Chapter 14

Test Design to Assess the Qualities of Science Students’ Prior Knowledge

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ABSTRACT

Prior knowledge is a complex variable that greatly determines the outcome of learning of science students. Prior knowledge inherent qualities facilitate or interfere in the process of learning; however it hasn’t always been possible to determine the extent and explicitness of these effects on learning. A test to measure these effects was developed with the intention to discern the specific influence of the inherent qualities of prior knowledge of incompleteness, correctness, misconceptions and the absence of declarative knowledge. This multiple choice test includes topics such as vectors, trigonometry, unit systems and prefix definitions, contents considered to be essential to learn Coulomb’s law for electricity and magnetism course in engineering major. The ultimate goal of this project was to design a test with content validity and determine the reliability of this test using Cronbach’s alpha coefficient with a minimum value of 0.7. Finally we present suggestions that can guide future research and the applicability of this test.

INTRODUCTION

Quality education is key in the development of any nation. It provides opportunities for people to develop their competencies that can allow them to perform well in society and it enhances the social, intellectual and economic growth of communities (Openheimer, 2010).

Education must bring the possibility to face continuous changes and professional competitiveness. Learning is a multifactorial phenomenon that requires attention as it is dependent on many social, politi-

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cal and psychological elements. Many studies related to factors attributed to students’ characteristics and the effect of these on their learning process. Some of the most mentioned factors are: prior knowledge (Alexander & Judy, 1988; Ausubel, Novak, & Hanesian, 2006; Dochy, 1991a; Dochy & Alexander, 1995; Hailikari, 2009; Hattie, 2009; Marzano, 2004; Meltzer 2002; Roschelle, 1995; Sagastizabal, Perlo, Pivetta & San Martín, 2009; Shapiro, 2004; Thompson & Zamboanga, 2004), social factors (Alexander & Judy, 1988; Dochy, 1991a; Tinto, 1992), cultural factors (Sagastizabal et al., 2009), individual attributes like gender and race (Hattie, 2009; Tinto, 1992), interests and intentions from student (Hattie, 2009), commitment (Hattie, 2009; Tinto, 1992), motivation (Alexander & Judy, 1988; Boiché, Sarrazin, Grouzet, Pelletier & Chanal, 2008; Garris, Ahlers, & Driskell, 2002; Graham & Weiner, 1996; Hattie, 2009; Wong, 2012), economic factors (Sagastizabal et al., 2009; Tinto, 1992), self-efficacy (Bandura, 1971, 1982, 2006; McKenzie & Schweitzer, 2001; Zimmerman, 1989), stress and anxiety (Hattie, 2009), communication and social skills (Porter, 2008), personality (Porter, 2008), emotions (Kleres, 2010), time spent to study (Grouws & Cebulla, 2000), learning approaches from student (López, Esteban & Pérez, 2006), metacognition and prior academic development (Dochy, 1991b), and more of them that could be listed.

The Coleman report (1966) analyzes education in public institutions in the USA through a qualitative study, including types of teachers, students, principals, and he says that the most important factor influencing academic achievement is what students bring to school with them such as prior education, family background, culture and interests (Coleman, Campell Hobson, McPartland, Mood, Weinfeld & York, 1966). They conclude that the majority of the contribution in the variance for academic development in students comes from those personal features.

Thus learning should be significant and should be studied as a process that includes the interaction of the new knowledge to be learned and the knowledge subjects already possess. This research takes learning as a process of active construction of knowledge (Ausubel, Novak, & Hanesian, 2006). Among the problems observed in education there are low grades, high failure rates (close to 50% of the students) and high dropout indices (approx. 50% on first semester engineering major), large groups when students have inconsistencies in their prior knowledge (Fernández, Mena & Riviere, 2010; González, Castañeda & Maytorena, 2000; Palacios & Andrade, 2007; Stinebrickner & Stinebrickner, 2013; Tinto, 1992). Ibáñez (2007) for example, suggests that the main causes of low school achievement are: missing study habits, low motivation from students, bad teaching practices, incorrect politics and unfit education models.

In this chapter, the authors take the perspective of learning as a process, the relation to change from knowledge existing in the memory interacting with the new knowledge to be acquired. Information processing theory considers prior knowledge as an assimilation environment and states that new material is related and integrated to it (Dochy, 1991a). Ausubel (2006), when discussing assimilation theory, maintains that acquiring new information depends mainly on the preexisting ideas in the cognitive structure, and that meaningful learning would be determined by those ideas. Thus it is important to study prior knowledge as a determinant of new learning (Alexander & Judy, 1988; Ausubel, Novak, & Hanesian, 2006; Dochy, 1991a; Dochy & Alexander, 1995; Hailikari, 2009; Hattie, 2009; Karabel & Halsey, 1977; Manzano, 2004; Thompson & Zamboanga, 2004).

Hailikari (2009) established that one of the first researchers who affirmed the relevance of prior knowledge on the learning process was Bloom in 1956, when he wrote that the learning process is determined mainly by the cognitive behaviors or prerequisites, term used referring to prior knowledge. Bloom also mentioned that more than a half of the variance of learning outcomes depends on prior knowledge.

In the same direction, Ausubel, Novak & Hanesian (2006) pointed that if they had to reduce education to a sentence, the main factor influencing learning, is what the learner already knows, and that professors
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