The STEM Curriculum for Future Engineers

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Definition

While higher education has been facing the consequences of low fertility, remodeling it from the inside out has seemed inevitable. The current study sought to apply the concept of theme-based STEM curriculum design to the new engineering education program by planning several thematic clusters during the university period, covering various professional fields within the department.

1. The Current Reality

Due to the low birth rate, the amount of students enrolled in higher education in Taiwan has been decreasing since 2009 [1]. This year, the Central Intelligence Agency (CIA) of the US reported that Taiwan has a total fertility rate (TFR) of 1.07 (i.e., the number of children born per woman), which is ranked last among 227 countries [2]. The condition results in fewer students enrolled at all levels of education, and this has recently begun to impact higher education. While a lower birth rate resulting in lower student enrollment is a difficult challenge for higher education, the current COVID-19 outbreak is another. It is forcing the formats of hybrid, asynchronized, and synchronized online learning to take over from the traditional face-to-face learning setting. However, research has found that higher education students are generally dissatisfied with their online learning experiences [3]; as such, this could further deter them from enrolling in classes [4].

STEM majors (i.e., science, technology, engineering, and mathematics-emphasized majors) in higher education in Taiwan have experienced lower student enrollment and low student interest (or motivation) in their educational paths, and learning ineffectiveness has become a common issue discussed among professors [5][6]. Ultimately, the goal of promoting STEM for student careers and fostering educational effectiveness in science, technology, engineering, and mathematics-related majors for the next generation of society seems to be facing a dilemma. STEM-related subjects have been regarded as challenging to learn for young people [7]. Most of the core coursework requires the learning of extensive theoretical foundations (e.g., scientific concepts, engineering mathematics, calculation, and computer programming). While the training of STEM majors is naturally challenging, stimulating students' learning interest, especially for those with lower academic achievement, can be difficult, leading to a vicious cycle [8].

In traditional curricular design, one or a few summative courses in the senior year (e.g., a capstone course or project) are normally arranged for students to demonstrate how they may integrate the professional knowledge and skills that they have learned. It is the final test before the undergraduates launch their careers, and verification of the departments' course effectiveness and curricular design. However, the problem with the traditional method may be the lack of real-world connections. A capstone course or project may reflect whether students have obtained a comprehensive understanding of the skills being taught. However, if the curricular design is not relevant to some authentic scenarios or does not fit into the mainstream, such that the curriculum is lacking (hands-on) interdisciplinary connections (e.g., humanities and arts) or practice-driven understanding and skills (i.e., real-world problems in workspaces), we may be less likely to find students motivated to learn [9].

In this vein, a common need arises for universities to re-consider how the current STEM curriculum can be reformed [10][11][12][13][14]. Immense strategic teaching and learning methods have been proposed, practiced, and documented; furthermore, a reformation has been led by the teachers [15] (i.e., teachers' collective or individual responses to the curriculum reform). A consistent suggestion from the current literature is that a localized curriculum reformation is needed [13], instead of a top-down reformation led by governments [16]. Although there have been related studies associated with the movement in higher education, research data collected associated with institutional-wide curricular reformation are lacking. Therefore, the current study was an exploration aiming to understand a reformed STEM curriculum while caring for student performance and motivational effects.

2. The Role of STEM Education in Higher Education

In most cases, STEM education has been practiced for non-engineering majors, such as integrating STEM elements in general education courses for non-engineering students [17] or interdisciplinary learning objectives that seek a cross-dimensional solution for larger scales (e.g., environmental issues) [18]. For cultivating future engineers, STEM education delivers not only professional knowledge but also new ways of thinking and the ability to think ahead of new problems in a technology-enriched future society [19]. “New thinking and problems” refer to the ability to recognize new needs to be foreseen and solved with known techniques and technology. The ability requires immense expertise from different areas and creative collaboration in an interdisciplinary setting [20].

Meanwhile, sustainable STEM education echoes the aforementioned needs. Today, the movement in higher education integrates reformed knowledge, innovation, and practice while considering the humanities, ethical issues, social learning, and civic engagement with a learning process that is exploratory, action-oriented, reflective, and transformative [21]. While the curriculum has been rapidly reformed at the primary and middle school levels toward STEM, the movement has prompted higher education to change and make their ways of teaching more multifaceted [22].

However, how STEM can be remodeled for engineering majors is still unclear [23]. In response to the changing learning needs in higher education, to invest actively in online education by trying out various possible delivery models to continue to provide adaptive and dynamic teaching seems insufficient; it may be more important to consider possible changes to the internal system, curriculum, and teaching for engineering education.

Among several approaches that are generally focused per course on teachers’ unconventional strategies of teaching (e.g., problem-based learning and online/flipped instruction) or students’ constructive ways of responding to/exploring/learning the course materials (e.g., inquiry-based learning and collaborative group settings), a curriculum-based reformation (or the New Engineering Curriculum Program approach (NECP)) has been proposed in Taiwan in some universities to reorganize the curriculum aimed to reconcile students’ interest to the STEM learning experience.

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Keywords

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