Development of a PBL-based curriculum for data-driven precision medicine

Pedagogiskt docenturarbete

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1. Introduction

Progress in next-generation sequencing and multi-omics technologies has led to vast amounts of human health-related data, experience and knowledge for the development of precision medicine. By utilizing advanced data-driven strategies, standard clinical care is shifting towards more individualized patient management and therapeutics. Thus, there is an increasing demand for training programs to develop next-generation data-driven biomedical researchers with knowledge in both precision medicine and data-driven study design (Williams et al., 2015).

Currently, the traditional teacher-centered way of education is being challenged by learner-centered teaching when measuring the long-term retention of knowledge and skills of students. Many studies suggest that it is important to create an open and active environment to develop critical thinking and problem-solving skills (Wright, 2011; Young and Paterson, 2007). For the reason, new student-centered course designs are in need to complement the existing curriculum systems, especially for the interdisciplinary area.

Problem-based learning (PBL) is an instructional student-centered approach that utilizes open problem scenarios to facilitate constructive, collaborative, contextual, and self-directed learning (Dolmans et al., 2005; Yew and Goh, 2016). PBL originated from the Medical School at McMaster University, Canada, in the 1960s (Barrows and Tamblyn, 1980). Now it has been world-wide adopted in diverse fields and multiple disciplines. Different from traditional lectures and other top-down teaching approaches, PBL is featured by small group discussion, where students learn from interacting with each other, and consolidate their learning through reflective writing (Servant-Miklos, 2019; Yew and Goh, 2016). The effectiveness of PBL has been evaluated in different educational settings (Capon and Kuhn, 2004; Dochy et al., 2003). The results suggest that students who have experienced PBL frequently outperform their traditional counterparts in critical thinking skills and knowledge of practice (Allen et al., 2011).

2. Pedagogical theory and reflection
**2.1 Teaching and critical thinking**

Teaching is a system art and learning is a lifelong activity. The experience that we have gained from our life, education and work plays an important role in learning. According to the constructivism learning theory, knowledge and understanding is constructed and not received as transmitted knowledge (Vermunt, 1998). It involves a process of individual transformation. A good teacher should use more student-focused approaches to encourage and lead students to relate concepts to existing understanding, to distinguish between new ideas and existing knowledge, and to critically evaluate and determine key themes and concepts, rather than just getting the students to “absorb some knowledge” (Earley and Porritt, 2014). A good course should also aim to help students to create a general understanding of the study area and conceptualize it at a high level of abstraction with the ability to apply to new and broader contexts. Teaching and learning should guarantee that students not only learn the facts but also to use the facts to make decisions about what they understand or what they should do (Darling-Hammond, 2008). Hence, teaching is beyond the “facts memorizing” and is actually in a rich context of problem solving, issue identifying, ideas debating, questioning, methods acquiring, and abstract conceptualization.

Developing critical thinking skills and high levels of innovation and creation are the key aims of higher education (Behar-Horenstein and Niu, 2011). Teaching is not only about the teachers and teaching materials. The teachers should take students into consideration when they do course design, selection of teaching and assessment to make sure students have enough opportunities for practice and exploration, space for thinking or reflecting, and learning from and with peers and experts. Feedbacks, discussions and small groups can be used as effective tools to help improve the learning experience. In addition, how to encourage reflection and include reflection practice in the course is critical for the success of the course. This is a key part of learning. In this way, students will be question-driven and able to form their own ideas as well as integrate the new knowledge with old. In the end, they will be able to use the enhanced understanding to make decisions and problem-solve. In contrast, when there is an overload of content in the course, there will be limited space for reflection and result in a surface learning.

**2.2 Problem-based learning**

Problem-based learning (PBL) is a great example which is expected to enhance student-centred learning, promote active learning, and help the students to retain and develop lifelong
learning skills (Spencer and Jordan, 1999). In order to plan for PBL in courses, five steps needed to be taken into considerations: (1) providing project or real-life problems rather than theoretical situations; (2) encourage the students to discuss and deconstruct the problem and develop a solution through self-directed learning approaches; (3) aligning the evaluation/examination of the problems to the intended learning outcomes; (4) abstraction, where the solutions are contextualized with other known cases and help the students to reach relational and extended abstract level of understanding; (5) enough space for reflection (Koschmann et al., 1994).

A good design of a Teaching-Learning Occasion (TLO) is critical for the implementation of PBL in the subject. It’s important to identify the course goals and learning objectives at the very beginning. And these have to be key ‘threshold concepts’, instead of rote facts or formulas, and have an ‘applied nature’. Then, teaching methods and resources can be selected based on the alignment of teaching learning outcomes. To optimize the teaching-learning processes, blended learning techniques are most common to support a PBL course and it is often extremely important for medical study (Garrison and Kanuka, 2004). Hands-on lab exercises, project work and jigsaw discussions are good complements to traditional lecture-based classes and can promote a deeper learning.

Accordingly, effective assessments of multiple teaching scenarios are integral to learning (Gibbs and Dunbar-Goddet, 2007). A good design of assessment will help improve students’ performance and show trusted certificate of the students’ ability in the subject area. Thus, assessment design is an important component of course syllabus. Also, to design assessment before designing the content of the course will help teachers to be informed about the learning outcomes and know better how to progress. Usually, a combination of assessment methods, including unseen exams, reports, multiple choice questions, presentations, projects etc., can be used in the course to test students’ ability from multiple perspectives. Using a range of diverse methods of assessment is also valuable to promote fairness and equal opportunities to students because each single method could potentially disadvantage some students.

2.3 Facilitating students’ learning and development

A natural and inclusive learning environment is the foundation of a successful teaching activity (Navarro et al., 2016). It’s important to be aware that different learners can experience the same teaching in different ways. Students with different cultural/professional backgrounds, beliefs, possible disabilities, skills, expertise, experience and learning styles may have different
expectations about the course and the teaching style (Gurin et al., 2002). To be an international teacher, there is a need to be aware of the impacts from diverse backgrounds and make the course to be more inclusive. Teachers should also need to understand the starting levels of the students as well as the possible threshold concepts that are necessary for the course. For optimal learning, various teaching approaches can be used as a combination to meet the demands from different aspects. Transparency of the course plan and grading criteria would also help to build an accessible and inclusive learning environment.

Active learning is another influential factor in student learning (Michael, 2006). It becomes a bit tricky to increase students’ engagement nowadays when we do online teaching. But as a teacher, it’s important to be aware that the students are the main components of a course. To facilitate students’ learning, interactive teaching methods and PBL-based small group discussions can be included in even traditional lecture-based courses.

3. Pedagogical plan

Precision medicine offers tremendous opportunities to shape the future of healthcare. With the development of human genetics as well as novel high-throughput molecular technologies, there has been a rapid increase in knowledge and new data-driven strategies regarding the utilization of individual genetics, molecules, and environmental variables for multi-level patient stratifications, which forms the basis of precision medicine. Thus, there is a growing interest in students to develop multidisciplinary knowledge of precision medicine at a higher level by combining data-driven skills in omics technologies, systems modelling, medical imaging as well as health information.

The plan is to create a new doctoral/third-cycle course ‘Omis technologies and data-driven precision medicine’ to enrich the students’ knowledge in the field. The aim of the course is to train future data-driven researchers in precision medicine. To enhance the quality of the learning outcomes of the course, a series of PBL sections will be designed to discuss the potential clinical applications and challenges in the era of precision medicine. It will cover key knowledge and tools to understand the fundamentals and clinical practice of precision medicine. Knowledge on clinical study design using advanced molecular technologies as well as human data management will be provided.

After the successful completion of the course the student will be able to: 1) explain the theory and the fundamentals of precision medicine; 2) describe the ethical considerations for precision medicine and the management of human data; 3) outline the phenotyping
technologies in precision medicine; 4) demonstrate different types of clinical trials in precision medicine; 5) perform multi-omics experiments in different clinical settings; 6) interpret the data analysis results; 7) discuss the challenges and progress in precision medicine.

4. Future challenges and implications

Nowadays, the practice of medicine is undergoing a paradigm shift from traditional ‘one-size-fits-all’ medical care to a more personalized medicine based on the rise of novel individualized data-driven approaches, including the integration of multi-omics technologies and systems modelling of health information. Due to the high-level interdisciplinary nature of precision medicine, the educational programs of precision medicine often target a broad range of students with multiple background, academic profiles, and expectations. The traditional lecture-based way of teaching is hard to meet the diverse learning demands from different stakeholders. PBL-based small group learning, on the other hand, has emerged as a new model of teaching and is self-directed with the aim at practicing and developing skills by collaborative working with real-life problems. Students participated in the PBL course are taught to self-formulate their goals and objectives of learning of particular topics.

However, to successfully establish a new PBL-based course is not easy. There are more responsibilities and requirements for a PBL tutor compared to a traditional course teacher. One of the key components within PBL course is the quality of the problem identified by the students. The quality of the problem influences the degree of quality of the tutorial group process as well as the learning outcomes (Gijselaers and Schmidt, 1990). To be an effective PBL tutor, it is important to create an open and inclusive environment for students to discuss and brainstorm freely. Also, it is equally important to indicate the students when the breadth and depth of the problem has not been achieved without interfering with the discussion process. This is challenging. Linköping University has a long history of the development of PBL-based course since 1986 with various supporting PBL training programs. The new proposed third-cycle ‘Omics technologies and data-driven precision medicine’ course will also be a good program for the application of PBL in medical education and a good complement to the existing curriculum system in Linköping University.

References


