Connectivity related issues in a modularised course involving mathematics

CONNECTIVITY RELATED ISSUES IN A MODULARISED COURSE INVOLVING MATHEMATICS

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Keywords: Engineering education, modularisation, qualitative study.

Universities of technology are increasingly looking for ways to facilitate individual student study paths, moving away from a prescribed sequence of courses. In the envisaged modularised curricula, authentic engineering tasks or forms of Challenge-Based learning play an important role (Gallahar & Savage, 2020). Students may need particular mathematical knowledge in order to successfully solve these engineering tasks or problems. Modularisation of mathematics courses is considered a way to provide students with the required knowledge when they need it during their education at the university or even after their graduation. Modularisation involves dividing the learning process into relatively small independent curriculum packages (modules) (Kiliç & Pepin, 2020). Digital technology is used for their provision and access.

In this poster presentation, we report on a study at a university of technology in the Netherlands. We posed the following research question: In which ways can modularised courses involving mathematics for engineering education be enhanced for the benefit of student learning?

In terms of data collection, we observed a modular course requiring mathematical knowledge of statistics and probability. The course consisted of three modules, which were enacted sequentially and assessed separately. The first module addressed mathematical pre-knowledge that was required to understand the subsequent modules. The second and third modules concerned embedded systems and their modelling, and used knowledge from the first module. We conducted interviews with course instructors (N=5), selected students (N=6), and university employees (e.g., deans, education directors, teacher support) (N=4). In the interviews, we asked the course instructors and university staff about the conditions for effective modularisation of courses and their specific experiences with modular courses. We asked the students about their experiences in modular courses and their expectations regarding modular courses in general. We asked how guidance and support in modular courses could help for their learning, in particular how to connect mathematical knowledge to their disciplinary knowledge and skills. Moreover, we asked how modularisation could help students to develop themselves in the engineering profession. We analysed the data using a grounded theory approach (Strauss & Corbin, 1994).

Four main themes emerged from the interview data that are likely to have an impact on modular course design: (1) the importance of connectivity, (2) the role of mathematics knowledge in engineering education, (3) the need for technological support, and (4) practical related issues regarding the sequencing of learning activities and assessment. Out of these themes, specific suggestions were formulated to enhance modularised courses involving mathematics: (a) clear outline of dependencies within and between modules; (b) provision of flexible and adaptive technology-based resources catering for diverse student backgrounds and needs; (c) identification of mathematical pre-knowledge for each module involving mathematics; (d) support for students and instructors to bridge the gap between general and applied mathematics knowledge in engineering modules; (e) support of students (e.g. via technological means) to follow the module flow; and (f) provision of learning activities and assessment to support self-directed student learning. According to the respondents, mathematics modules need to be well-connected to each other and tailored to each engineering program in which they will be used in order to to make them fit into the learning lines of the curricula and to create 'undisturbed' student learning paths. These connections might be realised by a self-explanatory module structure and by flexible and adaptive resources for learning, allowing for differentiation. To meet these demands, a technologically enhanced learning environment would be required. Such a system might also be used to support students and instructors: guiding students (e.g. with digital self-assessment/feedback) on how to accomplish their goals with the help of the knowledge and skills they develop using the modules and supporting instructors in terms of coherence of their modularised courses. Regarding the assessment procedure, unlike conventional courses, assisting students at particular times before final assessment will be difficult in the constructed and pressured form of modular courses. Therefore, assessment usually takes place at the end of each module (that spread over the semester). Moreover, structured and iterative formative feedback might help students to become autonomous learners. Providing feedback on student progress throughout the module will help students to know where they are in their knowledge development and to develop metacognitive strategies (Pepin & Kock, 2021).

Critical for modular course design and use seems to be the concept of connectivity (Pepin, 2021) that refers to the links and relations made (1) within the mathematical module content (e.g., between different mathematical representations; intra-modular connectivity); (2) between modules and courses (e.g., how the contents of different modules are related; extra-modular connectivity). An appropriate level of extra-modular connectivity is necessary for students to develop their own meaningful study paths and meet curriculum requirements when a prescribed sequence of courses is no longer available. Moreover, connections made between a mathematical module and engineering applications of mathematics will help students give meaning to the mathematical content. A sufficient level of intra-modular connectivity appears essential for students to develop a rich network of mathematical concepts and, in this way, a comprehensive appreciation and understanding of the mathematics itself (Pepin, 2021).

As far as we are aware, the electronic learning environments used at universities of technology do not generally offer the levels of connectivity we have discussed here. Hence, technological developments of these systems need to be considered. Moreover, teachers and educational designers who configure the systems need to be aware of the importance of connectivity to enable the full potential of modular mathematics courses in engineering education.

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