The Building Blocks for Enhanced Technological Literacy

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Abstract

Many students have experience with smart phones, internet browsing, and social networking. Although exposure to these types of technologies are pure indicators of society's evolution towards a more integrated and pervasive computing environment, they do not serve as accurate indicators of technological literacy. With the advent and rapid expansion of knowledge and technology intensive industries, these skills do not provide a sufficient core/foundational literacy to the development of characteristics possessed by technologically literate students. Gonzales and Renshaw (2005) identified six computing competency skill areas for pre-engineering majors – 1) Computer use and file management, 2) Word processing, 3) Spreadsheets, 4)Databases, 5) Presentations, and 6) Information and Communications. These competencies, previously the focus of engineers, have now transferred to society at large with 38% of all the value created in the U.S. requiring the skills of a technologically literate workforce (National Science Board, 2010). The widespread use of technology in society and everyday life has forced the need of technological literacy amongst non-Science, Technology, Engineering and Mathematics (STEM) majors, hence the need for a comprehensive course that provides the building blocks for technological literacy. However, there is still skepticism on the value of classes that focus on the introduction of computers. These classes lay the foundation that is crucial for non-STEM majors to become technologically literate. The goal of this paper is to show that there is still a need for these types of classes and also that they provide a gateway for these students to become technologically literate before their graduation. By reviewing the performance of 130 students in an introductory level computing course at Indiana State University the need for such a class will be evidenced.

Introduction

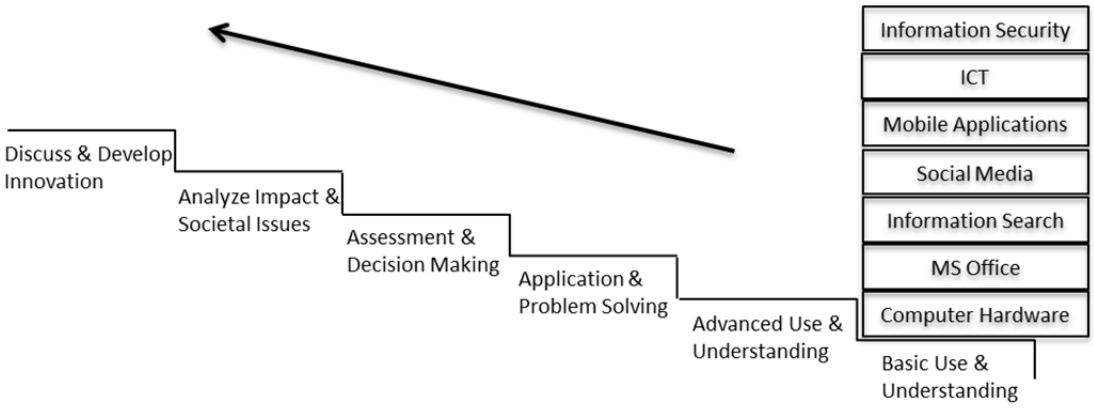
In an age of persuasive technology, eliminating introductory computer courses from course schedules would be a disservice to students. The fact that a large percentage of students can browse the internet and use cell phones does not indicate that they are computer or technologically literate. Potential employers will require more technical skills and abilities. In addition, student must learn how to use other applications that

support problem solving and decision making in business or research settings. Introductory courses must be redesigned to account for the evolution of information communication technology and the level of its rapid integration into the different aspects of society over the years. The courses need to extend the content and learning objectives to include higher order computing concepts. These are the building blocks that will provide students, non-majors, with the tools needed to achieve the higher order goal of becoming technologically literate (Branchet & Jullien, 2009).

Students should be challenged to acquire higher levels of aptitude. Now that students are more technically apt, we can remove lessons on how to double-click and open a browser. We should start integrating lessons more relevant to current technological use in industry, academia, research, and society. There will still be a difference between computer science, engineering, and non-STEM majors. The introductory computing course design supported by this study does not promote programming or circuit building. Our proposal builds on previous studies call to integrate higher order of computing components - information search, and information communication technology, mobile applications, social media, and information security components. For instance, communication technology serves as the main means by which information is obtained by information seekers in the 21st century. The proliferation of these technologies makes it necessary for its potential users to be able to use, manage and understand how to obtain, in as efficient a manner as is possible, the information which they seek. Due to the overlapping nature of all these devices it is necessary that potential users be aware of the advantages and disadvantages of these devices.

Recent efforts have been emphasizing the need increase the number of STEM programs and graduates, which is supported by the authors. In addition, non-STEM majors cannot be left behind to increase problematic dimensions of the digital divide. Non-STEM majors need the experience and exposure to the higher order components - the building blocks – to make them employable and productive members of today's society (See Figure 1). Basic use and understanding is only the first step/block. This refers to the introduction of the steps and their primary functions or features. Advanced use and understanding would be the next step which allows students to complete more complicated functions and tasks. A classic example would be the creation of a template in MS Word to draft an APA style research paper. The following step creates a stimulating learning experience by incorporating problem solving and application of learned lessons. The first three steps create strong computer literate students.

Figure 1: Critical Steps to Obtain Technological Literacy



Technological literacy implies knowledge, ability, responsibility, and capability, which are related to the last steps in Figure 1, are important. Assessment and Decision Making skills will demonstrate students' critical thinking regarding technological issues. Analysis of technological impact on society prompts the ability to engage and identify technology that reflects the culture and value of the intended society. Finally, Discuss and Development Innovation illustrates the students' knowledge via articulation of the pervasiveness of technology in everyday life. The first three steps are critical for non-STEM majors and provide a strong pathway to achieving objectives defined for technological literacy. The building blocks are essential for the improving introductory computing courses.

In the following sections, learning objectives for a redesigned Introduction to Computers course will be presented. In addition, data will be presented to support the continued need of these types of introductory courses.

Background

There are many debates concerning the elimination of introductory computer courses as a requirement, especially for non-majors. According to Watkins *et al*, most of today's students have grown up with computers, and have been using them for years. Although this may appear as a benefit and support for eliminating the course, it is not a benefit. It actually equipped the students with a sense of overconfidence – "because these students have mastered email, the web, and instant messaging, they feel they already know everything a computer can do"(Watkins, Byars, & Barry, 2005). The results published in Watkins *et al* demonstrated an average percentage overestimation of proficiency of Microsoft application by 25%. These basic computer skills alone do not offer an adequate foundation for students to excel towards acceptable levels of technological literacy.
For example, students may have a great amount of experience surfing Facebook. Their experience demonstrates an ability to connect with others via this application increasing awareness of friends' activities, but most students are not aware that companies collect

user activity, which provides great marketing data, insights on users' habits, and profitable interactions. In addition, students' posts have been unfiltered and potentially hazardous because they are unaware of the impact of such accessible information. Students need to learn more than how to login to new applications. They must make responsible sociotechnical decisions and analyze impacts. Furthermore, experience with social media applications does not satisfy the technical experience criteria for future employers.

The downstream outputs of basic level research and development, concentrated in the fields of Science, Technology, Engineering and Mathematics (STEM), have had a profound impact on the global marketplace. These technologies have led to the creation of work environments that relish the use and extensive adoption of new technology that improves productivity. Knowledge and Technology Intensive (KTI) industries accounted for 30% of global economic output in 2007 and have resulted in the creation of jobs that span service and high-technology manufacturing(National Science Board, 2010). For every one manufacturing job that has been created over the last decade there has been seven to eight service sector jobs that have been created (Bureau of Labor Statistics, 2014). For non-STEM majors the majority of jobs that will be available to them in the future will be in the area of Information and Communications Technology (ICT). ICT relates to the use of technologies that are specific to computers and office machinery, as well as, communication services and its surrounding equipment technologies(National Science Board, 2010). Critical to students with non-STEM backgrounds is their ability to analyze the impact of technology on society and then utilize and/or contribute to the improvement and evaluation of existing technologies. A technological literate user must be fluent with the tools and techniques necessary for constructive participation in society. A technologically literate student, therefore, is one who has a working knowledge of concepts, techniques and jargon utilized by professionals in the STEM field, the creators of such technologies (Gustafson, Krupczak, & Young, 2011; National Academy of Engineering, 2011).

The purpose of this study is to demonstrate the importance of computer literacy and introductory computer courses via its relationship to technological literacy (TL) and students' lack of critical computer skills. Utilizing the International Technology Education Association's (ITEA) Standards for Technological Literacy (STL) a conceptual model of technological literacy can be formulated. This model illustrates the basic undergirding of TL which makes it easier for the launch an investigation of the efficacy of CL as it pertains to TL. At Indiana State University, students completing their bachelors in Social Work are required to take and introduction to computers class. The course covers topics ranging from the installation of software needed for the class to being competent in the Microsoft Windows 7 and Office environments. While taking the course does not make these students technologically literate, it provides an undergirding that makes them more cognizant of the STL content.

Technological Literacy

Technology can be conceptually defined as a modification that has been made to the natural environment through innovation, change or modification in an effort to fulfill apparent human necessities and desires(International Technology Education Association, 2003). Technology represents devices, the capabilities these devices offer and the knowledge surrounding them. This concept and its' tangible assets are so pervasive that in today's work environment employers most often refuse to train employees on the most common of these. Employees are expected to be familiar with the most commonly used technologies and they are also expected to possess an ability to discern and adapt to new technologies. Possessing such a broad understanding of technology one could define such a person as being literate in technology. Literacy, in a technological sense, can be described as a basic level of education that allows one to be familiar with related technologies. Technological literacy is the basic understanding of technology that allows one to be able to use, manage, and understand technology (International Technology Education Association, 2007).

Although TL's recognized importance in today's society, TL has not been a significant focus of instruction and assessment in K-12 curriculum or post-secondary education outside of engineering and computer science for years[5]. Initiatives, studies, and reports from the National Academies, National Science Foundation, and academic institutions nation-wide established a foundation for the development of TL concepts, standards, educational objectives, and assessment. At the K-12 level, the National Academies reports (Gustafson et al., 2011)have defined TL as "an understanding of technology at a level that enables effective functioning in a modern technological society." (Gustafson et al., 2011) In addition, three major cognitive dimensions were identified: knowledge, capabilities, and critical thinking and decision making within four content areas (technology and society, design, products and systems, and characteristics).

For post-secondary education, researchers' efforts extended the reach of TL from the limited areas of engineering and computer science to non-majors. Gustafson *et al.*, developed a model set of educational objectives and outcomes that are mostly congruent with publications from International Technology Engineering Association and ABET, with slight deviations to account for a lower level of mastery for some aspects appropriate for non-majors. In higher-education there are four objectives that are considered to be high-priority TL objectives for non-STEM majors. These objectives are described as follows(Gustafson et al., 2011): 1) knowledge of the impact technology has on our natural surroundings, 2) an ability to understand and explain the impact technology has had and is having on our world, 3) an awareness of the traits of individual and communal responsibility when consuming and crafting technology and 4) an ability to critically dissect technological advancements across both general and specific domains. Additionally, Gustafson *et al.* published eighteen outcomes that align with the objectives listed above.

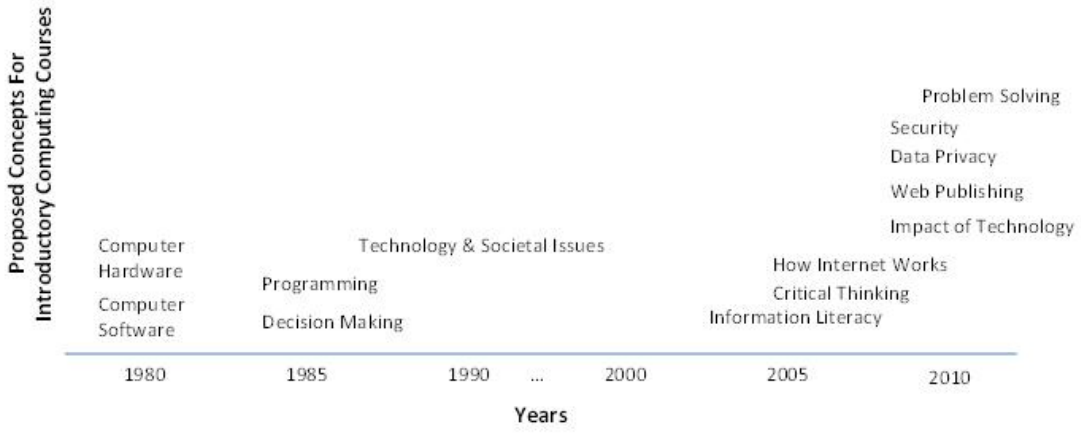
Computer Literacy

The study of computers dates back to the 1980s. Since, computer competency and computer literacy have been discussed in many venues. There have been many variations of the definition of computer literacy in publications over the years. The constant evolving nature of computers and technology-related fields, systems, and devices may be the major contributor. Although the definitions have varied, the increasing relevance of computer skills and applications is a consistent agreement among researchers, industry workers, and educators. Ezziane (2007) denotes the following definition of computer literacy, "as understanding computer characteristics, capabilities, and applications as well as the ability to implement this knowledge in the skillful, productive use of computer application to individual roles in society" (p. 178).

Academic institutions have been charged with the responsibility to educate and support the development of student's computer skills and capabilities. Many computer science and engineering programs have accepted the charge and provided courses that provide the instruction and courses needed for STEM majors. In addition, introductory computer courses are offered for non-majors. The list of introductory computer courses offered by these programs can vary greatly from one institution to the next. Among the more common courses are Introduction to Computer Science and Programming and Introduction to Computers. The latter course is usually the one customized for non-majors and computer literacy. From a survey of 160 institutions, Epperson reported 60% offered credit-based computer introductory courses. Of the 60%, 35% listed the course as a requirement for all students and 34.5% listed the course as an elective (Epperson, 2010).

Introduction to Computers/Computing courses are low level courses that provide basic computer competencies that the students will need as they move through the curriculum. Components related to MS Office skills are the most common; however, institutions displayed common integration of technical terminology and computer security. Over the years, the components of the course have been evaluated and modified. Below is a timeline that illustrates the linage of proposed additions to the course components.

Figure 2: Proposed Concepts for Introductory Computing Courses



Mostly, the objectives of this course are related to computer basics. As the graph above illustrated, more emphasis on supporting elements and advanced topics are starting to emerge. Below is a short example of learning objectives and outcomes from Introduction to Computers/Computing courses from different universities.

- Familiarity and comfort with basic computing concepts and the ubiquity of computers.
- Fluency in finding, evaluating, processing and presenting information.
- Exploratory knowledge of the art and science of information presentation.
- Define and describe the hardware used in information technology (IT).
- Define and describe the types of software used in IT.
- Define and describe the different aspects of computer security, privacy, and ethics.
- Delineate and discuss societal issues involving the use of IT and networks.
- Demonstrate the ability to create and use documents, spreadsheets, presentations and databases in order to communicate and store information as well as to support problem solving.
- Use IT to acquire, differentiate and evaluate information and technology.
- Demonstrate an understanding of the manipulation of vector graphics in PowerPoint.
- Create Web pages from Microsoft Office applications.
- Demonstrate methods of sharing information between Office applications.

From reviewing the syllabi for these different institutions, instructors are developing learning experiences based on problem-based learning and hands-on techniques. An in-depth review of the courses, revealed a commonality of projects, lectures, assignments, and exams centered on Microsoft Office applications and popular internet browsers.

Implementation Methods

An Introduction to Computers is a general level course that encompasses the basics of computer function and use. The course assumes that the student has limited prior experience with computers and therefore needs to be briefed on the critical facets of a computer system. This exposé ranges from the comparison of different types of computers (handheld, personal, mainframe, and supercomputers) to the identification of popular software applications and cloud computing platforms. Once this section is completed students then move on to learning how manage files within the Windows 7 operating system. Reintroduced is the usage of the most prominent browsers available and how to use the Microsoft office platform to check their student emails. For the rest of the class students are introduced to Microsoft Word, Excel, Access and PowerPoint. Once competency has been achieved their knowledge of these office products are then utilized in an integrated final project. Once the concept of cloud computing has been introduced, it is simultaneously reinforced through usage as all files create are managed through Microsoft's One drive.

While the course may seem to be rudimentary at first, subtle topics such as file size and processing speed are discussed in an effort to engender a broader understanding of some of the critical metrics used to gauge a computer system. This skill is transferable to other areas of life such as determining weight, length and volume in the metric system of measurement. With this basic understanding students then progress to determining what an operating system is and how this software application is found on any computing device. Due to the interrelated concepts surrounding these devices students are provided foundation for being technologically literate through the use of computers. Being able to do simple queries in a database and that off a more refined search on Google a similar in nature and is constantly being reinforced in the Introduction to Computers class. The class therefore provides the basics foundations of being technologically literate. The basics of technological literacy follow the critical steps identified earlier, that of: a basic use and understanding of computing technology, an advanced use and understanding of computing technology and an ability to solve problems germane to computing technology.

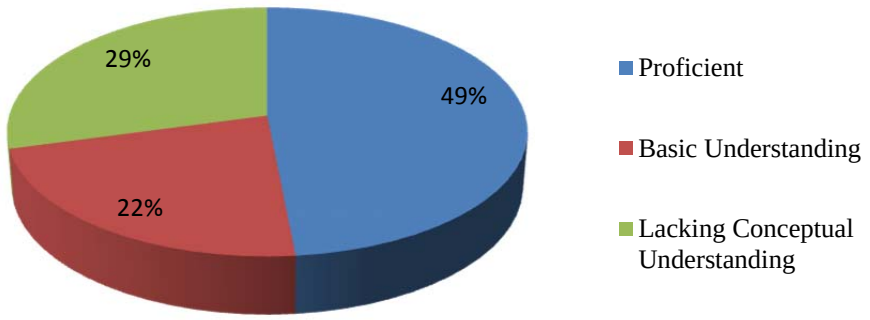
In an effort to map topics from the Introduction to Computers class, to that of technological literacy, a basic use and understanding of computing technology can be derived from lessons that are covered the essentials of computing systems. These lessons entail the understanding of operating systems and how they are useful for meta-level processes such as file management, communication and information gathering. An advanced use and understanding of computing technology is derived from the conventional and unconventional usage of software applications germane to the operating system in the manipulation of gathered data. For example, students utilize the Microsoft Access database and perceive their usage of this software application as being unconventional. Their unconventional usage of this software application teaches them how to do queries which is an essential concept to grasp when using what they consider to be a conventional database, a Google search, in their final assignment.

By being able to use, manipulate and understand differing software applications and platforms students are now able to problem solve. This problem solving skill is displayed in the final integrative assignment that requires them to employ object linking and embedding in the office platform. Application and Problem solving, basic and advanced use of computing technology can be mapped to Introduction to computing through the first test which assesses one's basic understanding of computing systems. A complete understanding of this topic is reflected in the test one results, in which students must achieve a grade of 80% or more. Computer competency is displayed in the culminating assignments in surrounding word processing, spreadsheets and data base management. The culminating assignments build on three prior tutorials that are sequential in nature. The accomplishing of these critical assignments reflects competency and is also something that is documented. Finally application and problem solving is displayed in the open-ended final assignment that requires the integrative linking of word processing, spreadsheets, databases and presentation software.

Results

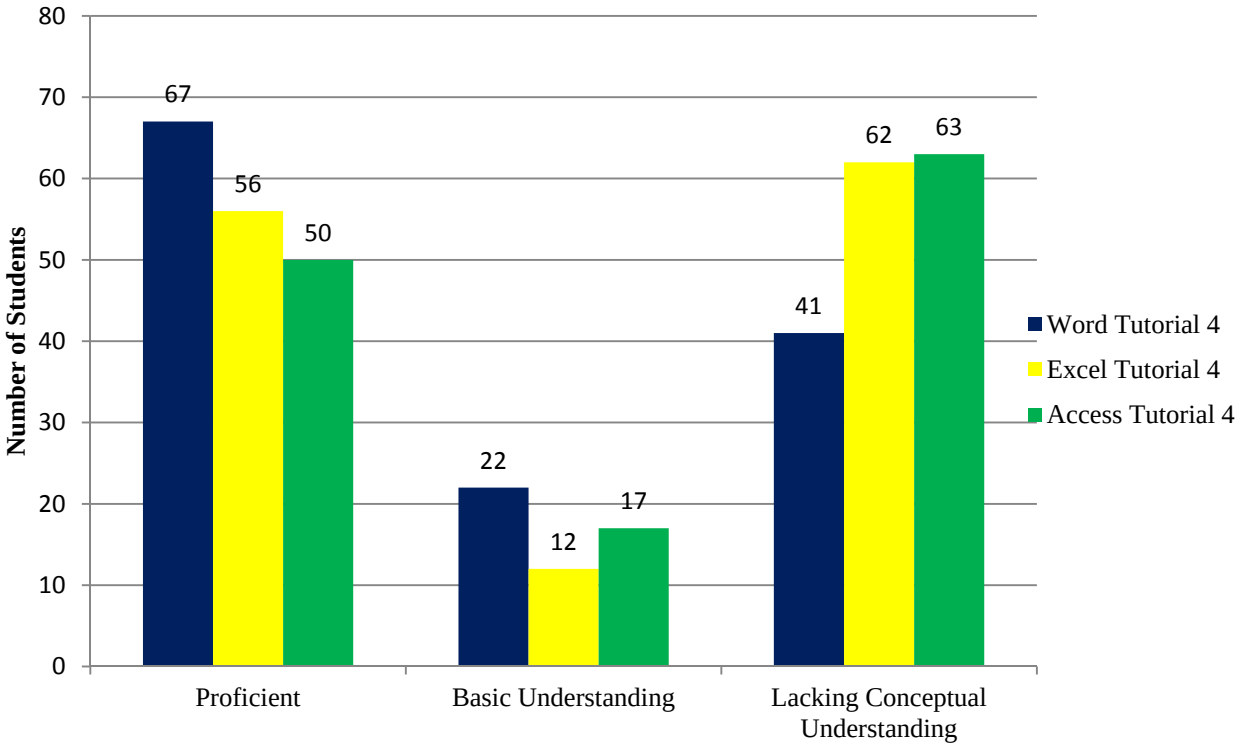
After three semesters of data collected regarding 130 non-STEM students, their proficiency is obtained when students make a grade of 80% or more on their first exam (which assesses their basic use and understanding of computing technology) or when they have completed their culminating assignments in their entirety. If students completed up to 80% of their assignments they have a basic understanding of the software and its capabilities. Below 70% completion students lack a conceptual understanding of computing technology or computer software capabilities. For the first set of data collect a basic understanding of computing technology was analyzed. Of all the students completing this section 49% demonstrated proficiency, 22% demonstrated a basic understanding of the concept and 29% lacked conceptual understanding (See figure 3). In essence this assignment showed that most students (71%) had at least a basic understanding of computing technology (file management, communication and information gathering).

Figure 3: Basic Use and Understanding of Computing Technology



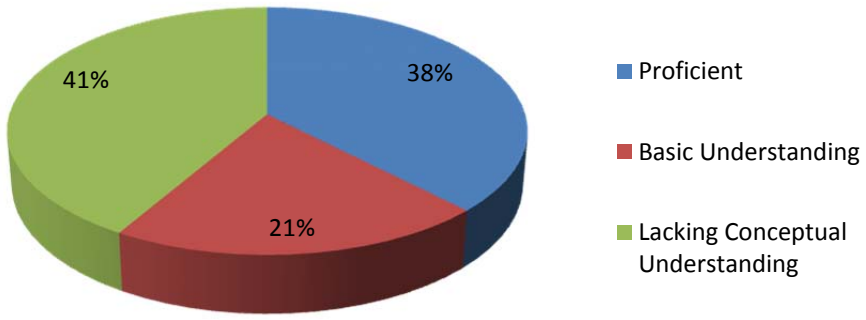
For the second critical step towards the understanding of Computing Technology, proficiency in the three base areas, word processing, spreadsheet and database management ranged from 51% (67 students) to 39% (50 students). As students progressed from word processing, to spread sheets and finally to database management culminating assignments their proficiency fell. Figure 4 shows that most students (67 students out of 130) where proficient at using word processing software, however, for spreadsheet (56 out of 130 students) and data base management (50 out of 130) software this was not the case. When combined most student had at least a basic understanding of word processing (68%) and spreadsheets (52%), while the inverse was true for database mastery, with 61% displaying a basic or lack of understanding.

Figure 4: Number of students displaying Various Levels of Understanding on Culminating Assignments



How well a student did at the application and use of word processing, spreadsheet and database management assignments seems to have affected their ability in the third step of being able to integrate the three. Integration of these three facets measured the student's ability to problem solve and apply the software covered in the class to a real-world scenario. Proficiency obtained in the final assignment declined as only 38% (49) of the students' demonstrated proficiency while 41% (54) lacked a conceptual understanding of the assignment (See figure 5).

Figure 5: Integrative Final Assignment



Conclusion & Discussion

The results from this class show that non-STEM majors benefit from an introductory level computer course that is redesigned and structured in a way to provide the basic steps to becoming technologically literate. The first step in becoming technologically literate is computing competency. Skill areas for computing competency are – computer use and file management, word processing, spreadsheets, databases, presentations, and information and communications (Gonzales & Renshaw, 2005). While students demonstrate a common knowledge of computing technologies, they lack a basic and applied knowledge and use of these systems. This study reveals that there still is a need for these types of classes and in an effort to prepare students for their immersion in a field of work that is constantly evolving by the integrated use of technology in the workspace.

Integrative technical know-how is an important asset that employees of the future need to possess in a period of time where private data could easily become public information. Having a conceptual understanding of how word-processing, spreadsheets and databases can all be integrated will lead them to improve productivity in their various fields of employment in the future. Issues such as security and privacy, which are top priorities for companies nationwide, become easily broached topics with workers that understand the basic implications of their actions on computing infrastructure. Simply training individuals who are based in the STEM field to be technically literate will not help employers in the future overcome the implications of poor security and privacy. As we enter the age of cloud computing anyone who interacts with a computer must understand these implications and that is why a focus on introductory level computing courses needs to be revisited.

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