Technology Management as a Tool for Learning Outcomes Improvement

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Abstract

Educators have been constantly searching for the most effective strategy to improve student learning outcomes over a diverse spectrum of educational programs. Some representatives of the educational sphere believe that the quality of education relies on the teaching approach; others claim that the students' responsibility and attitude toward learning is the key element in educational program outcomes. Either way, the reason for constant argumentation and propagation of research is to find an effective approach to learning.The cognitive, affective, and psychomotor domains of Bloom's taxonomy can guide the process of students' transformation from the basic level of information comprehension to the upper level of creativity in their chosen field. Technology, on the other hand, provides a valuable tool for stimulating learning and serves as a connective element between educational theories and practical approaches to the learning process. In this review article, the authors outline influential factors on learning outcome improvement, emphasize the important role of technology in learning advancement, and provide an overview of existing teaching methodologies implemented at Michigan Tech and Finlandia Universities.

Introduction

Technology has revolutionized human comprehension at all stages of development. It became an inevitable part of human existence and social life management. Technology is part of communication, industrial processes, health care systems, entertainment, and plays a crucial role in education. Not that long ago, due to a lack of technological development in portable electronics, knowledge transfer, as part of the educational process, was restricted to traditional methods of information delivery: educators had to use chalk and a blackboard to explain subject matter. Currently, technology is developing at an uncatchable pace, providing a wide selection of electronic devices to incorporate in the classroom and virtual environments at different educational levels. The quality of learning outcomes is not related to the educational field but rather based on the methods of knowledge distribution, degree in technology management, and incorporation of Bloom's taxonomy in the teaching process.

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Introduction to Bloom's Taxonomy

The idea of a hierarchical approach to learning outcome improvement was recognized by a group of psychologists when Benjamin Bloom "set forth in motion the production of the *Taxonomy of Educational Objectives, The Classification of Educational Goals, Handbook I: Cognitive Domain*" [1, p. 29] during the meeting of the American Psychological Association in 1948. The original classification system has been reviewed and redacted many times, growing from cognition to affective and psychomotor learning domains. Anderson and Krathwohl produced the final revision of the handbook in 2001. It was "formally titled *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*" [1, p. 36], giving the classification system a wider application in the educational sector. Now, this system of intellectual behavior in learning is known as "Bloom's Taxonomy," and it is widely utilized by educators and students.

The cognitive domain of Bloom's taxonomy has been most widely utilized in the educational field. The concept is based on a progressive development of the learner's cognition, starting with the simple memorization and continuing with the more complex skills of understanding, application, analysis, evaluation, and creation. To perform the higher-level skills, according to Bloom's taxonomy, learners have to implement the low-level skills. As an example, "to critically appraise the medical literature (evaluation), one must have knowledge and comprehension of various study designs, apply that knowledge to a specific published study to recognize the study design that has been used and then analyze it to isolate the various components of internal validity, such as blinding and randomization" [2, p. 152].

The affective domain, on the other hand, refers to emotions, "to touch the learner's heart to impact his or her learning" [3, p. 22]. Emotion is an inseparable part of human nature and plays a significant role in the communication process. Emotions are contagious. Educators have been utilizing this knowledge to develop educational strategies that evoke enthusiasm, motivation, curiosity, and other positive feelings in students' minds in order to improve learning outcomes. Bloom's taxonomy subdivides the affective domain in five hierarchical groups: receiving, responding, valuing, organizing, and characterizing.

The last component of Bloom's taxonomy is the psychomotor domain. Even though the psychomotor domain is not as popular subject for discussion in the educational sphere as the cognitive domain, it creates the connective element between mind and body. The psychomotor domain addresses learning outcomes that "emphasize some muscular or motor skill, some manipulation of material and objects, or some act which requires a neuromuscular coordination" [3, p. 22]. The ability of students to perform a task based on good motor coordination is equally important in engineering- and health-related practices. Nursing students, for example, directly contact hospitalized patients and gradually advance their level of psychomotor activity from basic to skilled. Engineering students are trained to operate robotic technology. Their capacity to perceive technological innovation and adapt their skills to continuous industrial revolution is crucial to their future profession. Figure 1 shows the three different domains.

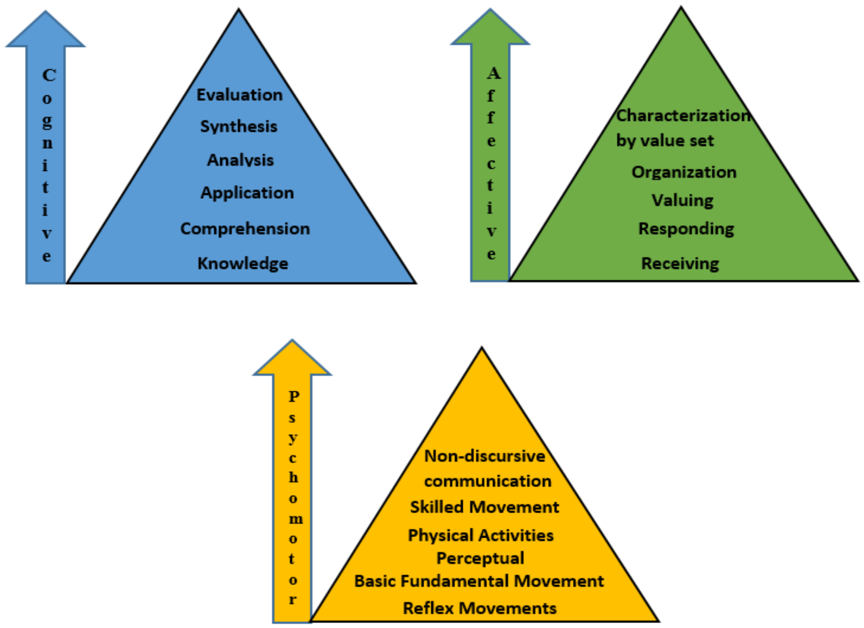

Figure 1. Three domains of Bloom's taxonomy

Three domains of Bloom's taxonomy create a road map for managing the learning process in the contemporary educational environment. They are connected elements of students' progressive development toward professionalism and confidence in working settings. The question is who is going to follow this route, and what is going to help the ventures to reach the final destination successfully? The answer to this question lies in the modern world of technology evolution.

Role of Technology in Education Management

Technology use in the educational sector has served as a tool to assist educators in reaching the established teaching goals in more effective and efficient way as well as accommodating the learners' needs. The diversity of existing technological innovation allowed educators to create a wide variety of methods for cognitive, affective, and psychomotor progression of learning in the on-campus and off campus settings. Nevertheless, changes in learning environment constantly challenge teaching professionals and prompt them to adapt to the accelerating pace of technology evolution and new generation of adult students.

Changing Demographics of Students

Currently, adult education is experiencing significant demographic variations due to globalization and an increasing interest in continuing education. Anderson (2003) has noted that today "a third of undergraduate students are twenty-five years old and older." Since

1970, the number of older undergraduate students “increased by 144 percent, whereas the number of students under the age of twenty-five increased by 44 percent” [4, p. 3].
The mindset of the younger student population is affected by the constant exploitation of online media. The virtual environment possesses the social life of this “Net generation” of students. Worley (2011) described this generation of students, who were born between 1982 and 2002, as “impatient, self-centered, extremely social, materialistic, and technologically advanced” [5, p. 36]. On the other hand, the older population of students is team-oriented, prefers personal communication, and has multiple social responsibilities in addition to school assignments. Work, community service, and family obligations are just some examples. Despite the fact that these students have less technological dexterity, a virtual type of education may be a great convenience because of flexibility, which provides a choice for location, pace, and methods for learning.

A mix of several generations in the educational sphere makes a great impact on teaching institutions, dictating new requirements and expectations. Educators should analyze the learners’ characteristics, such as age, background, self-direction, and intrinsic motivation, to apply Bloom’s taxonomy of learning and create a clear pathway that would guarantee the progressive growth of learners. In addition, educators have to recognize the learner’s needs and identify the relevance of the educational material and methods to the learner’s experience.

Teaching Methodologies

Technological advancement and its rapid evolution requires students to demonstrate current and relevant skills. In addition, students are responsible for paying for the high cost of education, which may obligate them to work. In many cases, working while attending college creates a very busy and complicated schedule. Providing flexibility in class offerings should help many students in need to attend and successfully finish college without compromising their work. To meet student needs, educational units must adequately adjust curricula, allowing students access to traditional, blended, or purely online class styles [6].

Educational Models

Figure 2 represents the three exisiting educational models practiced by academic institutions. In the traditional model, faculty members deliver theory and hands-on activities in person. Blended learning involves a mix of in-person and online representation of the subject, combining the best approaches of in-person and online education in a single model.

The online portion of a blended course can provide students with necessary theoretical background of the subject while in-person interaction can offer active educational scenarios and brainstorming sessions to enhance students’ interaction with each other and faculty members. In addition to adding flexibility, there is evidence that the blended instructional approach can “result in learning outcome gains and increased enrollment retention” [7]. Currently, blended learning is one of the most common modes.

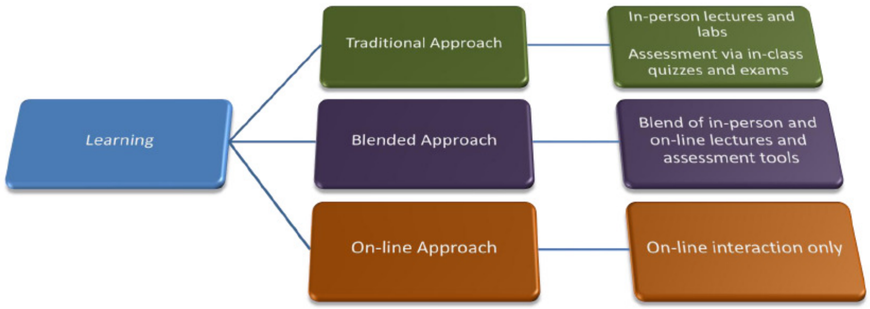

Figure 2. Traditional, blended, and online educational models

With an online approach, subject matter is delivered via the Internet, which may include text, images, animation, streaming video and audio. Increasingly popular, “by 2006, 3.5 million students were participating in online learning at institutions of higher education in the United States” [8]; “according to the Sloan Foundation reports [9-10], there has been an increase of around 12-14 % per year on average in enrollments for fully online learning over the five years 2004-2009 in the US post-secondary system, compared with an average of approximately 2% increase per year in enrollments overall” [6]. Online education provides flexibility for the students who cannot attend college due to work or other obligations. It also provides an opportunity to self-learners who prefer to pursue higher education at their own pace. Currently, many traditional programs include an online option for taking courses and even securing specific degrees [6, 11-12]. Educational research shows that student perception of their participation and motivation are different in online courses [6, 13-15]: “Positive attributes of online learning include: increased productivity for independent learners; diminished fear of public speaking, which increases class participation; efficiency in assignment completion; and easy access to all lecture material during the entire course” [11]. It has been also shown that online learning reduces the active process of learning [6, 11, 16]. Various demographic groups perceive online education differently: older students have significantly higher performance compare to their younger peers [6].

Educational Model Preference

“With the growing emphasis on student learning outcomes and assessment, faculty and educators constantly seek ways to integrate theory and research in innovative course design methodologies” [6]. In-person teaching represents static lecture-discussion formats [17, 16], resulting in graduates not having a full range of employable skills and abilities to apply the knowledge skillfully, communicate effectively, and work in teams. On the other hand, educational research [18, 19] shows that active learning involves all three components of Bloom’s taxonomy and significantly improves student comprehension and proficiency in subject matter [6]. The US Department of Education reports that blended learning produces statistically better results than in-person equivalents [20]. Students also respond to the value of blended course delivery models: “An Eduventures survey of 20,000 adult students found

19 percent of responders were enrolled in blended courses" [21]. "However, 33 percent of all respondents cited it as their preferred format" [22, 6]. While theoretical knowledge remains a fundamental component of any comprehension process, the students greatly benefit from active learning techniques as a part of blended courses. The tendency of students to value (affective domain) the blended methodology leads to more effective conceptual development, thereby positively influencing learning outcomes. What remains unclear is the "gold standard" for pedagogical approaches that combine theory, hands-on, and active learning in various fields of education. The question to be answer is where is a balance between statically transmitted information, and how much knowledge can be delivered via active learning techniques? Another important question is how can current advances in technology assist educators in course development and delivery?

Technology Use in Engineering and Health Science Educational Fields

The rest of this paper is a detailed description of various teaching methodologies and technology use to accommodate these methodologies with specific examples from Finlandia and Michigan Technological Universities. The authors' intention is to not only provide details of current teaching methodologies used in the health science and technical departments of these universities but also "draw a line" how similar technological tools can effectively deliver educational curricula.

According to its website, "Michigan Technological University (MTU) is a public university committed to providing a quality education in engineering, science, business, technology, communication, and forestry" [23]. In fall 2015, total enrollment was 7,238 students, including 1,521 (21%) graduate students [23]. Over 69% of Michigan Tech students are enrolled in engineering and technology programs. Cumulatively, the School of Technology (SOT) and College of Engineering (COE) granted 1,060 undergraduate degrees in 2014-15, 67% of total degrees [23]. Twenty-two research centers and institutes support interdisciplinary research, partnerships with industry, and collaboration with community and informal education organizations. The SOT awards bachelor's degrees in computer network & system administration, construction management, electrical and computer engineering technology, mechanical engineering technology, and surveying engineering—all degrees that require an understanding of robotics. Michigan Tech is rated highly for academics, career preparation, and quality of life in the *Princeton Review's Best 379 Colleges*, 2015 edition, and ranked in the top tier of national universities according to the *U.S. News & World Report* [24]. Employers, especially in the Midwest, rely on Michigan Tech to deliver experiential educational opportunities; more than 350 companies recruit on campus annually, and Michigan Tech students average five interviews before graduation. Michigan Tech has a 96% job placement rate.

Finlandia University, the only private university in Michigan's Upper Peninsula, has deep historical roots. Since its establishment as a seminary in 1896 with the purpose to preserve Finish culture, it has gradually evolved to a four-year college with a wide diversity of programs offered through the International School of Art and Design, International School of Business, Suomi College of Arts and Sciences, College of Health Sciences. Because of its affiliation with the Evangelical Lutheran Church of America, Finlandia University's mission is not only to help the students to achieve academic excellence but also to dedicate its existence to spiritual growth and service. The student body is diverse: "More than 485 students from 25 states and six countries attend Finlandia. About 39% live on campus; 43% are male, 57% are female; 14% are minority students; about 96% are seeking bachelor degrees" [25].

Faculty from both universities actively utilize various technological tools to create advanced teaching methodologies. A significant number of courses at Michigan Tech and Finlandia are still taught using the traditional approach; however, for the past few years, more and more different derivatives of teaching have been observed.

Technology Use at MTU

Michigan Tech is constantly evolving in using advanced technology, which not only allows instructors to make recitations more interactive but also promotes in-depth assessment of students' subject perception and comprehension. Use of classroom technology also often allows instructors to collect instant feedback from the students and adjust teaching accordingly. Michigan Tech instructors are starting to focus on interrupting lectures with a variety of interactive methods and technologies. By far the most common technology is clickers [26], which allow students to respond to multiple-choice questions. Some instructors utilize them as a reading "quiz," but more are using them in a method called "peer-instruction": students first answer on their own and then discuss the question. Some instructors have also begun experimenting with phone/tablet/laptop-based response systems like Nearpod [27], which allows text and picture responses in addition to multiple-choice polls.

Instructors are also extensively using small student whiteboards for collaborative small group exercises like brainstorming, simple problem solutions, drawings, etc. The advantage of a whiteboard is that students can hold them up so an instructor can quickly check answers and/or make sure students are on the right track and adjust teaching as necessary. With a single marker/eraser, students in a group must discuss what goes on the board. This has become so popular that several classrooms now have boards mounted on walls, and some departments have invested in carts full of boards to wheel between classrooms.

Other innovations include group quizzes, both conventional and using the Immediate Feedback Assessment Techniques (IF-AT) [28], which are similar to lottery scratch-off tickets. Group quizzes are often used either just before (as a review) or just after an exam. Students in a group must agree on a single answer, which results in extensive discussions (and learning) as they justify answers.

Outside of the classroom, instructors make extensive use of the Canvas Learning Management System [29]. Students are often asked to work through a series of pre-class readings, videos, or other content and then take a quiz within the system. Quizzes can simply measure student understanding to give an instructor insight into how class time would best be used or set so that students must meet a minimum level of mastery before progressing to the next activity. This "flipped classroom" model encourages the delivery of content outside the classroom and more analytical, in-depth work on problems or exercises during class, often using the interactive methods above. Canvas also hosts discussion boards, on which students can post required reflections, questions, or comments and interact 24 hours a day. These can be outlets for homework help, discussion about projects, or pre-class reflections on reading. Most assignments are now submitted, graded, and returned through Canvas (including markup and comments), which can include automatic plagiarism checks, if desired. The Google Docs/Drive system is also used for student collaboration in a wide variety of ways, from aggregating lab results to creating collaborative presentations. When combined with online conferencing options (Big Blue Button, Google Hangouts, or GoToMeeting), a completely online collaborative environment is used in some online sections.

The Panopto video streaming system [30] has made making both lecture-capture and other videos easily available to students. Michigan Tech now has more than 30 classrooms campus-wide in which voice and video recording can be scheduled to automatically take place and be posted for students. Instructors can also more intentionally create video lectures or problem solutions on a computer (using voice-over PowerPoint), on a document camera, or in front of a whiteboard. Problem solutions are especially aided by Swivl [17], a small robotic device that allows placement of a tablet or phone. It then tracks a Bluetooth-connected marker and microphone worn around the neck to create a video that follows the instructor as s/he moves throughout the classroom

Technology Use in Finlandia Health Science Program

Instructors in Finlandia Health Science programs are using a wide diversity of technology to enhance the process of delivering new material, providing a communication portal, and guiding students from a simple perception of information to expert evaluation and performance. To obtain a knowledge base for the academic progression according to Bloom's taxonomy, students must read the textbook and attend the classes for lectures and educational activities.

The simple projector, one of the oldest representatives of the technology evolution in the educational sector, serves as a visual aid to knowledge acquisition by displaying images, video files, graphs, etc. on a wall screen. This device also assists educators in structuring lecture flow and implanting a variety of features in classroom activities, resulting in more engaged and motivated students. Another valuable characteristic of a projector is its ability to unite all attending students in a mutual process of learning, not only by displaying the information but also by accommodating another technological tool: clickers.

A common name for clickers is a "personal response system." Instructors of health science programs have recently used a clicker-based system to challenge students to answer several multi-choice questions after a lecture. Students vote on a right answer by pressing a clicker button, and the results are displayed as a graph indicating the percentage of participants who chose each available answer, therefore providing an immediate assessment tool. Clickers invite students into an active discussion revolving around a current assignment, as some learners are easily involved in the instructor-student interactions in the classroom environment while others feel intimidated or uncomfortable. Clickers can eliminate the discomfort. As a result, this approach to learning improves academic performance. As a three-year study conducted at the University of California demonstrated, “the clicker treatment produced a gain of approximately 1/3 of a grade point over the no-clicker and control groups, which did not differ significantly from each other” [31, p. 51].

Discussions do not have to happen inside the classroom. Communication technology adapted by many educational institutions, including Finlandia University, provides an opportunity for students to be engaged in interpersonal dialog via social media or in a virtual environment. Online and blended systems allow learners to participate in course activities at a convenient time and location, accommodating students who have additional responsibilities beyond school; at the same time, non-traditional approaches require discipline and make students responsible for the learning process. Finlandia University faculty utilize eCollege to connect course participants in one virtual environment by assigning reading material and discussion questions that lead the students through the cognitive stages of development. Students are required to provide personal experiences to support their answers. This prerequisite stimulates emotional responses, encouraging learners to explore and memorize the new information.

To complete the learning cycle and help students reach desired proficiencies, educational programs should consider the psychomotor aspect of Bloom’s taxonomy. Once again, the technology evolution assisted Finlandia programs in this endeavor. Previously, nursing students had to experience an abrupt transition from theoretical knowledge to the skills practiced in hospital settings. Usually, hospitals can offer only a limited number of patients who need certain procedures. This situation created discomfort, dissatisfaction, and stress for students. Finlandia University solved this problem by offering simulations as an educational method for psychomotor and critical skill development of learners. According to Swenty and Eggleston (2011), simulations are different in terms of fidelity: role playing and case scenarios represent low-level simulation progressing to the practice in laboratory settings; lifelike interaction with a mannequin is high-level simulation [32]. Finlandia University faculty have been implementing case studies and role-playing scenarios in online and classroom environments. Now, the nursing faculty advance student experiences by providing interactive activities with a mannequin. This approach mimics the clinical setting and allows students to overcome the discomfort during skill performance and practice the skill as many times as needed. Specifically, the nursing faculty utilizes a medium fidelity mannequin, Noelle, to simulate the birthing experience. This close to real-life medical case motivates students to apply critical thinking skills to a specific clinical situation.

Mutual Aspect of Technology Use

Implementation of clickers by both educational institutions helps to engage students in course activities, reflecting research findings related to learning outcome improvement. This technological invention encourages learners to collaborate on a task, exposes them to the opportunity to analyze previously acquired information, critically evaluate the present situation, and make a personal decision, advancing them in the cognitive domain of the learning process. The personal response system also engages a wide diversity of students despite age, background, life experiences, or individual differences.

Virtual environments supported by learning management systems, such as eCollege or Canvas, accommodate students' preference for a blended model of education by providing flexibility in the learning process. In addition, online discussions cultivate a creative atmosphere for students' communication, prompting them to work together on course material analysis and evaluation. These fundamental features optimize learning for adult and the "Net generation" of students, leading them through the Bloom's taxonomy of learning.

Conclusion

Despite differences in educational fields, technology use supports students' advancement in the learning process by providing a communication system and accommodating educational progression based on Bloom's theory. Engineering- and health-related programs at Michigan Technological University and Finlandia University demonstrate the similarities and varieties of technological tools utilized in students' education. These tools allow educators to expand the scope of educational methodologies and conquer the evolving challenges of student diversity and differentiation of learning needs. It is important to recognize that Bloom's taxonomy of learning, from the time of its inception, will supplement educators with an authentic structure and guidance for an effective learning process. The current pace of technology advancement, on the other hand, impels educators wishing to provide the best educational experience to constantly update their knowledge of technology.

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