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Video Enriched Pedagogy in Manufacturing Processes

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Abstract
This paper presents an effective video-assisted pedagogy in manufacturing processes courses. Teaching manufacturing processes is fundamental to manufacturing education. However, the dynamic and complex concepts and phenomenon in manufacturing processes are difficult to teach and comprehend using stationary pictures and verbal explanation. In this paper, we systematically select and prepare video clips for teaching the concepts and demonstrating applications in manufacturing process courses. Four aspects of this pedagogy are discussed, including lengths of video and interruption for comments, timing for playing video, video selection, and student engagement. The effectiveness of utilizing video clips is demonstrated by three case studies: 1) ME482 Machining Processes at the University of Michigan, 2) MEEN 360 Materials and Manufacturing Selection in Design at Texas A&M University, and 3) ME61120240 Manufacturing Process and Engineering at Zhejiang University (China). To facilitate this pedagogy, a cloud-based video library for manufacturing processes has been established. Other issues related to implementing this pedagogy including adoption in distance education, the credibility of the video, and copyrights are discussed.

Keywords: Manufacturing education, video enriched teaching, pedagogy

1 Introduction

Teaching manufacturing processes is the foundation in manufacturing education. The introductory manufacturing processes course is often the first time for most undergraduate students learning

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manufacturing in a systematic way. This course is critical to build their interests and knowledge and shape their perspective in manufacturing.

The fundamental knowledge and practical skills in manufacturing processes are commonly developed in two ways: hands-on manufacturing lab and classroom lecture. Pedagogical approaches in teaching manufacturing processes via laboratory (Iqbal et al., 2014; and Qian, 2005) and project (Chan, 2004; Dutta et al., 2004; Neal, 2013; and Rodriguez et al., 2005) based hands-on experience have been studied. Students operate machines to experience manufacturing processes and learn the process capabilities and limitations in material removal rate, dimensional accuracy, surface roughness, and cycle time. This hands-on experience is typically scheduled in their sophomore year and gained from operating manual lathes and mills to learn basic turning, milling, and drilling processes. The hands-on manufacturing lab is an effective and direct way to teach manufacturing processes. However, the cost of machine, tooling, work-material, fixture, facility, staff support, etc. in the manufacturing lab is high. Students' safety, available time in machine, and the lack of broad perspective in manufacturing processes limit the manufacturing processes instruction via hands-on labs. Computer simulation was developed to illustrate the manufacturing process conditions and results (Fang et al., 2007; Qian, 2005; and Qian and Mohammad, 2007), though the broad availability and fidelity of simulation software are limited.

Classroom lecture is critical in learning manufacturing processes, covering the traditional machining, forming, casting, molding, joining, assembly, surface processing, and powder metals and ceramics processes as well as nontraditional (laser, electrical, chemical and hybrid) manufacturing processes. Selecting appropriate topics of manufacturing processes and connecting them in a systematic and logical way for one semester course is an art.

An approach to lecture a specific manufacturing process consists of teaching: 1) concept, 2) mathematical model and numerical examples, and 3) applications in industry. First, the basic concept of a manufacturing process is explained. Mathematical models and practical, quantitative examples are then presented to provide in-depth engineering knowledge of the manufacturing process. To give students the breadth of knowledge, examples of practical industrial applications of this manufacturing process are introduced.

Pictures and graphs are commonly used as the teaching aid to explain various manufacturing processes. Students are often bored in the classroom when many stationary pictures and graphs are presented repeatedly to illustrate details of different manufacturing processes. Many manufacturing processes are difficult to explain by lectures assisted with figures/graphs alone (Iqbal et al., 2014).

Using video in lecture is a transformative approach in student learning. Videos have been widely used in engineering education and considered to increase student performance and engagement (Brecht, 2015; Halupa et al., 2015; Marques et al., 2012; Onita et al., 2015; and Zhang et al., 2006). A large selection of videos is available in open sources. Websites have been developed to collect and download videos for education purposes (Burke et al., 2009; and González et al., 2010). A successful example is the 2D barcode in the manufacturing processes textbook to guide students who purchase the textbook to a cloud-based collection of video (Kalpakjian et al., 2013). Some computer- (Balazinski and Aleksander, 2005; Bengu and William, 1996; and Hailey and David, 2000) and web- (Jou et al., 2015) based education modules have been created to teach manufacturing based on visualization of concepts. None of these education tools has been broadly adopted.

At the University of Michigan, an initiative to use videos to aid teaching manufacturing processes has been explored and implemented in classroom teaching in the past 10 years. This pedagogy has been adopted and practiced in other universities to teach manufacturing processes. To date, a cloud-based library of videos for teaching machining processes has been established. In this paper, the pedagogy in utilizing videos to teach manufacturing process course is introduced. Three cases, ME482 Machining Processes at the University of Michigan, ME360 Material and Manufacturing Selection for Design at Texas A&M University, and ME61120240 at Zhejiang University, which all apply the short videos in teaching are presented.