Chapter 14
Collaborative Design Education Using 3D Printing

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ABSTRACT
Design education is important at technical universities and colleges. In general, real product design requires collaborative work. In this chapter, the authors discuss collaborative design education. An A360 cloud platform on Autodesk’s 3D computer-aided design “AutoCAD” is adopted to illustrate a collaborative design activity implemented in the Engineering Graphics class offered at the College of Science and Technology, Royal University of Bhutan. By using A360 cloud, students can share a 3D model with group members. Based on feedback received, students can modify the initial model, share it, print, and discuss the modified object with members. This collaborative work allows students to create enhanced 3D design objects while engaged in discussions and interactions. The authors also discuss some difficulties encountered during the collaborative process and offer recommendations and future research ideas.

INTRODUCTION
Design education is important at universities and colleges for engineering and technology (Sheppard & Jeniso, 1997; Dym, Agogino, Eris, Frey, & Leifer, 2005). For example, all first-year students learn 2D and 3D modeling using AutoCAD as 3D Computer-Aided Design (CAD) software at the College of Science and Technology (CST), Royal University of Bhutan (RUB). Also, at the same institution, civil engineering students learn design and construction of facilities such as buildings and bridges in the second year of the four-year course. Similarly, electrical engineering students learn the basic concept of design of electrical installation for residential and commercial buildings (Muramatsu & Wangmo, 2017).

Usually, at the CST, each student learns 2D and 3D design using CAD software individually in these classes. However, real product design requires collaborative work. For example, automobile design involves teamwork; each designer contributes from his or her experienced knowledge base. Also, concurrent

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engineering (CE) is popular in manufacturing companies. CE is a method of integration for designing and developing products (Andersen, 2004; Sapuan & Mansor, 2014). Automobile design is not only shared with designers but also with engineers under CE. Therefore, collaborative design education is necessary for students’ future careers. In addition, in the automobile design, modelers model a real-size prototype out of clay, which is called clay modeling (Yamada, 1993). If clay modeling is replaced with 3D printing, the design process time will be shortened.

In this chapter, the authors illustrate a collaborative work and 3D printing in design education. The following section provide background on collaborative design education, software and hardware to support collaborative design. This is followed by an illustration of collaborative design work using a A360 cloud platform. This chapter focuses on presenting the collaborative work with the purpose of generating further discussion and ideas for future work and research.

BACKGROUND

Collaborative Design Education

Collaborative learning is an approach in which two or more students learn or solve problems together (Dillenbourg, 1999). Rochelle (as cited in Miyake & Kirschner, 2014) added that collaboration is the “process of building and maintaining a shared conception of a problem or task, distributing responsibility across members of the group, sharing expertise, and mutually constructing and negotiating cognition.” (p.421) From this perspective, Miyake and Kirschner (2014) suggested that interaction among group members and characteristics of their discourse are key in this process where negotiation determines what can be considered to be forms of team learning behaviour leading to mutually shared cognition.

There are numerous benefits related to collaborative learning. Panitz (1999), for instance, listed over 50 benefits such as development of a social support system for learners, development of positive attitudes towards teachers, and reduction of anxiety by cooperation. Laal and Ghodsi (2012) categorized the benefits into four major types namely social, psychological, academic and assessment. Within the academic assessment, the benefits are as follows:

- Critical thinking skills are promoted
- Students are involved actively in the learning process
- Classroom performance is improved
- Appropriate student problem solving techniques are modeled
- Large-scale lectures can be personalized
- Students get more motivated to study in specific curriculum.

Due to technological advancements in communication tools such as instant messaging and video chat, collaborative education has also become available remotely. Furthermore, as reported by Stahl, Koschmann, and Suthers (2014), computer-mediated worldwide networks have enabled a shift from co-located learning groups to asynchronous distributed learning groups. For example, Graham and Scarborough (1999) introduced computer mediated communication (CMC) with remote students at Deakin University’s Warrnambool campus. Also, Thorsteinsson and Page (2007) developed pedagogy of CMC on collaborative learning environment for in-service teachers’ training. Xia, Wang, Li, and Hu (2015)