

December 2004

What Intro Students Know About Computer Concepts

John Dyer
Georgia Southern University

Ronald MacKinnon
Georgia Southern University

Thomas Case
Georgia Southern University

Follow this and additional works at: <http://aisel.aisnet.org/amcis2004>

Recommended Citation

Dyer, John; MacKinnon, Ronald; and Case, Thomas, "What Intro Students Know About Computer Concepts" (2004). *AMCIS 2004 Proceedings*. 352.
<http://aisel.aisnet.org/amcis2004/352>

This material is brought to you by the Americas Conference on Information Systems (AMCIS) at AIS Electronic Library (AISeL). It has been accepted for inclusion in AMCIS 2004 Proceedings by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

What Intro Students Know About Computer Concepts

John Dyer

Georgia Southern University
jdyer@georgiasouthern.edu

Ronald MacKinnon

Georgia Southern University
rmackinn@georgiasouthern.edu

Thomas Case

Georgia Southern University
tcase@georgiasouthern.edu

ABSTRACT

The results of an assessment of incoming knowledge of computer concepts of more than 300 students enrolled in a introductory computing course at a moderate-size comprehensive university are summarized in this paper. Students completed a 160-item computer literacy assessment test during the first week of Spring Semester 2004. The average test-taker provided correct answers to fewer than 50% of questions. While considerable variation in student performance was observed across 15 computer concept content areas, test takers failed to demonstrate acceptable “proficiency” levels in all areas. The results suggest that the prior knowledge of most students entering the introductory computing course falls short of a minimal threshold needed to consider the elimination of the course from the curriculum. Examination of content area performance provides insights into the types of adjustments that might be made to high school computing courses to better prepare their graduates for success in university introductory computing courses.

Keywords

Computer literacy, introductory course, computer concepts

INTRODUCTION

The value of the introductory computing course in the IS/IT curriculum has been the subject of a long-standing debate. Numerous investigations suggest that prior computer use and attitudes about computing technology have a significant impact on student performance in university-level computing courses (e.g. Davis, 1989; Harris, 1993; Henry, Stone & Pierce, 1995; Papp, 1996). Students with greater knowledge about computers and students who have positive perceptions of computers are more likely to be successful in computing courses than counterparts with less knowledge and/or less positive perceptions. Results from other investigations suggest that the percentage students enrolled in university introductory computing courses who completed one or more computing courses in high school is increasing (e.g., Case, MacKinnon, & Dyer, 2004; Dick, Edmundson, Elliot, & Tolhurst, 1999). The increasing prevalence of students with high school computing backgrounds has led numerous universities to scrutinize the need to continue to offer introductory courses. It has also inspired some scholars to focus on whether there is a continuing need to include computer literacy components in the Information Systems curriculum (e.g. Gordon and Chimi, 1998). The proponents of the IS 2002 Model Curriculum also wrestled with the value of the introductory course in the IS curriculum. While the course was not removed from the last version of the model curriculum, it was relegated to prerequisite status.

The educational implications of the introductory students’ computing background are not insignificant. As noted by Bialaszewski, Case, and Wood (1996), student familiarity with information technology is likely to affect the teaching methodology used by instructors as well as instructors’ academic expectations about their students’ ability and readiness to use sophisticated computing tools. Students familiarity and prior experience with such information technologies are likely to raise instructors’ expectations for course outcomes; instructional approaches that capitalize on their students’ experience and knowledge are more likely to be used in order to increase the overall value of the course’s learning experience.

Most instructors of university-level introductory computing courses would agree that their courses' ability to significantly contribute (add value) to the curriculum is either enabled or constrained by their students' incoming knowledge and prior experience with computing technology. If the foundation knowledge of incoming students is strong, course content can be focused on extending the depth and/or breadth of their knowledge to ensure that the course provides a significant contribution toward the achievement of curricular objectives and learning outcomes. When the knowledge base of incoming students is less, instructors are likely to have more modest expectations for course outcomes; in such instances, course content is more likely to be focused on ensuring that students leave the course with the minimum knowledge base needed to enter upper-level courses. Appropriate adjustments to course content can only be made through the ongoing assessment of the knowledge and experience of incoming students.

The content of the introductory computing course should also be influenced by the expectations of university stakeholders, especially employers. Continual changes in the minimal skill sets that employers expect new hires to possess should inspire universities to make appropriate adjustments in their curricula and course content. Over time, the minimum level of computing literacy sought by employers has ratcheted upward. Curricula revisions to changing stakeholder expectations logically begin with introductory courses. However, attempts to provide closer alignment of course content and stakeholder expectations should not overlook the prior knowledge and experience of students. Hence, the ongoing assessment of the knowledge base of incoming students should play an important role in the decisions to revise the content of introductory courses.

OVERVIEW OF THE CURRENT INVESTIGATION

This study was designed to assess the knowledge of students entering an introductory computing course at a medium-sized comprehensive university in the southeast U.S. Toward this end, a knowledge assessment test administered very early in the semester. This timing was used to minimize the impacts of exposure to course content on assessment test results. Students enrolled in five sections of the university's Computer Concepts course were offered the opportunity to earn extra credit by completing a 160-item Computer Literacy Assessment Test during the first week of the Spring Semester 2004. More than 800 students were enrolled in the five sections of the course and more than half chose to take advantage of this extra credit opportunity. The items on the assessment instrument covered a wide range of concept categories that are commonly addressed in introductory computing courses.

PROCEDURE

The extra credit opportunity and was announced during each of the first three class meetings in each section of the course. It was also placed each section's course calendar in WebCT. The test was administered to 426 students during the first week of class during a 120 minute period. The test addressed topics spanning 15 concept areas summarized in Table 1. The test consisted of 160 multiple-choice questions drawn from the textbook publisher's course question database, formatted as an electronic testing utility in WebCT. Each question had 4 answer alternatives, A, B, C, or D, and the distribution of correct answers was approximately equal, that is, each letter represented a correct answer approximately 25% of the time.

1	Basic Computer Concepts
2	The Internet and the World Wide Web
3	Application Software
4	The Components of the System Unit
5	Input
6	Output
7	Storage
8	Operating Systems and Utility Programs
9	Communications and Networks
10	Database Management
11	Computers and Society, Security, Privacy and Ethics
12	Information System Development
13	Programming Languages and Program Development
14	Enterprise Computing
15	Computer Careers and Certification

Table 1: Content Areas Addressed in the Computer Literacy Assessment Test

The number of assessment test items measuring content areas varied. The distribution of the number of questions per concept area is shown in Table 2. However, the number of questions for each content area was proportional to the amount of coverage the content area received in the course. Hence, the test as a whole reasonably reflected the degree of attention devoted to each of the different content areas during the semester. Additionally, all questions relating to each concept area were not necessarily offered in a structured sequence. For example, the location of the 10 questions measuring concept area 1 were questions 1, 2, 3, 4, 8, 9, 37, 39, 84 and 104.

Concept Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of Questions	10	15	5	7	17	8	11	13	9	11	17	9	11	10	7

Table 2: Number of Test Questions Addressing Each Content Area

Although 426 students attempted the test, only 324 students responded to every question. It is not understood why some students failed to respond to all the questions, but it is assumed that the possible reasons include test fatigue and/or lack of knowledge of a reasonable answer. As such, summary findings are provided relating only to the results of the 324 completed tests. It should be noted that only a marginally significant difference exists between test results based for the complete set of 426 test takers versus the 324 students that responded to each of the items on the test. The overall results are 42% correct answers for all 426 versus 46% for the 324 that responded to every question.

OVERALL RESULTS

A test for randomness was performed to determine if the overall test result of 46% was due to random chance or to other reasons. Under the null hypothesis an overall test result of 25% was expected, while the observed result of 46% was significant with $p\text{-value} = 0.0000$. This implies that at least a majority of the students had some basic knowledge of computing concepts beyond that expected if a simple guessing strategy were employed. Additionally, each student's complete score was tested for randomness, indicating that 58 of the 324 students performed no better than what would be expected if employing a guessing strategy. After removing these 58 students, the overall test result increased to 49% for the remaining 266 students. This would tend to imply that 18% (58 of 324) of the sampled students possess one or more of the following three characteristics:

- (1) Have no broad knowledge of the computing concepts and hence employ a guessing strategy,
- (2) Have some basic knowledge of the computing concepts but still choose to employ a guessing strategy, or
- (3) Try to answer each question without employing a guessing strategy but still have no broad knowledge of computing concepts.

Since it is debatable whether analysis should be performed on all 324 student tests or only the 266 student tests for which a random guessing strategy can be ruled out, the results are provided for all 324 students to facilitate a more conservative approach.

RESULTS – QUESTION ANALYSIS

An item analysis was performed on each of the 160 individual questions, without regard to content area, to determine if student performance on each question was random or non-random. If a question's percent correct value was due entirely to randomness, such as most students using a simple guessing strategy to answer the question, the expected value of the score would be 25%. At the 0.05 significance level, 30% of the questions (48) indicate that a guessing strategy was used. Based on the binomial distribution, question scores evidenced as resulting from random guessing are those with less than 31% correct responses. Figure 1 displays the distribution of the scores of the 160 questions. Based on the item analysis, only 17% of the questions had 70% or better correct responses, while the 75th, 50th and 25th percentile correct responses were scores of 65%, 43%, and 27%, respectively. That is, the 75th percentile correct response rate was 65%, and so on.

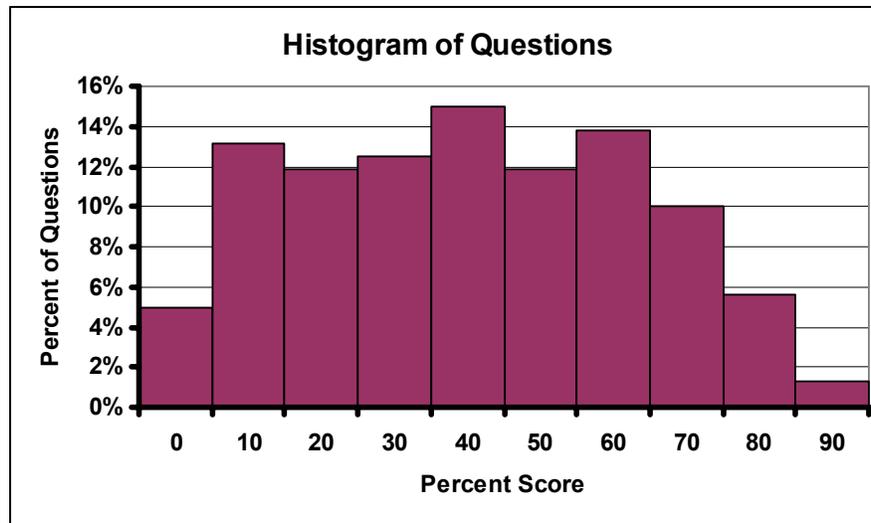


Figure 1. Distribution of Correct Answers to Assessment Test Items

RESULTS - CONTENT AREA ANALYSIS

An analysis was also performed on each of the 15 content areas. Table 3 displays the summary statistics relating to each of the 15 content areas. Most importantly, Table 3 reveals the average percent of individual questions in each content area answered correctly, the Z-score and p-value measuring each content area's departure from randomness, an indication of if each content area's average percent correct was random or non random, and the percent of questions in each content area that were shown to be non random. For example, content area 1 contained 10 questions, and the average percent correct of the 10 questions across all 324 responses was 65%. If a content area's average percent correct value was due entirely to randomness, such as most students using a simple guessing strategy, the expected value would be 25%. Based on a 0.05 significance level and a resulting Z-score of 5.11 and p-value = 0.0000, there is strong evidence that students have some knowledge of content area 1 over what would be expected from employing a guessing strategy. Additionally, the item analysis of the questions relating to content area 1 reveal that 90% of the 10 questions indicate student performance greater than what would be expected if students were employing a guessing strategy.

Content Area	Number of Questions	Average Percent Correct	Z-Score	p-value	Non Random	Percent of Questions Non Random
1	10	65%	5.11	0.0000	Yes	90%
2	15	49%	3.02	0.0013	Yes	67%
3	5	50%	4.29	0.0000	Yes	83%
4	7	51%	3.23	0.0006	Yes	71%
5	17	52%	5.87	0.0000	Yes	65%
6	8	58%	5.21	0.0000	Yes	75%
7	11	49%	12.63	0.0000	Yes	91%
8	13	40%	4.06	0.0000	Yes	77%
9	9	39%	1.73	0.0415	No	56%
10	11	48%	3.54	0.0002	Yes	71%
11	17	50%	4.08	0.0000	Yes	71%
12	9	36%	1.49	0.0680	No	67%

13	11	27%	0.24	0.4038	No	45%
14	10	39%	2.18	0.0147	No	80%
15	7	31%	1.18	0.1187	No	43%

Table 3: Summary Statistics for Content Areas on the Assessment Test

It should also be noted that the average percent correct value for each content area is similar to an exam score covering the specified content area. As such, it is evident that the sample of students possesses an unacceptable level of proficiency in all of the content areas. While a majority of the content areas (67%) do show performance at a level above random guessing, content areas 9, 12, 13, 14, and 15 indicate performance consistent with random guessing. As such, there is no evidence that the sample of students, as a whole, possess any knowledge of these content areas.

CONCLUSIONS

Based on the analysis of the overall assessment test score for the 324 students, as well as the individual question and content area analysis, the evidence suggests that students do have some broad knowledge of computer concepts above what is expected with random guessing, but the students do not possess an overall acceptable level of proficiency in computer concepts. The student's greatest level of knowledge and proficiency relates to basic computer concepts, particularly terminology and uses of computers, as well as the Internet and the World Wide Web, and hardware elements of the information processing cycle (input, processing, and output). The student's lowest level of proficiency relates to communication and networks, information systems development, programming languages and development, enterprise computing, and computer careers.

LIMITATIONS OF THE STUDY

There are several limitations of this study that should be understood in order to better interpret the results of the study as well as to facilitate a better design in future studies. One such limitation was using the textbook author's unedited "test-out" database as the source of questions. Although the number of questions representing each content area was proportional to content coverage in the course, the resulting analysis may suffer from an inadequate number of questions from certain content areas. This can tend to make analysis and comparisons among content areas weak and/or inconclusive.

Additionally, some of the correct answers to many questions in the database require only a common sense approach to answer correctly, and many others can be guessed with greater likelihood by simply eliminating the obviously wrong answer(s), then guessing from the remaining choices. This situation can lead to biased results that tend to measure a student's common sense and guessing ability instead of content knowledge.

Another limitation of the study is the inability of the investigators to determine how many correct answers are based on knowledge versus common sense and guessing. A more suitable set of questions would not only test specific knowledge of the content by forming questions and correct answers in a way that only a student with exacting detailed knowledge could answer correctly, but to also provide a fifth alternative answer to each question that allows students to indicate that they do not know the answer. This would tend to reduce the effects of common sense answer selection and guessing, and provide results that more accurately measure the student's knowledge of computer concepts.

DISCUSSION

The results suggest that the majority of students enrolling in university-level introductory computing courses do not possess a sufficient prior knowledge or experience base to warrant removal of such courses from the curriculum. Although the number of students enrolled in such courses that completed one or more computing courses in high school is increasing, their mastery of fundamental concepts tends to fall short of the minimum proficiency levels required to move into more advance courses in the curriculum. Hence, the introductory course may not be superfluous for most of the students that take it.

We suspect that the best explanation for our findings is the probability that prior coursework was more likely to focus on keystrokes rather than computing concepts. Many high school courses are applications oriented rather than computer concepts oriented. As a result, students enhance their ability to use particular applications without ever really having to come

to grips with how the program works with the operating system and hardware to accomplish user tasks. If high school courses focused more squarely on fundamental computer operations, rather than computer applications, our results may have been very different.

Our findings suggest that students entering introductory computing courses are strongest in the areas of basic terminology and uses of computers; in addition our results suggest that students generally possess some prior knowledge of the Internet and the World Wide Web, and hardware elements involved in the information processing cycle (input, processing, and output). Areas in which students are weakest include networking, information systems, and systems development. Our results suggest that further attention to communication and networks, information systems development, programming languages and development, enterprise computing, and computer careers would enable high schools to better position their graduates to be able to master concepts they are exposed to in university-level introductory computing concepts courses.

In light of the deficiencies evidenced in student's overall competencies, it is important that remediation measures be considered in an effort to improve the student body's degree of computer concepts literacy. There can be no real expectation that the K-12 system will shift teaching emphasis or even share the emphasis on concepts, rather than applications, so it is critical that a path to remediation be investigated to improve computer concepts competency. In many colleges remediation is already established in the form of a computer concepts course or as technology integrated into the curriculum, but in light of the IS 2002 Model Curriculum's placement of such courses as "prerequisite," it may be necessary to further define standards for computer concepts literacy, and to fully integrate these standards into a concepts course or across the curriculum.

Computer Concepts Literacy Standards

Computer literacy is a necessary foundation for information literacy, and information literacy is paramount to building the student's knowledge, skills and abilities related to producing and consuming information. Considering the ALA Standards or Information Literacy (<http://www.ala.org/ala/acrl/acrlstandards/informationliteracycompetency.htm>), the road to remediation might be better paved through the establishment of standards for computer concepts literacy. The authors of this paper suggest computer concepts literacy may best be delineated from information literacy by modifying the ALA Standards with regard to computer concepts literacy. Modified for computer concepts literacy the standards might read as follows:

Standard 1: The student who is literate in computer concepts can use and interact with contemporary hardware, systems software, and applications software efficiently and effectively.

Standard 2: The student who is literate in computer concepts can evaluate hardware and software components critically and competently in regards to the role of the various components in the information processing cycle.

Standard 3: The student who is literate in computer concepts can correctly and creatively apply their knowledge, skills, and abilities to more efficiently facilitate the information processing cycle.

Standard 4: The student who is literate in computer concepts can demonstrate understanding of software categories and the appropriate use/value of each category.

Standard 5: The student who is literate in computer concepts can demonstrate understanding of computer network architectures, components, communication protocols, and network-centric applications.

Standard 6: The student who is literate in computer concepts can articulate the differences between data and information and can demonstrate understanding of data integrity, data security, the qualities of valuable information, and role of database management systems and data warehouses in data and information management.

Standard 7: The student who is literate in computer concepts can demonstrate understanding of information system components, different categories of information systems, and the approaches used by organizations to develop, implement, maintain, protect, and replace information systems.

Standard 8: The student who is literate in computer concepts can demonstrate understanding of the program development life cycle and can critically evaluate alternative approaches to software development, acquisition, evaluation and testing, and maintenance.

Standard 9: The student who is literate in computer concepts can demonstrate understanding of the organizational and societal impacts of information technology including legal and ethical issues and IT's impacts on work processes, educational systems, business processes, and culture.

It should be noted that these standards overlap slightly with the knowledge areas/items of the first two modules included in the European Computer Driving License (ECDL) and the International Computer Driving License (ICDL): Basic Concepts of IT, and Using the Computer and Managing Files (http://www.acs.org.au/icdl/content/upload/files/pdf/ECDL_Syllabus.pdf). While the EDCL and IDCL manifest a combination of what information scientists mean by computer literacy and what we are describing as literacy in computer concepts, they are strongly tilted toward software proficiency. Because of this, the EDCL and IDCL are, more acceptable as demonstrations of computer literacy than for indicating literacy in computer concepts.

Parallels among Computer Concepts Literacy and Fluency with Information Technology

It should be noted that this “straw man” set of standards is closer to the National Research Council’s description of “fluency with information technology” than to the ALA’s depiction of information literacy. The National Research Council (1999) states that fluency with information technology (FITness) “requires that persons understand information technology broadly enough to be able to apply it productively at work and in their everyday lives, to recognize when information technology would assist or impede the achievement of a goal, and to continually adapt to the changes in and advancement of information technology” (p. 15). They also stress that FITness requires a deeper understanding and mastery of information technology for information processing, communication, and problem solving than that associated with information literacy.

The National Research Council (1999) outlines three major characteristics of individuals that exhibit fluency with information technology. These can be summarized as:

- Intellectual capabilities that enable the individual to apply information technology in complex and sustained situations and to understand the consequences of doing so
- Understanding of enduring concepts that are fundamental to computing and information
- Contemporary skills that enable the individual to use contemporary hardware and software to accomplish information processing tasks

Individuals that are fluent with information technology may also be described as being able to organize and navigate information structures and evaluate information, leverage IT to collaborate, anticipate changing technologies, and to think about information technology abstractly.

It is our view that the objectives of many introductory computer concepts courses are geared toward developing a knowledge base beyond that associated with information literacy. In many instances, including ours, overarching objectives are to enable students to critically evaluate information technologies, their applications in organizational settings, and their societal impacts. Such an objective appears to be closely aligned with those of programs designed to instill fluency with information technology. The computer concepts literacy standards outlined above may provide a mechanism for delineating desired outcomes of introductory courses focused on computer concepts. They may also serve as an important communication medium between universities and secondary schools about the concepts that students enrolled in university-level introductory courses will be expected to master. Hence, they have the potential to provide important input to processes for adjusting high school computing curricula.

Final Remarks

Although the introductory course has been relegated to prerequisite status in the IS 2002 Model Curriculum, it may still fulfill an important need at many universities. It may play an especially important role in narrowing the wide diversity in the computing backgrounds of enrolled students. The introductory course may also help to ensure that student mastery of computing concepts extends beyond hands-on experience with productivity software applications. It can assist students in developing lifelong learning foundation needed to be more knowledge consumers and managers of information technologies.

Instructors of introductory computing courses may also constructively use the results of this investigation. Our findings shed light on the concept areas in which entering students have the strongest knowledge base. These findings also assist in surfacing concept areas in which students have had limited or no prior exposure. Such insights enable instructors to adjust course content to build on student strengths and to overcome deficiencies. They may also provide an important baseline for revising the introductory course to address the changing needs and expectations of employers.

REFERENCES

1. Bialaszewski, D., Case, T., and Wood, B. (1996). Data Communications: Theoretical and Experimental Instruction Incorporating the Internet. *Proceedings of the Eleventh Annual Conference of the International Academy for Information Management*, 63-66.
2. Case, T., MacKinnon, R. and Dyer, J. (2004). Computer Literacy and the Introductory Student: An Analysis of Perceived and Actual Knowledge of Computers and Computer Applications. *Proceedings of the Sixth Annual Conference of the Southern Association for Information Systems*.
3. Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13, 319-40.
4. Dick, G. N., Edmundson, R. H., Elliot, S. R., and Tolhurst, D. (1999). Changing Skills, Changing Demands, Changing Expectations: What Implications for IS Schools? *Proceedings of the Fourteenth Annual Conference of the International Academy for Information Management*, 274-279.
5. Gordon, G. M. and Chimi, C. J. (1998). Should the Introductory Information Systems Course be Removed from the Business School Curriculum? A Preliminary Investigation. *Proceedings of the Thirteenth Annual Conference of the International Academy for Information Management*, 1-7.
6. Harris, A. L. (1993). The Impact of the Introductory MIS Course on Students' Attitudes and Perceptions Towards Microcomputers. *Journal of Computer Information Systems*, Winter 1992-1993, 38-41.
7. Henry, J., Stone, R., and Pierce, M. (1995) Determinants of Student Performance in the Introductory Computer Programming Course in the College of Business. *Proceedings of the Tenth Annual Conference of the International Academy for Information Management*, 91-104.
8. National Research Council. Commission on Physical Sciences, Mathematics, and Applications. Committee on Information Technology Literacy. Computer Science, and Telecommunications Board. (1999). *Being Fluent with Information Technology*. Washington, D.C.: National Academy Press (<http://www.nap.edu/catalog/6482.html>).
9. Papp, R. (1996) Student Perception and Knowledge About Information Technology: A Computer Attitude and Experience Survey to Measure Changes. *Proceedings of the Eleventh Annual Conference of the International Academy for Information Management*, 7-15.