Thus, the concept of the new pedagogy evolved as the approach where learners create new knowledge and connect it to the world [8]. New pedagogies require revision of educational outcomes otherwise known as the 21st century life skills – problem solving, collaboration, creativity, thinking in different ways and building effective relationships in teams [7].

Task-based learning fits the bill at least through two perspectives, as it enables a teacher to introduce language forms through meaningful tasks [15; 16]. Tasks can

vary in scope and complexity from 'simple exercise type to group problem-solving, simulations and decision-making' [6].

Language is acquired simultaneously with accomplishment of a task, and in this case, learners become more independent in choosing the vocabulary and grammar they need to get their meaning across [3].

In the strive for meaning educators turn to problem-based learning and project-based learning, where students work collaboratively on a real-life problem and thus developing competences they need in their studies and in the future job.

One of the aims of project work for an English teacher can be the introduction of discipline-specific language through authentic content and problem-solving tasks, such projects for engineering students being described by Artemeva et al [1] and Bergman et al [5].

In this paper the authors suggest the adaptation of the problem-based learning model, originally developed by Dr Hannigan [10] as the critical thinking framework Situation-Problem-Response-Evaluation (SPRE), to a wide range of projects for technical students. While the original model was based on 'big problems' in science and technology, this paper investigates the possibility of applying SPRE in domain-specific inter-disciplinary context.

2 Context

National University of Science and Technology MISiS is one of the leading technical universities in Russia, with students majoring in engineering, science, information technology and economics. The medium of instruction in all disciplines is Russian, but English is considered an essential asset to do research and to study through online tutorials and written sources.

Noteworthy that the English language needs of the junior year undergraduates are quite vague, mainly 'in order to work abroad or to land a well-paid job in a large international company' (our interview data). However, by the end of the 3rd year, when students start working on their course papers connected with research, they are becoming much more aware of the need to read professional literature and even to write research papers in English in the future [13; 14].

The English course at our university comprises General English, Academic English and IELTS preparation modules, the focus during 4 years being on language proficiency and academic skills. Professional English (ESP) does not form a separate module, though students could definitely benefit from the opportunity to apply and develop their English language skills in their subject disciplines. In the interviews conducted by the authors in the needs analysis framework [14] subject professors expressed their concern about students' poor command of technical vocabulary and inability to deal with authentic research materials. The task-based approach implemented in project work seems the best response to the ESP challenge.

The teachers of our department were lucky to get support and supervision from Dr Sharon Hannigan in the implementation of her English for Science and Technology course based on the critical thinking framework Situation-Problem-Response-

Evaluation (SPRE) at our university. Following her guidelines, we taught this 'prototype' [10] in wide- and narrow-scope projects.

In this paper we want to share our experience in introduction of domain-specific English vocabulary and materials to 3rd and 4th year undergraduate students, majoring in engineering, material science, economics and IT. The intended level of language proficiency is B1 and higher, but the approach is suitable even for A2, as long as reading and listening input sources are carefully selected and language support is provided during the whole project work.

3 SPRE Framework for ESP Projects

Situation- Problem-Response-Evaluation (SPRE) format sets into motion a critical thinking engine which allows to describe a project dilemma (Situation), identify and prioritize the problems and sub-problems (Problem), generate an action plan for solutions (Response) and critically assess the response feasibility, strengths and weaknesses and possible improvements (Evaluation) (Fig 1).

Each project revolves around either a global challenge to the humanity which can be resolved by means of science and technology, or a specific problem drawn from a single subject area. During the first two or three input sessions a teacher introduces not only the topic, but also the language, for example, some semi- technical or technical terms [17], or the passive structures. This stage should be used to practice listening through academic videos and podcasts and reading selected scientific journal articles.

The second part of the project starts when the class is divided into project teams of four, with each team member being responsible for one component of the SPRE framework (Fig 1). This model enables the team to distribute roles equally, as every student researches their part independently, but at the same time in the close cooperation with teammates. SPRE works in such a way that a problem cannot be formulated without prior understanding of the situation, the response is developed out only after negotiating it with the problem member, and the fourth team member provides a critique of already developed solutions. The response does not have to be feasible and easily implemented, but it is usually creative, imaginary or even fantastic within the framework of scientific approach [10].

The third stage proceeds as a 'panel discussion', where each team presents their expert opinion on the module problem. This stage can be considered as a pre-writing activity as panel members present their clear and well-structured idea of the problem and its possible solutions as well as illustrate it with a visual representation.

After having experienced all three stages, students are ready to write a report following the guidelines. The assessment in this project is based on students' actual performance in a language use situation [4], that is a panel discussion and report writing.

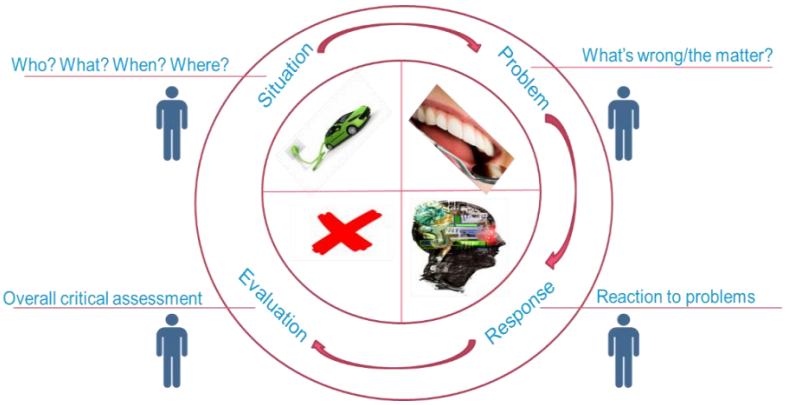

Fig. 1. SPRE Framework

The original framework was designed for multi-disciplinary classes and as such was arranged around deemed scientific issues, e.g., how to avert a catastrophic disaster of an asteroid falling on the Earth.

Our English groups are mainly monodisciplinary, which enabled us to use more subject-specific context and thus introduce ESP component to the projects. This article looks into possible ways of applying the SPRE model to engineering problems in a broad sense and then narrowing down the scope to intra-disciplinary problems.

3.1 Wide scope engineering problems

Department of Modern Languages and Communication faced the problem of designing the syllabus for an extra semester for the 4th-year students of all majors. The need for a short English for Specific Purposes course (ESP) was expressed by subject professors, who wanted their students to have a better command of technical vocabulary and more experience in reading research articles in English. As students have already taken their final IELTS exam and had some time before graduation, the administrative decision was to arrange the whole semester around project work in the SPRE format.

The selection of appropriate tasks for the project posed a certain challenge for us, as they were to be both domain-specific and broad enough to give space for students' independent research and creativity. To address the problem, the language teachers hold a session with content specialists and, as a result, three areas were approved, namely electric cars, biocompatible materials and artificial intelligence (Fig.1).

The consensus view among our teachers is that the most successful was the electric cars project, and that is why it will be used as an example hereafter.

Table 1. Electric Cars Project Task

Situation and problem	**You need to travel from Moscow to Lipetsk by electric car. The distance is 400 miles, but your battery needs to be recharged every one hundred miles and there are not enough recharging stations along the way and besides they are scattered randomly**
Task	As a team of engineers, your job is to make electric cars more welcome vehicles with consumers. Articulate solutions and evaluate them. You will present your solutions in a panel discussion is held in class and in a formal report is written by each expert.

During the first two sessions a teacher gives input introducing the context; at the same time these classes are an excellent opportunity to provide academic skills and language practice. Students tend to see separate jigsaw pieces of the situation and the task of a teacher is to demonstrate a big picture using both audio-visual and text materials. The linguistic complexity of the input videos and articles is set by a teacher according to the learners' level of English. B2 students can watch Top Gear series or university lectures, while A2 learners can listen to popular podcasts and commercials.

At the second stage of the project after the groups have been formed, students have to go through the situation again and formulate clear and precise issues that arise in the given circumstances. The immediate problem which most students identify is the lack of charging stations along the way to Lipetsk, and students often do not realize that this is 'classic chicken-and-poached-egg conundrum' , where low demand for cars prevents business from investing in charging points. Over time the list of problems becomes larger and more specific, and so does the response (Fig 2). At this stage team members do search of online resources, work with them individually first and then bring to class to exchange ideas and form their stance together. A teacher might ask them to take notes on each other's contribution and even put points, and this peer- assessment will count toward an individual final grade for the project. Each team member depends on the work done by others in order to develop their part.

Evaluation is a controversial issue as a few students are aware of this notion from critical thinking. We recommend students to do evaluation as SWAT analysis, that is think of their response in terms of its strengths, weaknesses, opportunities and threats.

The third stage is 'expert panel discussion', where members of each team present their parts, illustrating them with visuals. We encourage students to prepare graphs, diagrams or tables, but if they choose pictures or photos, we accept them as well.

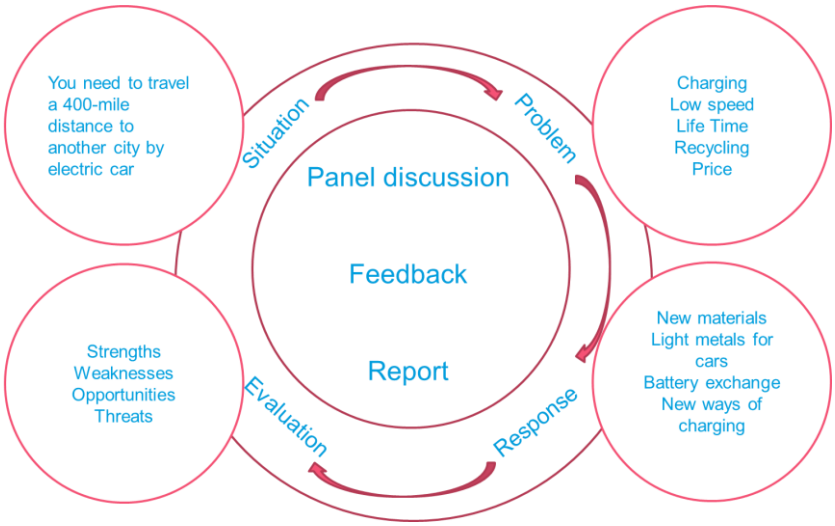

Fig. 2. Situation-Problem-Response Evaluation components of the electric cars project.

The final stage is aimed at synthesizing everything students have experienced while working their way across the problem. The results of the processing information and structuring results find expression in the report, which is written by each team member separately and accordingly assessed.

3.2 Narrow scope intra-disciplinary problems

The previous section demonstrated the way the SPRE framework can work with students majoring in different disciplines or not yet immersed in their discipline. For 3rd year bachelors we modified the original SPRE to accommodate more authentic issues and approaches and to get away from obvious simulations. We supposed that senior year students would be able to formulate the problem drawn on their subjects. The prerequisite for successful project work is identifying an engaging specific topic or a problem in the field of study. This task always causes problems as in the beginning students tend to formulate the problem very broadly or as a task which does not shape further research. For example, science majors would study the role of nuclear energy in the world or IT graduates could consider IT management in general and demonstrate how data are examined. The problem-solving task in this project is basically research and as such needs narrowing the focus to a particular subject matter.

This can be achieved only through several iterations, which involve interaction with peers and an instructor and the following reflection over the feedback. This goal can be achieved by addition of one more stage, a written proposal described in the work of Artemeva et al [1]. The proposal had compulsory sections, and they can be related to SPRE framework: background and literature review (Situation), research

gap and the purpose of the project (Problem), proposed research design and action plan (Response), initial hypothesis and possible implications (Evaluation).

At the proposal stage students give and receive feedback from peers and a teacher both online on LMS and face-to face and after several drafts they are able to formulate a tangible aim for their research. Thus, instead of describing the role on nuclear energy in the world they move to deployment of nuclear energy in France, then to the key factors contributing to its successful application focusing on science behind.

Another example of a clearly worded problem is given below (style and grammar are kept):

We are basing this study on research articles and our own experience. We are students who live in a dormitory. First, we had standard lamps in our room and did our home tasks with it. After the moment, when lamps were changed to a high-price, we feel that our activity increased. Articles told just about light influence on human's eyes and productivity level. We decide to make an experiment with our neighbours by using different lamp types. We will know how the light influence learning process and information memorizing. We will count ratio usefulness / price. Also, we will know how this influence depends on age, and if young people are more or less vulnerable (physics major).

After the problem has been formulated, students proceed to work through the classical SPRE scheme, elaborating on solutions and their evaluation. As the project progresses, learners acquire a lot of technical language and become more proficient in professional communication skills.

4 Conclusion

Engineering projects based on performing certain technical tasks have proved their value in the English language course design [1; 5; 9; 12], where the task can be very practical or more of a problem-solving type. In these ESP projects in the process of modelling extra-linguistic professional reality students become involved in profession-oriented communication in English, and target language together with reading, listening and writing skills can be organically integrated in learning activities [15].

The problem-solving SPRE is another framework for students' immersion in their professional context. We consider this scheme successful, as it enabled us to design the whole 8th semester of the undergraduate English course as project work, comprising electric cars, biocompatible materials and artificial intelligence *'problems*. Even though students had already taken their final exam IELTS by the 8th semester, their attendance did not decline, which can be regarded as an indirect indicator of their motivation.

Role distribution in SPRE, where each team member is responsible for their own part, whether is it a situation, a problem, a response or evaluation, overcomes the common for cooperative learning problem of free-riders [2;11]. As each student works on their task from the research stage, analysis and synthesis to the final product

on their own, it is easy to determine how much an individual contributed to the group's success. Another advantage in our view, which not all teachers might agree with, is that students cannot pick up tasks they are good at and neglect new skills [2]. Everyone lives through all the stages of the project, but the quality of the final product depends on the efficiency of communication and collaboration within the team [8].

The focus in inter-disciplinary projects and those designed for students majoring in one narrow subject field can be on different competences, depending on the teacher's aims. Thus, wide scope projects might put the emphasis on creativity and collaboration, while narrow scope tasks require deeper level of analysis and more expertise in the evaluation of the consequences.

Having said that, the major challenge in all domain-specific projects was identifying the research gap and the aim for further elaboration. Students tend to formulate the problem very widely and descriptively, and the role of a teacher here is to help them narrow it down to a manageable task. We suggest introducing a proposal stage, where these proposals are drafted and redrafted after getting peer- and teacher feedback.

Subject-specific projects can be best handled only with students being supported not just by language teachers by having subject teachers by their side [5]. Unfortunately, as this liaison between the language and technical departments is mostly absent as NUST MISiS remains a Russian-medium university, the choices that our students come up on their own might be aiming at less challenging side of things in their scientific domains. This is obviously the direction in which engineering projects will move in the future.

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