Assessment Tests for Digital Skills: A Tool for Learning Outcomes and University Accreditation

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Abstract: An important question asked by academicians is whether students use Internet languages constructively to further themselves in their chosen field of study while in college, or merely use them for social networking and entertainment.

The iSkills Test is a possible tool for assessment of students' skills in using digital technology on the Internet. This paper seeks to investigate the test's usefulness in helping to answer the question stated above and in the process, add positively to the reaffirmation of accredited universities where these students are enrolled.

An original method has been shown to allow instructors/coaches and institutions to assess the effectiveness of their programs through the use of this test, even though the grading scheme has been changed between the initial and final assessment tests (in one term). The grading code of the iCritical Thinking Certification test (now updated as the iSkills test) has been found, at least for the present.

After two years of testing data at the University of Miami, the University has been provided with three major strengths and three major weaknesses of the students. The undergraduate strengths are (1) shopping, (2) following directions, (3) using information ethically. The students' weaknesses are (1) selecting resources, (2) researching, (3) knowing or understanding what they find. It is apparent that the areas of weaknesses are areas of opportunity for the University to improve their students' digital skills. Some useful suggestions have been developed to help students improve their critical thinking abilities and thus perform better in the certification test.

The iSkills tests involved organization of information, development of a search strategy, creating a slide, summarize researched information, creating a visual representation and constructing an advanced search. These tasks involved a variety of skill sets and they mimic real world tasks. This test is recommended for the assessment by universities of their students' improvement in digital skills development while on the Internet, across the disciplines. The tests are used to help convince university accreditation bodies like Southern Association of Colleges and Schools in the U.S.A. International acceptance of the test is recommended since the use of the Internet is global, and digital skills development is an undeniably important asset.

Keywords: Tests, critical thinking, digital, Internet.

1. INTRODUCTION

University accreditation in the U.S.A. involves applying for accreditation from the appropriate body, the submission of documents (off-site review), and the on-site review. The off-site review committee determines whether each university/institution is in compliance with all Core Requirements, Comprehensive Standards, and Federal Requirements. As part of the reaffirmation of accreditation process, the institution will provide two separate documents, the Compliance Certification and the Quality Enhancement Plan (QEP). The QEP, submitted about a month before the on-site review is a document developed by the institution that includes a process identifying key issues emerging from institutional assessment, which amongst many other matters, includes a focus on learning outcomes of students.

It is this last item of the learning outcomes of students, and the subject of digital skills that the current work is being focused. Assessment tests have long been accepted in the U.S.A. as a viable tool for learning outcomes in subject areas. The author has used assessment tests for thermodynamics for over ten years. These thermodynamics assessment tests were originally formulated by a consortium of U.S. universities (with funding from the U.S. National Science Foundation), in collaboration with counterparts in China, India and elsewhere.

Electronic books or e-books have been available for a while. There is talk and action about the market potential for e-books, especially in a higher education context, but few robust user studies, Armstrong *et al*. [1], Hannigan [2], Rowland *et al*. [3]. Even before that, there was a report put out on the affordability of e-books, California State University [4]. In this related area of electronic delivery is the e-delivery of information, research papers, and other informational news through social media and the Internet.

Critical thinking has been explained as "reasonable reflective thinking focused on deciding what to believe or do" Ennis [5]. It has also been called "thinking about

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E-ISSN: 2409-9848/15 © 2015 Avanti Publishers

thinking" Raiskums [6]. It has been described in greater detail as "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action", Scriven and Paul [7]. In recent times, critical thinking has been explained as "the process of purposeful, self-regulatory judgment, which uses reasoned consideration to evidence, context, conceptualizations, methods, and criteria", Facione [8]. Good digital skills require good critical thinking, with an emphasis on speed and time.

A collection of research works was done by the Northeastern Illinois University, Illinois Wesleyan, DePaul University, and the University of Illinois's Chicago and Springfield branches. Since surveys alone were not as revealing, the librarians employed two anthropologists. The studies utilized open-ended interviews and direct observation, along with other standard scientific procedures.

The ultimate objective was to find out how students and professors, as well as librarians view the library and each other at the five institutions of higher education. The resulting papers that were written about these studies were published in 2012 by the American Library Association (ALA), [9].

It was reported that "over the course of a two-year, five-campus ethnographic study examining how students view and use their campus libraries: students rarely ask librarians for help, even when they need it." Generally, students do not really think of a librarian as an academic expert who discuss about assignments and help them with the research process. The most intriguing discovery in the *Ethnographic Research in Illinois Academic Libraries* (ERIAL) studies, Free Government Information [10], was well known by their professors: when it involves critically searching for sources in the Internet, undergraduate students need guidance.

It is quite the motivation then, that universities show that their students have improved their knowledge not only in their selected areas of study, but in finding and evaluating sources online in the Internet age. Hence, the coining of the phrase "iCritical Thinking" instead of just critical thinking, in initially naming the assessment tests under discussion; the "i" presumably to emphasize the Internet connection. "iCritical thinking" may be elaborated as digital critical thinking, or critical thinking while using the Internet. The updated name of iSkills tests is more appropriate.

The iSkills tests by Education Testing Service (ETS) and Centiport, are a tool for assessing and certifying the digital skills of Internet users. The test allows institutions to assess their contribution to their students' abilities to use the Internet in an efficient and critical fashion. The test itself was about an hour long with 14 computer-based tasks. It employed simulated software for word processing, email and search engines to be used for the questions asked.

The test comprised a number of interactive tasks that involve organization of information, development of a search strategy, creating a slide, summarize researched information, designing a visual representation and making an advanced search. These tasks involved a variety of skill sets and simulate real world tasks. They included common, vendor-neutral applications and real workplace situational tasks.

For universities this test could be a university-wide assessment test for all the undergraduate students. For employers of engineers, it can provide information on how "tech savvy", "information savvy" and precise/critical new/old hires might be about obtaining information *via* the Internet.

This certification tests was used as an assessment test by the home University of the current author, which obtains accreditation of the entire University from an authority such as the Southern Association of Colleges and Schools (SACS) in the U.S.A. It is not used for assessment of individual programs.

2. OBJECTIVES

A group of worldwide leaders came together in San Jose, California, to confer about the 'Internet language' for three days, starting April 26, 2005. Those leaders included authors, researchers, policy makers, educators, and artists. Their aims were to discuss and arrive at plans of action that will educate the masses about this new and very important language. It was recognized that this new language included sound, images and videos. A group of young digital natives were learning and using a medium that used to be the purview of artists and filmmakers. Additionally, this happening was very similar around the globe. That conference/workshop, the Twenty-first Century Literacy Summit, caught the attention of researchers, policy-makers, and others, The New Media Consortium [11].

The question that had to be answered amongst academicians like the author, was whether these same young, digital natives of the new language could use it constructively to further themselves in their chosen field of study while in college, or simply use it for social networking and entertainment. When the iSkills test became better known, and even as the test evolved, a likely tool to assess students' digital abilities seem to have surfaced. One of the current paper's main objectives is to investigate the test's usefulness in adding to the Quality Enhancement Plan (QEP) of a university seeking reaffirmation of accreditation.

Another objective of the current work is to arrive at suggestions/guidelines that could be used by academics when coaching their students to do Internet research and investigatory work, and hence perform well in the digital skills assessment test.

3. THE ISKILLS TEST

Tasks that are asked in the test are, Education Testing Service (2009):

1) Obtaining information from a database.

2) Forming conclusions from a spreadsheet.

3) Composing an email using researched findings.

Seven skill sets are tested, viz. access (AC), communicate (CM), create (CR), define (DE), evaluate (EV), integrate (IN) and manage (MA). The number of mouse-clicks made by the test-taker is somehow significant in the final scoring. The access skill set is measured by a question, say, for the retrieval of information from a store's database in response to a customer's enquiry. The *create* skill set is measured by questions that require the test-taker to create a webpage from multiple sources of information provided, as one example. The persuasiveness of a poster could be a second example of a task in this CR category. The *manage* skill set is measured by questions that require the test-taker to manage the time-schedule of appointments and activities of a supervisor, for instance, by putting them into folders. The *communicate* skill set contribution comes from making a slide arguing a position, as an example. The *evaluate* skill set is measured by questions that include requiring the test-taker to judge the probable usefulness of sites returned in a web search. The *integrate* skill set is measured by questions that require the test-taker to take information from several standard tasks and come up with an integrated or combined solution for a new task, as an example. One type of these questions is to compare different reviews to select a product; another type is to combine several electronic suggestions in order to plan a scientific experiment. The *Define* skill set contribution comes from selection of a research topic according to specific criteria and an explanation for the choice, as an example.

There is a reported individual score which is out of a maximum possible of 500 points. The result report includes detail percentage scores on the seven skill sets that are tested. The minimum passing score is 260 points, which was determined by the international testing agency.

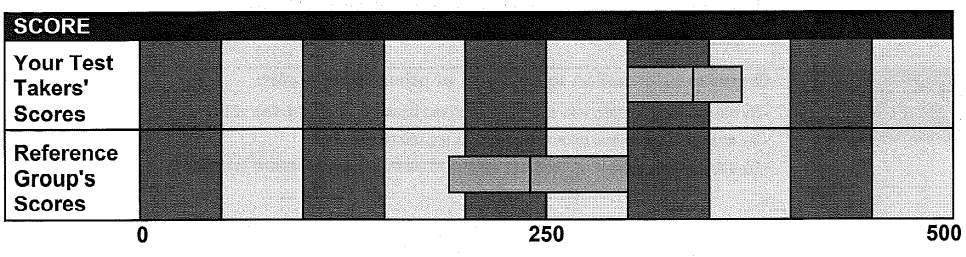
3.1. Student Results

Forty students in the class taught by the author were amongst the first group of students who took the test under discussion. They were seniors of the Mechanical and Aerospace Engineering department at the University of Miami(UM) in Coral Gables, Florida, U.S.A. The first year of testing comprised 8 groups.

The middle 50% of the UM Mechanical and Aerospace Engineering group is above the middle 50% of the whole group (1425 people in the global group). Their average is 335 which is about 100 points over the

Table 1: ETS Report of the UM Engineering Group

The graph below represents the performance of your reporting group compared to the performance of the reference group in terms each group's overall score. The boxes indicate the range of test taker achievement for the middle 50% of each group and the vertical line represents the median score for the group.



whole group's average of 240 which is failing. It should be noted that 260 is the minimum passing score, Table **1**.

The Mechanical and Aerospace Engineering class was chosen since the author was in the first group of faculty who participated in the first UM Faculty Learning Community, University of Miami (2008). The author coached the students in the taking of the standardized test. In addition, the author had them write their laboratory reports and do a semester project which required them to perform many literature searches. They were exposed to the use of several technological tools in the classroom, e.g. Youtube, videos, iClicker, Refworks, Camtasia, blogging about energy issues, etc. These experiences and exercises assisted the students in improving their critical thinking abilities while using the Internet.

3.2. Coaching Tips

The following are suggestions polled from the students themselves in how to perform well in the certification test:

1. Take your time. Many students left the test after a short period of time. Taking a closer look with a little extra time (plenty of time is allocated) can go a long way to improving scores.

2. Place more importance on covering the objectives that the program requires in each task, rather than doing what you personally believe sounds/looks best. The objectives are always located on the left side of the monitor and a quick check before moving on to the next section can minimize mistakes.

3. Read the instructions carefully, so that clicks are not wasted on going back and forth from the actual problem.

4. Focus on the requirements. The test can add extra information to be distracting. Focus on exactly what is required and seek out just that information.

5. Work fast, but do not be afraid to slow down in parts that are confusing or hard to get through.

Besides the UM Mechanical and Aerospace Engineering group, the other 2 groups from UM taking the iCritical Thinking Certification test were from the School of Communications and the School of Architecture. The scores for the three groups of undergraduates who took the test at UM are summarized below:

% Pass % Fail Average Score,

College of Engineering 90 10 335,

School of Communications 60 40 287,

School of Architecture 20 80 160.

3.3. Analyses of Student Results: Difficulty and Use of Statistics

The detailed scores of the forty engineering students are as shown in Table **2**. The numbers of students in the corresponding classes in the Communications School and in the Architecture School were about the same. ETS does not publicize scoring schemes. From the detailed scores, it was apparent that there was weighting associated with the seven skill sets. Since this is rather an important factor to help future test-takers to improve their scores, one objective was to find this weighting scheme. The method to find this weighting scheme was to use statistical modeling.

The difficulty for the author that was the seed of one of the original contributions (in this paper) was that the grading scheme had been changed between the initial and final tests. Simple, direct statistical analysis would not be adequate. Exploratory data analysis (EDA) had to be used to help find structure in the data. EDA helped in building a useful model. Checking model plausibility and verifying assumptions *via* EDA was an essential prior step.

The University receives the detailed results from the provider. The first task was to do a linear Y versus X line-fit between the seven skill set scores and the total score. Of the seven, “create” is found to be the most important with a coefficient of 1.43 with a p-factor of less than 0.001. The “manage” skill set has a coefficient of 0.949 with a p-factor of 0.0011; the “integrate” skill set has a coefficient of 0.955 with a p-factor of 0.0022. The “evaluate” skill set has a coefficient of 0.605 with a p-factor of 0.0030 while the “communicate” skill set has a coefficient of 0.720 with a p-factor of 0.0148. The “access” skill set has a coefficient of 0.419 with a p-factor of 0.211 and the “define” skill set has a coefficient of 0.262 with a p-factor of 0.505. This last p-factor for the “define” skill set is too large to have absolute confidence on the coefficient found. The p-factor has to be really small (close to zero) for the correlation coefficient to be really good.

Interpreted another way, it may be said that AC contributed 7.8% to the total; CM contributed 13.5% to

Table 2: Student Results

ACCESS	CM	CREAT	DEFINE	EVALUATE	INT	MANAGE	TOTAL	INI	TOT	%
1	83	69	78	58	94	94	90	320	565	62
2	100	75	86	79	72	100	70	380	610	95
3	8	69	61	33	56	31	20	160	520	20
4	83	45	79	64	67	71	80	280	555	53
5	100	90	93	79	33	71	90	340	585	80
6	100	55	86	79	44	86	70	300	570	68
7	83	69	89	92	100	94	80	360	610	95
8	83	94	94	75	94	88	80	370	600	90
9	92	50	100	71	72	79	50	310	575	72
10	100	88	83	83	100	88	100	390	600	90
11	92	81	83	100	94	56	100	350	590	84
12								210	525	23
13	83	55	64	57	22	50	80	220	535	31
14	83	80	86	64	89	93	90	380	580	77
15	100	70	100	93	44	100	80	370	570	68
16								310	595	87
17	100	75	100	71	50	79	90	350	580	77
18	100	63	44	83	100	100	100	330	540	35
19	92	55	100	79	44	86	70	310	570	68
20	92	80	79	71	89	64	80	350	565	62
21	100	100	100	75	100	100	80	420	570	68
22	100	60	100	86	89	71	80	380	630	100
23	92	88	100	83	100	88	90	390	605	93
24	42	63	100	83	81	75	20	260		
25	100	69	72	92	100	88	60	330	590	84
26	92	45	100	93	89	71	70	350	610	95
27	92	85	100	79	67	93	90	400	615	97
28	83	94	78	83	81	81	90	340	595	87
29	100	100	93	71	89	93	100	470	600	90
30	100	100	100	75	100	63	80	370	620	99
31	100	70	71	86	61	86	80	340	595	87
32	50	88	83	75	94	100	30	300	565	62
33	83	70	100	93	89	100	100	440	615	97
34	100	88	83	75	94	81	100	330	565	62
35	100	88	100	75	94	100	80	390	600	90
36	83	69	94	83	94	75	100	350	590	84
37	92	94	94	75	81	94	70	360	570	68
38	100	60	93	86	22	79	80	290	585	80
39	100	75	78	83	88	94	60	330	585	80
40	92	55	86	86	61	86	70	320	585	80

the total; CR contributed 26.9% to the total; DE contributed 4.9% to the total; EV contributed 11.3% to the total; both IN and MN contributed 17.8% each to total.

From the scores obtained by the students at UM, the College of Engineering students performed the best of the three groups. This test was done towards the end of the fall semester, 2009. At the beginning of the fall semester, these same students took a very similar test from ETS, but under a different name and a different scoring system. In that initial test, not only was a final score out of 700 given, but a global percentile

Table 3: Actual and Predicted Scores

Student	TOTAL	Rounded Pred Total
1	320	310
2	380	380
3	160	210
4	280	270
5	340	330
6	300	280
7	360	360
8	370	370
9	310	290
10	390	390
11	350	350
12	210	230
13	220	250
14	380	380
15	370	370
16	310	300
17	350	350
18	330	320
19	310	300
20	350	350
21	420	420
22	380	390
23	390	400
24	260	260
25	330	320
26	350	350
27	400	410
28	340	340
29	470	440
30	370	380
31	340	340
32	300	290
33	440	430
34	330	330
35	390	400
36	350	360
37	360	370
38	290	280
39	330	330
40	320	310

ranking was given to each individual test-taker (the last two columns of Table **2**). There was no minimum passing score and there was no certification of proficiency. In addition, there were no skill sets and

individual skill set score details. As an assessment tool, this posed a dilemma because the scoring of the test had changed.

One way around this dilemma was to run a statistically best fit distribution model through the results of the second test. This second statistical analysis of the results data was done by fitting the "best" model fit to the data. The Weibull model was found to be the best. The Weibull distribution, Papoulis [12], for the variable x is

$$F(x;k;\lambda) = 1 - e^{-(x/\lambda)^{k}} \quad (1)$$

for $x \geq 0$, and $F(x; k; \lambda) = 0$ for $x < 0$, where $k > 0$ is the shape parameter and $\lambda > 0$ is the scale parameter of the distribution.

From the models that were used, there were 30 higher scores or about the same (within 2 significant Figures in the total score as reported by ETS) and 10 lower than their expected score (based on their initial test scores from the beginning of the semester). Hence there were 75% of the class of 40 who did the same or better than expected. The details of the model output are shown in Table **3**.

4. DISCUSSION

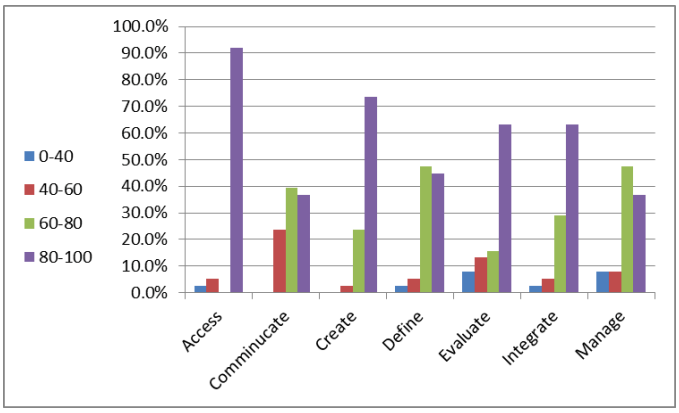
The original methodology reported here of statistical modeling of a university-wide assessment test for undergraduate students, would be useful to any university that has made the decision and investment to use the test to assess their incoming freshmen, and four years later, the graduating senior class. If the scoring system has changed (by the testing authority in the four years, which could be likely), the universities so adversely affected could use the method described in the current work to deduce the progress or otherwise of their students.

Further analyses of the results for the engineering students showed interesting strengths and weaknesses. Figure **1** is a collection of the distribution plots of the seven skill sets. The group showed strength in five of the seven skill sets, and not as strong in communicate skill set and define skill set. Since these later two contributed only 17.9% of the total score, it is obvious the performance of the group would be much better than average. It is interesting to note that normal weaknesses in communication and defining skills from engineering students are not entirely surprising. The strengths in creativity, integration, management and evaluation are all skills honed and polished especially well during their engineering undergraduate education. Accessing skills are probably the purview of the younger generation as opposed to the more mature generation, ETS [13], Kennedy *et al*. [14], Lenhart and Madden [15]. After about four years at a engineering degree program, there should be confidence that senior students will not continue to lack the evaluation and critical skills to analyze information sources with effectiveness, Fitzgerald [16] and Andretta [17].

There have been 2 years of testing data at the University of Miami [18], Figure **2**. The Group 1 (Year 1) students went from 51 to 63 passing before and after a FLC member's course. The Group 2 (Year 2) students went from 52 to 75 passing before and after their respective FLC member's course. The undergraduate strengths are (1) shopping, (2) following directions, (3) using information ethically. The students' weaknesses are (1) selecting resources, (2) researching, (3) understanding what they find. It is clear that the areas of weaknesses are areas of opportunity for the University to improve their students' digital skills. It is validating that the conclusions reached about student weaknesses mirror those found by the ERIAL study. This validation affirms that the test is a reasonable one to use to assess the digital skills of students.

Skills like critical thinking and analysis should develop in the context of facts. There has to be something to think and reason around. These facts cannot be searched online. These seedling facts need to be stored in the original hard drive, the long-term memory (or brain) of the students. Especially in the case of college students, factual knowledge has to precede skill. In other words, teaching by drilling the multiplication Table and memorizing the names of the world's capital cities are not long gone as yesterday's teaching methodology. Students need to gain a supply of stored knowledge so as to position and evaluate new information encountered. One cannot Internet-search for context. Unfortunately, it would seem that the teaching by drilling and other similar methods have been more or less abandoned at the university level. Hence, the use and justification of the digital critical thinking tests like the iSkills test, to quantify these weaknesses.

Simply raising awareness of the availability of this test (by the instructors) helped in increasing the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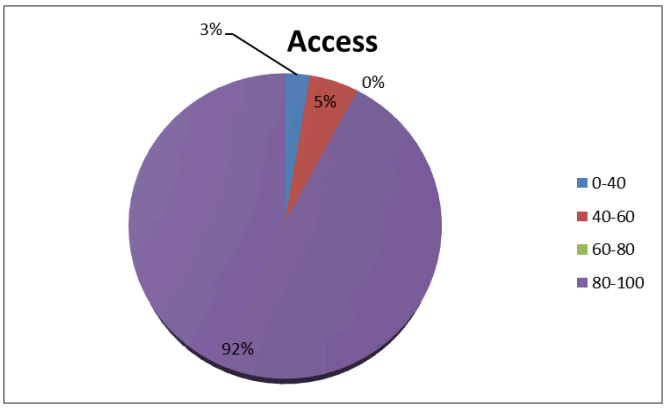
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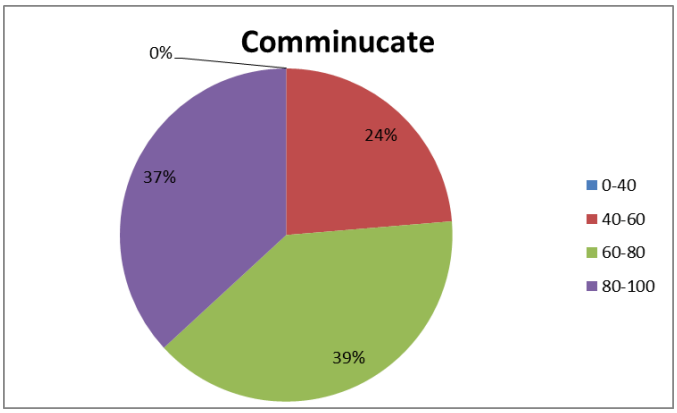
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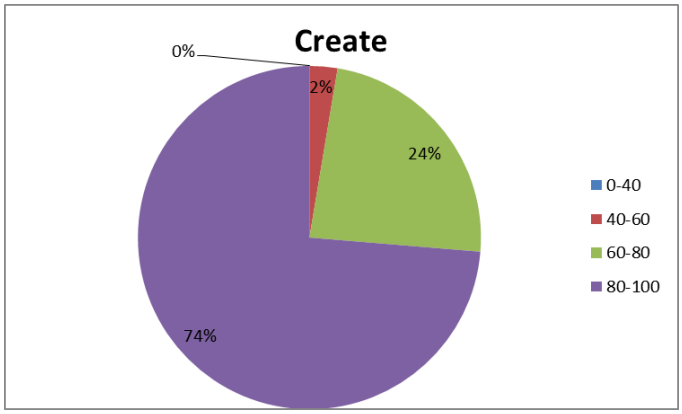
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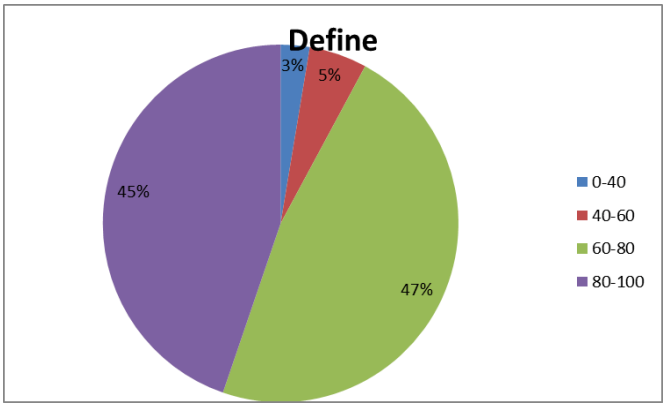
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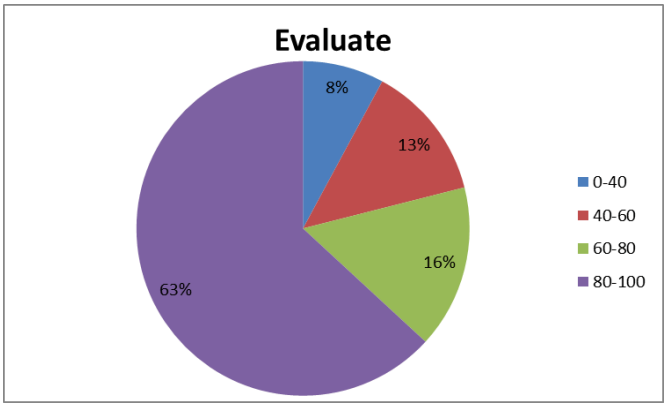
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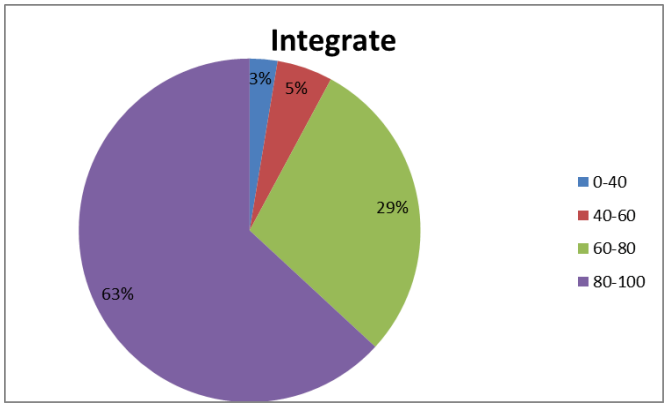
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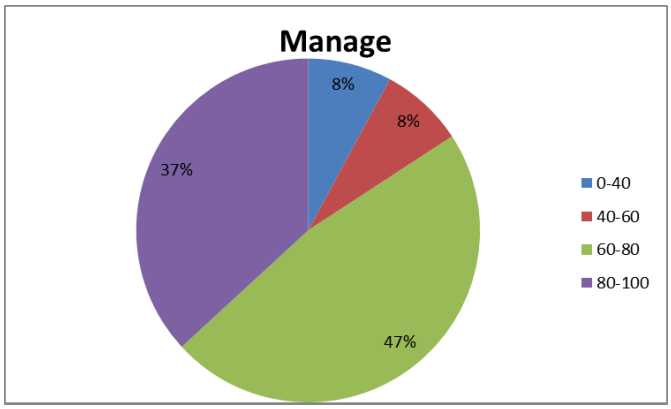

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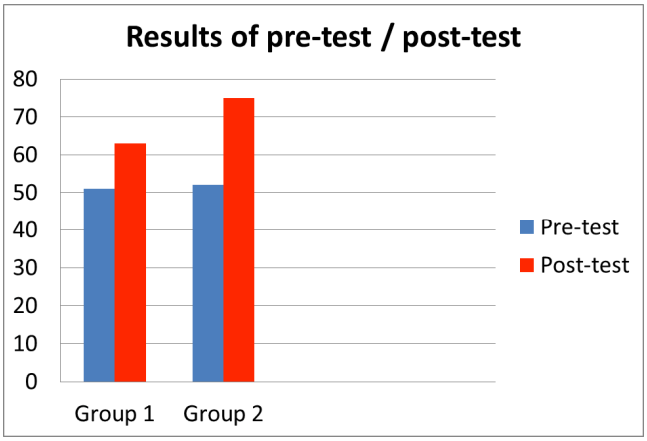
Figure 1: a: Distribution Plots of the Seven Skill Sets. **b:** Share of students in each level for access skill. **c:** Share of students in each level for communicate skill. **d:** Share of students in each level for create skill. **e:** Share of students in each level for define skill. **f:** Share of students in each level for evaluate skill. **g:** Share of students in each level for integrate skill. **h:** Share of students in each level for manage skill.

average scores the second year and beyond, since the test was used for a couple of years at the University of Miami. This is can be seen in Figure **2**.



Group 1 is Year 1 of Testing at UM.

Group 2 is Year 2 of Testing at UM.

Figure 2: Raising awareness seems to help.

Some useful guidelines have been developed to help students do better at Internet research and investigatory work, and thus perform better in the certification test. These suggestions have been encapsulated under the subsection 'Coaching Tips'. Universities can be confident that in improving their students' critical thinking abilities, that their digital abilities on the Internet should also improve. This test should be taken by incoming freshmen and by outgoing graduating seniors to really use it as a reliable assessment tool of digital skills development in the use of the world wide web.

This test is recommended for the assessment by universities of their students' improvement in digital skills (while on the Internet) across the disciplines. The tests are used by universities to help convince university accreditation bodies like Southern Association of Colleges and Schools (SACS) in the U.S.A.

5. CONCLUSION

The critical thinking certification test described here is recommended for universities within the U.S.A. and elsewhere around the world, as an effective way for universities to evaluate the improvement of their students across various disciplines in their ability to think critically while using the computer and the Internet. It is a useful assessment test employed by universities to convince their accreditation authorities.

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Received on 21-01-2015 Accepted on 17-02-2015 Published on 30-06-2015

DOI: http://dx.doi.org/10.15377/2409-9848.2015.02.01.1

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