



STEM Engagement with Special Needs Learners: Inception of Special Needs Engineering Pedagogy

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Abstract

Declining STEM Education interest is a key challenge to fulfil the technical job market demand to drive the future economic growth. Interestingly, various institutions comprising Universities, Technical corporations, NGOs, Govt organization, etc. have been practicing STEM education promotion at primary and secondary levels. However, engagement with students from Special Needs Learners (SNL) is less covered leading to a very different social challenge involving EDI (Equality, Diversity, and Inclusion). The aim of this study is to understand possibility of implementing engineering pedagogy for special needs learner. The research was carried out through a STEM workshop in the department of mechanical engineering involving students with additional support needs in S3 (14-15 years old) from deprived area. In this workshop, students were introduced to different materials, how materials can be used to increase human quality of life, how engineers test materials and how materials can be used to achieve a sustainable environment and economy through both conventional and active learning pedagogy which included undergraduate level engineering laboratory course involving optical microscopy of microstructures for engineering materials. Results showed that 90% of the learners agreed that after the workshop they had learnt something new about materials and their effect on the environment. Interestingly, it is also revealed that active learning pedagogy is more effective for Special Needs Learners (SNL) compare to conventional theory-based pedagogy. Using an auto-ethnography approach it can be concluded that students enjoyed the workshop and the opportunity to visit the university and the laboratory facilities. They highly engaged throughout the workshop. It is expected that this finding paves the way towards developing Special Needs Engineering Pedagogy in higher education and such innovative pedagogy could be extended to special needs learners in other disciplines such as language learner among SNL community.

Keywords: *Special Need, Engineering Pedagogy, Materials, EDI, Active Learning Pedagogy, STEM.*

1. Introduction

Declining STEM Education interest [1] is a key challenge to fulfil the technical job market demand to drive the future economic growth. On the other hand, in an intensely demanding and competitive employment market, the industry-readiness of graduates provides one of the important indicators showcasing the quality of university education as well as industry-oriented institutions of further and higher education. Since corporate expectation continue to escalate from university graduates in this 21st century, employers are constantly seeking graduates equipped with both soft and technical skills. Therefore, today's professionals need to be hold T-shaped skills sets which are highly sought by employers, where mastery of competencies has increased importance over focused academic discipline [2,3]. In such point of view, graduates with cross discipline competence [2], and soft skills such as critical thinking, problem solving, creativity, ability to adapt to change and communicate effectively [3,4,5,6] in a culturally diverse environment have distinct competitive advantage to succeed in addition to competency in technical expertise (hard skills). In 2012 Forbes [7] reported a rising gap between business and education and interestingly found that globally about 42% of employers believe that fresh graduates are adequately prepared for work while the industry concerns over impending skills gap. In this scenario, STEM education is one of the major enablers to provide such industry ready graduates. Interestingly, various institutions comprising Universities, Technical corporations, NGOs, Govt organization, etc. have been practicing STEM education promotion at primary and secondary levels [8,9]. However, engagement with students from Special Needs Learners (SNL) is less covered [10,11] leading to a very different social challenge involving EDI (Equality, Diversity, and Inclusion). Unfortunately, in such cuthroat reality, very little support available for special needs learners where engineering education is a far reach as engagement opportunities are low. Therefore,



following the UN SDGs 8-Decent work and Economic Growth and 10-Reduce Inequalities [12], the aim of this study is to provide equal opportunities and use the experience to pave the way towards developing Special Needs Engineering Pedagogy in further and higher education

2. Methodology

2.1 Pedagogical Approach

The research was carried out through a STEM workshop in the department of mechanical engineering involving students with additional support need i.e., SNL in level S3 (14 -15 years old) from deprived area. Special Needs Engineering Pedagogical hypothesis was carried out through two different approaches: (i) Conventional Classroom based learning, and (ii) Laboratory based active learning. In conventional classroom-based learning approached special needs learners were introduced to various engineering materials, their properties and applications through theory including graphical contents and through simple observation/manipulation related to strength, ductility, etc. Also, they were provided with an explanation on how materials are selected how they have been used to improve human being's quality of life. In addition, contents also included common mechanical properties of materials such as tensile, compressive, bending, torsion and shear strength similar to level 1 undergraduate engineering students. Then topics of material corrosion, smart materials and environmental impact including sustainability were introduced. Finally, they were asked their understanding with brief quiz-based feedback. The active learning approached including laboratory session were carried out through hands-on activity that included a metallographic preparation for microstructure analysis and a demonstration of tensile testing for different ferrous and non-ferrous materials. Similarly, as to the conventional session, feedback was received through brief oral questions during the active learning sessions. After completion of both approaches, overall feedback was received through written questionnaire as per following overall pedagogical approach shown in Fig. 1.:

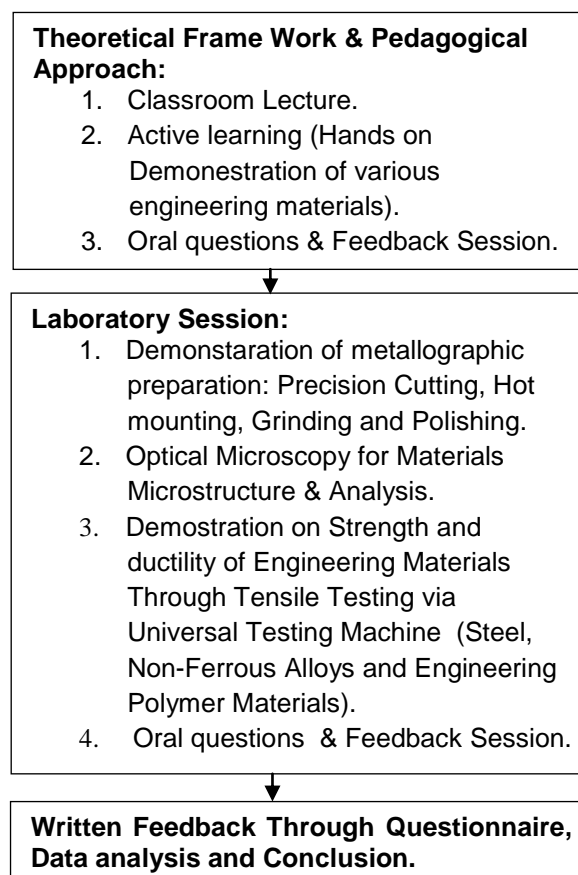


Fig. 1. Overall Pedagogical Approach.

2.2 Auto-Ethnography Approach



This approach is used for qualitative research and involves reflection from researchers [13] and it also enables researchers to become subjects of study while maintaining the flexibility to situate themselves in relation to the phenomenon under examination [14]. Based on this auto-ethnography approach authors judgment and experience agreed the following indicators of performance: 1-low, 2-Medium and 3- High.

3. Findings and Discussions

As previously mentioned, Special Needs Engineering Pedagogical hypothesis was carried out through two approaches: (i) Conventional Classroom based learning and ii) Laboratory based active learning. Table 1 shows Indicator Performance based on auto-ethnography approach for different Psychosocial Dynamics shown by SNL before and after their engineering experience.

Table 1. Indicator Performance based on auto-ethnography approach for different Psychosocial Dynamics shown by SNL during their engineering experience

| Psychosocial Dynamics | Indicator Performance | |
|-----------------------|-----------------------|--------------------|
| | Before the activity | After the activity |
| Enthusiasm | 3 | 3 |
| Interaction | 1 | 3 |
| Engagement | 1 | 3 |
| Anxiety | 3 | 1 |
| Worried | 3 | 1 |
| Enjoyment | 3 | 3 |

When students arrived, they were very enthusiastic as it was their first time coming to a university, seeing a lecture theatre, and being taught by academics. However, they were quiet and some confessed they were worried as they did not know what to expect and how they will perform, once the activity started, they started to feel more comfortable and their engagement increased rapidly to the point that they started to ask questions. After 15 minutes through the activity students were fully engaged and once the activity concluded all they asked was when were they coming back to the university that it was the best day ever.

Regarding the technical aspect it was perceived that students were very active in listening; however, it was noticed their struggle to comprehend the concept. On the other hand, during the active leaning approached including laboratory session where students were highly engaged and appropriate feedback was received from the questionnaire. Interestingly, this leads to finding that Special Needs learners' pedagogical development responsive more towards psychomotor domain compare to cognitive domain. Hence, this innovative pedagogical technique could be applied for any learning field involving SNL, hence students from other disciplines. For example, in order to facilitate language learning for SNL student, focus would be needed towards mimicking practicing compare to listening exercise. After analysing the response from the questionnaire, Fig. 2. shows the overall feedback response through simplifying simple conventional questionnaire considering Special Needs learners' perspective.

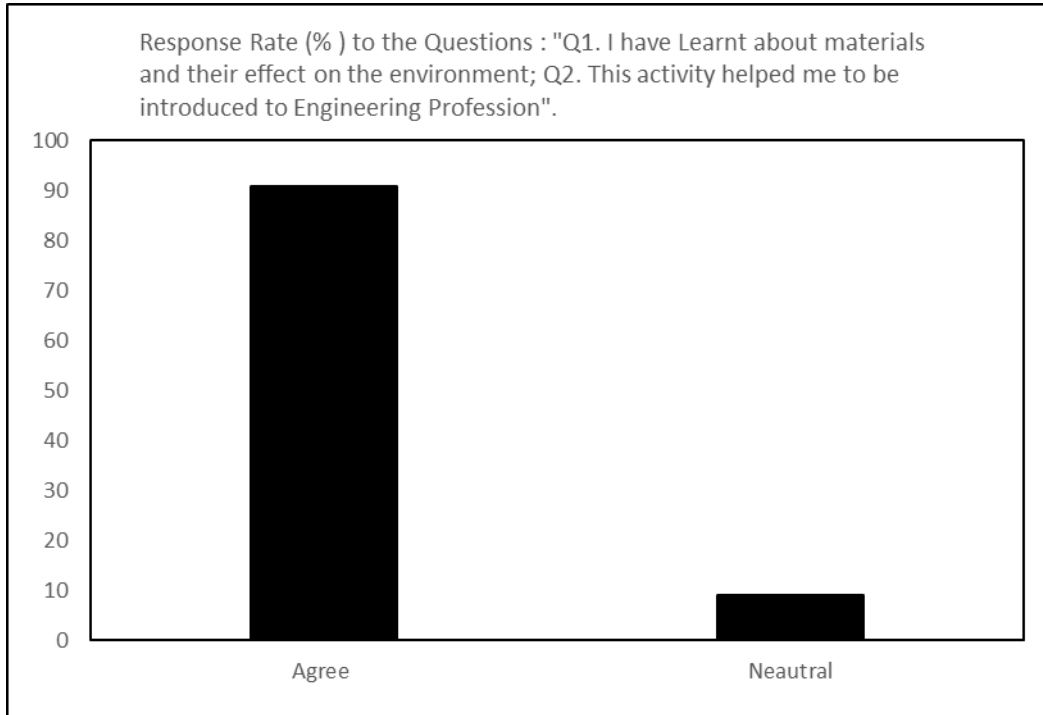


Fig. 2. Response to the both written questionnaires involving SNL perspective towards their learning about materials and engineering profession.

Results showed that both cases, 90% of the learners agreed that after the workshop they had learnt something new about materials and their effect on the environment as well as they were introduced with the engineering profession. Interestingly, it is also revealed that active learning pedagogy is more effective for Special Needs Learners (SNL) compare to conventional theory-based pedagogy. The pupils were highly engaged throughout the workshop which reflected from the following feedback of one of the students: *"I liked experience, we get to learn loads."* Also, another SNL commented: *"It was pretty good event. It was fun."*

4. Conclusion

Special Needs Engineering Pedagogical hypothesis was carried out through two different approaches: (i) Conventional Classroom based learning and ii) Laboratory based active learning. Interestingly, it is revealed that Special Needs Engineering pedagogy is feasible with carefully designed curriculum emphasising psychomotor based delivery. Such method could be further extended to language learners among SNL community. It is expected that such findings pave the way towards developing Special Needs Engineering Pedagogy in higher education to facilitate Special Needs learners in the professional field for their career progression and better life.

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