Importance of Mathematics in TVET Education in Bhutan

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Abstract

Technical Vocational Education and Training (TVET) refers to competency-based courses, unlike academic-based tertiary education, which focuses on academic subject enrichment. TVET consists of various practical courses where students are prepared to enter the labor market after graduating from these institutions. Mathematics is the basis of all subjects, including vocational education. To excel in either electrical course or mechanical, the student should be able to apply mathematical knowledge and concepts. This article discusses the role of Mathematics in enhancing employability and the foundation for higher education. Mathematics is considered irrelevant to TVET by most students because more focus is given to core skills or practical and also because the application of Mathematics is not seen directly. The relevance and requirement of Mathematics to Technical Vocational Education and Training (TVET) are also presented in this paper, which will help enhance students' interest in the subject. The vocational education system in Bhutan is also discussed, and the Bhutan Vocational Quality Framework (BVQF) is presented with a Mathematics syllabus.

Keywords: Technical Vocational Education and Training, Mathematics, Students, Bhutan, India

1. Introduction

The Technical Vocational Education and Training (TVET) system in Bhutan is on the verge of various reforms to make vocational learning the first choice of the students rather than the last. In Bhutan, after 10th and 12th grade [1], if a student does not qualify to study in other academic-based tertiary education, they enroll in Technical Training Institutes (TTIs). It means that low achievers
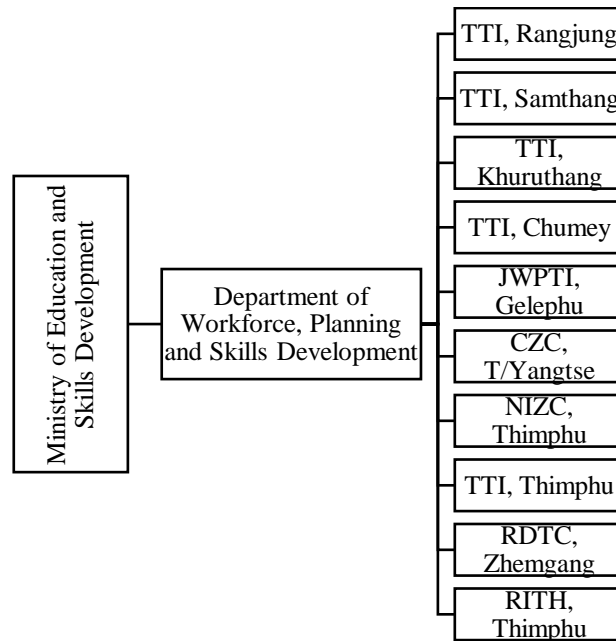
get enrolled in TTIs when they do not get enrolled in academic-based tertiary institutions [2]. Since low achievers get enrolled in TTIs, they find Mathematics challenging and show no interest in learning [3].

Figure 1. TVET Institutions under Government

There are ten government Technical Training Institutes and many private institutions in Bhutan (as shown in Figure 1). Various courses like electrical, plumbing, carpentry, mechanical, computer hardware, masonry, etc., are taught in the institutes [4]. In addition to core skills being taught, one of the subjects being taught is Mathematics, called the soft skill course. Mathematics is not given much importance since its credit is comparatively low and because trainees consider it the most challenging subject, on top of which students claim that there is no direct relevance to their workplace [5].

In contrast to TVET being the last option for students, it could also mean a new pathway to pursue higher studies [6], such as following a diploma, degree, etc. But students tend to be more concerned about getting a job and entering the labor market than pursuing higher education.

In vocational education, the most important thing for the students is to perform well in practical (i.e., core skills such as electrical, masonry, mechanical, carpentry, traditional art, and craft). Basic Mathematics is used in practical learning [7], such as simple algebra and basic trigonometry to measure angles and find lengths yet students question the relevance [8] of the subject to their

training. Therefore, their interest in Mathematics deteriorates.

In the second section of this article, Mathematics as a soft skill subject in TVET institutions in Bhutan is presented with a brief overview of the curriculum followed by a discussion on the career pathway for TVET graduates and the prerequisite to pursuing higher education (i.e., having mathematical knowledge). The importance and role of Mathematics in enhancing competency and employability is also discussed with its relevance in TVET in the fourth Industrial Revolution (I.R. 4.0). The last section concludes the paper by summarizing and justifying the importance of Mathematics in TVET.

2. Mathematics in TVET

Vocational Education in Bhutan comprises practical courses such as plumbing, masonry, carpentry, traditional art, craft, electrical, etc. (as shown in Figure 2). Besides practical courses, soft skill course has been introduced, such as English, Mathematics, Dzongkha (National Language), and basic Information Technology (ICT) to enable students to improve generic skills. Among all the soft skill courses, Mathematics is considered just numeracy, and the students consider anything taught beyond that hard. In Bhutan, there are two levels for National Certification (N.C.), NC II and NC III (as shown in Figure 3). According to the level of study, the curriculum for Mathematics is designed. The mathematics curriculum for NC II comprises basic numeracy, measurement, algebra I, etc., and for NC III, it comprises Statistics, Algebra II, etc., and Physics content, too [9].

BQFC-2

Numbers
Unit Conversion
Mensuration
Trigonometry I
Algebra I
Commercial Arithmetic
Mechanics
Stress & Strain
Pressure
Simple Machines
Heat

BQFC-3

Statistics I
Algebra II
Trigonometry II
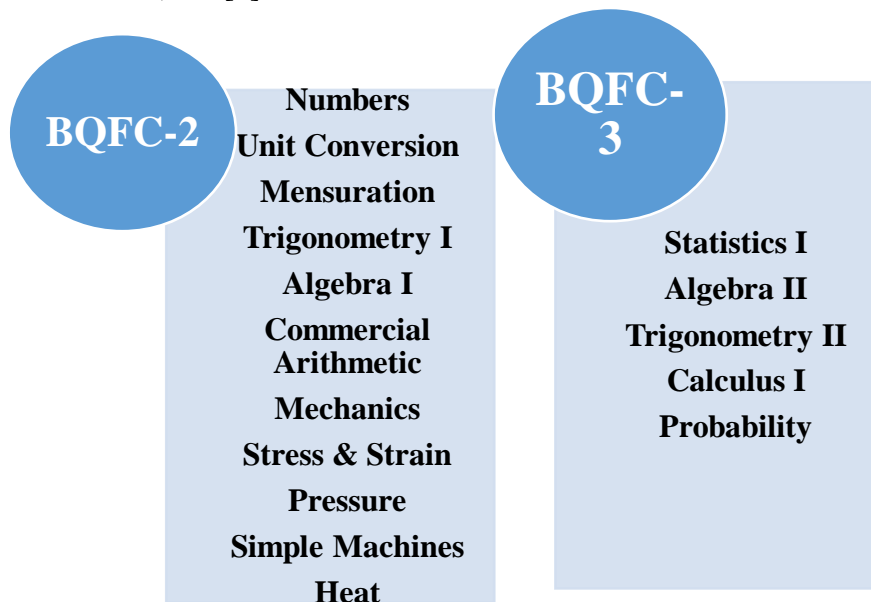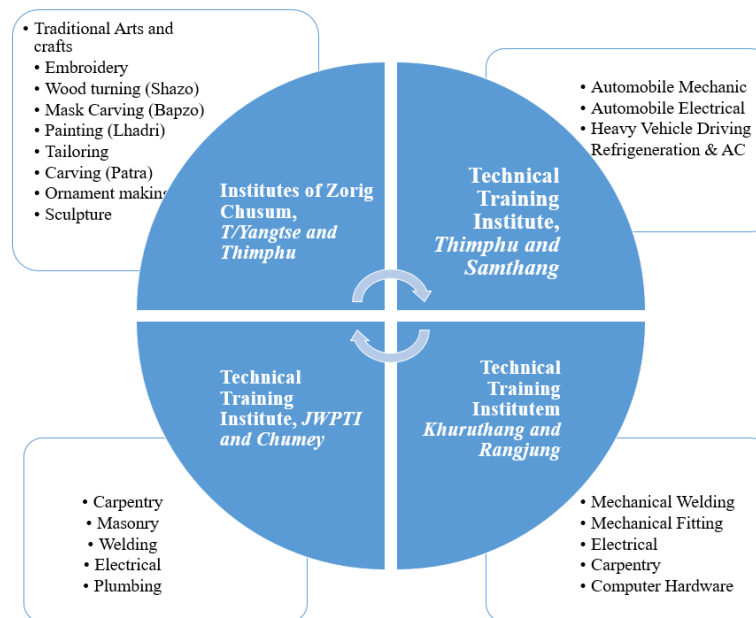**Calculus I**
Probability

Figure 2. TVET courses in eight institutes of Bhutan

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According to Bhutan Vocational Qualification Framework (BVQF), the main focus of the training course is on skills and competency to perform practical, with only 20% based on trade-related theory [10]. But out of the 20%, soft skill courses (Mathematics, English, Dzongkha, and ICT) take up only 5%. It means that each soft skill course contributes only 1.25%. Though the curriculum of practical courses is mentioned in Bhutan Vocational Qualification Framework (BVQF), there is no mention of Mathematics as a course. Before 2019, Instructors taught mathematics who also taught practical courses. The Ministry of Labour of Human Resources (MoLHR)[1] recruited qualified Mathematics tutors in all the Institutes in Bhutan only in 2019.

- Traditional Arts and crafts
- Embroidery
- Wood turning (Shazo)
- Mask Carving (Bapzo)
- Painting (Lhadri)
- Tailoring
- Carving (Patra)
- Ornament making
- Sculpture

Institutes of Zorig Chusum, *T/Yangtse and Thimphu*

Technical Training Institute, *Thimphu and Samthang*

- Automobile Mechanic
- Automobile Electrical
- Heavy Vehicle Driving Refrigeneration & AC

Technical Training Institute, *JWPTI and Chumey*

Technical Training Institutem *Khuruthang and Rangjung*

- Carpentry
- Masonry
- Welding
- Electrical
- Plumbing

- Mechanical Welding
- Mechanical Fitting
- Electrical
- Carpentry
- Computer Hardware

Figure 3. Mathematics Syllabus in TVET institutions

According to Maloney, Schaeffer, and Beilock [11], one of the reasons for considering Mathematics as a challenging subject by the students may be Math anxiety. They defined Math anxiety as the perceived knowledge and reaction towards Mathematics which starts early on in childhood and remains attached throughout. So, even if some basic Mathematics concept like simple operations of numbers is taught, people with Math anxiety will feel trapped with some advanced-level Mathematics question [12]. In the Vocational system also, many students feel that they need to gain mathematical knowledge and skills, and with trying, they conclude they are not good at it.

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[1] MoLHR is now dissolved and TVET is under the purview of Ministry of Education and Skills Development

2.1. Mathematics as the foundation for higher studies

Similar to Bhutan, Australian tertiary education is divided into two, i.e., Higher Education (academic-based colleges) and Vocational Institutes [13]. Higher education is knowledge-based, but in vocational institutions, it is competency-based [14]. Qualifying from vocational institutions will enable students only to be employed, but their career pathway will end. But suppose a student desires to pursue higher studies. In that case, they have to study a curriculum similar to higher education, where mathematical knowledge [15] is mandatory, especially in engineering courses. Therefore, Mathematics is a crucial subject to be learned in vocational institutes as it serves as the foundation for higher education.
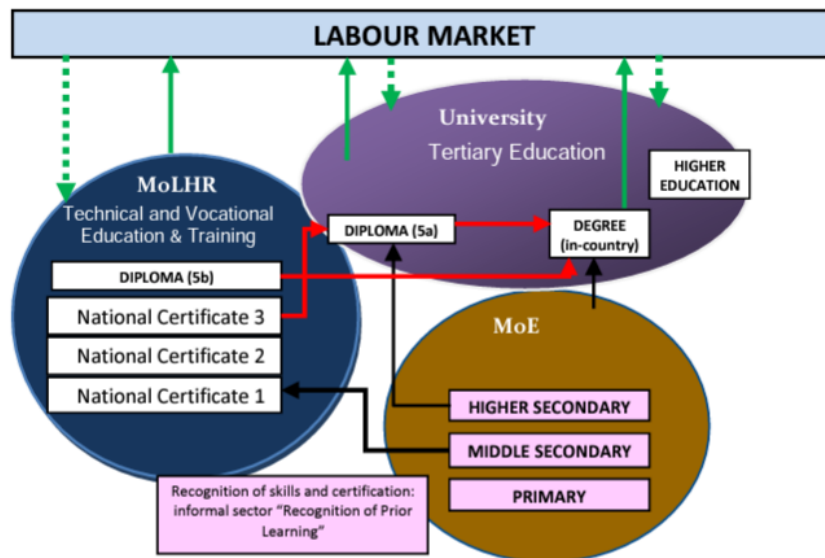
Figure 4. Higher Education Pathway for TVET graduates [4]

According to BVQF, the pathway for higher education is mentioned (as shown in Figure 4), but the implementation still needs to be done. Some provisions like entry requirements for higher education should be provided by the TVET sector so that those students who are willing to pursue a diploma or degree can do [16]. For students from Technical Vocational Education and Training to pursue higher education, students must fulfill the criteria set by the tertiary education system [17]. In this case, mathematics plays a vital role in fulfilling the set criteria because students should be well-versed in mathematical knowledge to enter academic-based tertiary education [18]. Also, if Mathematics is not considered necessary during the training days in TVET, that would create a gap when trying to enroll in academic-based tertiary education.

Most of the students in vocational education view their training period as the end of their education, and therefore, they focus on being employed [19], which indirectly makes them question the relevance of Mathematics to their workplace. Also, more importance is given to the practical courses because these skills prepare the students for the labor market, whereby the soft skill courses such as Mathematics are compromised [20].

Mathematics is considered to be crucial to learning during TVET to pursue higher education and to pursue higher studies [21].

2.2. Mathematics as a tool to enhance competitiveness and employability of Vocational Training Institutes

TVET graduates enter the labor market right after completing their course, but to sustain themselves in the labor market, they should be competitive and have the required skills. Graduates who took up Electrical, Mechanical, Traditional Arts and Crafts, etc., should have mathematical skills like problem-solving skills to do their work. For example, if someone is fabricating metal art, then dimensions, measurement, and estimation are required.

Problem-solving skills are the primary skill required in Mathematics [22]. If a person is proficient in problem-solving, their creativity is enhanced, enabling them to be competitive. In this era, every employer desires an employee who is creative, logical, a problem solver, analytic, good in ICT, etc. The students can achieve all of the mentioned skills if they are skillful in Mathematics [23].

In olden times, vocational education was considered solely for getting employed to work in a practical-based workplace. Still now, with changing times, a TVET graduate is expected to work in places such as workshops, factories, etc., and in offices where 3D printing, virtual reality, etc., is applied. To be competitive in this rapidly changing world, one should be aware and up to date with the advances in this world [24].

2.3. Mathematical Relevance in TVET in Fourth Industrial Revolution (I.R. 4.0)

In the fourth Industrial Revolution (I.R. 4), rapid changes can be seen in digital technology in the manufacturing industry, fabrication, and automakers. Also, with new courses in TVET, such as the Internet of Things (IoT), 3D printing, virtual reality, smart factories, etc., one should be able to perform the required skills and to do that, without mathematical knowledge, it would be hard to cope [25] and to be employed. Mathematics enables students to apply innovative solutions in their workplace and enhance their logical, creative, and critical thinking [26]. Therefore, the TVET system should embrace Mathematics as a crucial and necessary part of it to meet the demand of

the workforce [27].

3. Conclusion

Mathematics plays a vital role in enhancing the competency and creativity of students in Technical Vocational Education and Training (TVET). Since most of the students joining TVET are underachieving, they conclude that Mathematics is a complex subject. Also, they need help to connect Mathematics in their workplace through the application of Mathematics is seen everywhere. Even though mathematical knowledge is used in calculating dimensions, angles, and measurements, students tend to ignore mathematics' minor applications and conclude that it has no relevance in their workplace. Mathematics is crucial in higher education also. Students graduating from TVET, primarily Electrical and Mechanical, should be proficient in Mathematics if they want to pursue a diploma or degree. Therefore, Mathematics is crucial in Technical Vocational Education and Training (TVET) with the rapid change that is taking place in the fourth Industrial Revolution, where digital technology is developing rapidly. In conclusion, Mathematics should be considered an essential subject as a practical course since it is the foundation of all subjects.

Conflict of Interest:

Hereby, the authors (Dr. Geeta Arora and Tashi Lhamo) consciously assure that for the manuscript titled "Importance of Mathematics in TVET Education in Bhutan", the following is fulfilled:

1) This material is the authors' own original work, which has not been previously published elsewhere.

2) The paper is not currently being considered for publication elsewhere.

3) The paper reflects the authors' own research and analysis in a truthful and complete manner.

4) The paper properly credits the meaningful contributions of co-authors and co-researchers.

5) The results are appropriately placed in the context of prior and existing research.

6) All sources used are properly disclosed (correct citation).

7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

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