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# The Journal of Technology Studies



A refereed publication of *Epsilon Pi Tau* The International Honor Society for Professions in Technology.

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## Articles

# Russia Develops Educational Standards for Higher Vocational Training in the Technology and Entrepreneurship Specialty

A. A. Karatchev and N. N. Lavrov

*This article may not bring the reader to a sense of closure, or a conclusion as to what will happen in Russian vocational education. It does offer insight into what Russian educators are facing on a daily basis as they try and find and pursue the best course of action as they attempt to create a curriculum that will address the major needs of Russian society now and in the immediate future. This article may make more impact on our readers if they knew that the average salary that a Russian university professor makes is equal to one U.S. dollar a day, or that most schools either have no computers or ones that can only run DOS programs, or that Internet access is still a dream of the future for most Russian students and professionals.*

This article presents issues related to training teachers of technology and entrepreneurship in Russia's higher educational establishments, that is, those who will actually represent in 1<sup>st</sup> to 11<sup>th</sup> forms of Russia's general schools technological units, assigned to the technology educational field.

Technology, as a part of general education, ensures that the school children acquire technological competence, being in tandem with skills to master diversified means and ways to transform and transfer materials, energy, and data; to estimate the economy's efficiency and possible environmental implications of technological activity; and to set up their own course for life and career. It facilitates building up general skills and habits of work, simultaneously develops creativity, and enables the tackling of practical problems. In the system of general education, technology is aimed so that the school children are able to:

- Form technological knowledge and skills as the basis for successful creative and developing activity.
- Acquire inner need and deferential treatment of work and its products.
- Acquaint themselves with different types of vocational activity and contribute

to their career self-determination.

- Reveal and develop creativity; build up and widen their cognitive interest.
- Form their working, graphical, business, ecological, informative, ethic, and esthetic culture.
- Enjoy every opportunity for self-actualization, self-assertion, and socialization.

Used to this effect, technology concurs to develop wholeness of one's personality, harmonically combining inner need for both physical and mental work, continuous self-education, and self-development.

In Russia, teachers of technology are being trained in 69 pedagogical universities at the faculties of technology and entrepreneurship. Their training, in respect to future pedagogical specialty, is governed by the State Educational Standard for Higher Vocational Training (SESHVT). To educate a teacher, SESHVT includes the following sections:

- General humanitarian and socioeconomical disciplines (philosophy, history, sociology, economy, etc.) – 1,500 hr.
- General mathematical and natural-science disciplines (higher mathematics, physics, chemistry, etc.) – 1,000 hr.
- General vocational disciplines (pedagogy, psychology, teaching methodology, etc.) – 1,600 hr.
- Disciplines of subject training (engineering science, electro-radio engineering, technological practical training, information technologies, marketing, management, etc.) – 4,334 hr., including 900 hr. taken by disciplines referred to as a specialization.

In addition, there are standards developed to acquire both basic and optional specialties.

When, in 2000, the Ministry of Education of the Russian Federation adopted SESHVT for the second generation, it actually meant reviewing the achievements and starting a new essential stage of theoretical and practical work in the



field. Its results, worded in the respective standard regulations, teaching and methodological documentations, that is, curricula, educational programs, textbooks, training aids, methodological recommendations, etc., shall govern training of a specialist-teacher in the near future. Now within the university level, where the powers have been delegated, the issue of SESHVT's unambiguous interpretation has definitely become of prime importance. In view of this we, as the authors of SESHVT on the technology and entrepreneurship specialty, would like to dwell on certain conceptual notions, actually the staple of standard's development and application.

Presently, there is no uniformity among Russia's analysts in regard to how to treat issues of higher education standardization. And, standardization of higher pedagogical education as a subsystem of the general higher vocational education is definitely not an exception. In our opinion, SESHVT, specifying general parameters and requirements to train a specialist-teacher, can be considered as a methodological foundation for functioning and developing the respective educational system. That is why, taking a teacher of technology and entrepreneurship training as an example, we have been governed by the absolute importance, necessity, and expedience to draw up a federal regulatory document in view of the:

1. Insistent need to preserve education uniformity and, consequently, to ensure similarity of educational programs applied by Russia's pedagogical universities concerning their aims, objectives, requirements, and results of training a specialist-teacher.
2. Strategic significance to legislatively support academic freedom of universities, related to their self-independence in forming the whole package of documents to determine the respective educational program.

It is worth pointing out that practical implementation of the first requirement should in no way imply the absolute uniformity of university educational programs identical training of teachers based on previous years' common curricula. Equally, meeting the second requirement will

not justify unlimited educational freedom of the 90s. In other words, we regard the state standard as some sort of controller to maintain the required data balance, theoretically exclusive concepts, which dialectical uniformity makes it possible to establish a functioning system of democratic education.

We believe, and have used this as conceptual footing to develop the standard, that in the foreseeable future Russia's higher pedagogical education should be primarily oriented toward university education of a degree-holder specialist. This assumption has not been inspired by conservatism, the fashion of today; it has actually resulted from tough-minded and thorough analysis of Russia's education system. To a certain extent, such a classical introduction of the issue might seem too evident, so we would like to pinpoint that not only does it correspond to the traditional system of education in Russia and meet requirements of the general school, but it also forms a natural basis to modernize the entire system.

Moreover, the above-stated assumption implies our answer to the question concerning the least required educational level for a teacher to effect technological education in the school. The law of the Russian Federation on Higher Vocational Education stipulates three stages of education each of which should be sufficient to confer a certain degree or qualification to a university graduate. What we are driving at is a bachelor's degree (qualification), degree-holder specialist qualification, and a master's degree (qualification).

Unfortunately, the law does not differentiate between a bachelor's or master's qualification and degree. Nor does it comprehensively specify whether bachelors and masters are to be simultaneously educated for a degree and qualification. These abstrusities complicate the practical implementation of law-stipulated patterns of education, where diversity should theoretically enable a graduate to individually set up his or her educational trajectory. Not only, and it is its major advantage, can he or she pass "stages" in a strictly limited one-way direction, but he or she as well can get out of, or even alter direction within, a unit of the educational trajectory.

As it is, these patterns are far from being entirely realized in all spheres of professional activity due to the unequal demands required of graduates, determined by the peculiarities of their respective field. Quite often it results in system contradictions, solved only by generalizing further practical experience. To illustrate this point, let's analyze as an example the place of a "teacher-bachelor" in general education. In Russia, a school "discipline teacher" is assigned to the main subject; traditionally the position is taken by a specialist-teacher, holding a degree corresponding to the particular discipline. Other appointments, requiring lower qualification such as tutors, assistant-teachers, etc., are simply not available in Russia's modern school system. Qualified bachelors "added" to a specialist-teacher at Russia's schools will drastically imbalance the latter. Teachers with different professional backgrounds could apply for similar positions. But, equal professional duties evidently presuppose equal qualification.

Therefore, it seems justified to acknowledge that there is no need for graduate teachers with a bachelor qualification. Otherwise, mere admission of a bachelor-teacher to a school might threaten training of the more "expensive" specialist-teacher, with similar academic, but considerably higher, professional level. This would lead to a trivial reduction in teachers' educational qualifications and the subsequent general decline in Russia's entire educational system.

The approach mentioned above should not be considered as an attempt to generally abandon training of the bachelor-teacher. If a bachelor's training ends with granting him or her only a degree, it will not result in the above contradiction. In fact, a bachelor's degree will confirm the level of academic training, enabling the graduate to choose ways and forms of his or her further activity. It will be up to him or her whether to go on with his or her education, taking the subsequent stages, or to assume it completed and switch to any practical activity, i.e., entrepreneurship. However, professional pedagogical activity will be open, providing that the stages following the bachelor's degree are successfully mastered. So a bachelor with a degree and fundamental academic education, in terms

of the profession, is a bit "semi-finished," fit for further multitudinous "additional training" (including taken on his or her own), thus sufficiently widening his or her possible realization as a pedagogue.

Analyses carried out in respect of "a degree-holder specialist" and "a bachelor" with a preferential role of the former in higher pedagogical education can be applied to notions of "a degree holder-specialist" and "a master." A master's stage can be attained by two means: either by graduating from a bachelor's educational program or receiving a specialist's degree. A master graduate is educated to work as a teacher of a specific discipline at school, to carry out research work in the field of education, to teach at higher school within the chosen direction, etc.

In context of the present article, the key factor is the possibility for a master to conduct his or her professional activity at school. So, irrespective of any type of educational program, professionally a master should not be educated in any diminished degree from that of a respective degree-holder specialist. Nothing less than practice can provide an answer to the path of higher pedagogical education in Russia. The given considerations only justify training a degree-holder specialist as top priority in university education for a future technology teacher. Moreover, the given choice in no way limits any democratic chances to develop higher pedagogical education in the field. Naturally, a specialist level of training set up by general school requirements determines the limits used to educate a bachelor and a master of technological education; the difference is that the "upper" boarder is applied for a bachelor and the "lower" one for a master.

While developing the standard, we have faced another equally significant problem, that is, how to maintain a real level of university academic freedom when working out respective educational programs to train a teacher of technology and entrepreneurship. Currently Russia's legislation grants universities freedom to work out their own educational programs, curricula, etc. On the other side of the spectrum, the unified federal area, tendency towards simplicity

of certifying procedures, need for opportunities to change universities, etc., have resulted in availability and a recent increase in unification tendencies at higher pedagogical school management.

Formal data implementation, being a quite positive factor as a whole, specifies the hazard of shifting back to the traditional, strictly regulated pattern of educating a specialist-teacher; it questions the availability of the university (academic) freedom. In this context, the standard, due to its regulatory essence, might be considered as a perfect executive instrument. It seems worth pointing out that the preceding standards bore an air of strict unification concerning humanitarian, vocational, and pedagogical disciplines, with the universities free only to stipulate their curricula sequence with evidently low variability due to the natural logic of their subject. In developing the first generation standards, it was assumed that a thesaurus approach would constitute a democratic basis for implementation. Unfortunately, for various reasons too lengthy to discuss in this article, no significant results were obtained in the course.

Presumably, because the standardization of Russia's higher pedagogical school has not been developed enough and there are a number of mutually contradicting approaches, the problem cannot yet be unambiguously resolved. So, the authors are forced to apply largely imperative approaches. It essentially complicates the situation, because the nonavailability of the objective basis for a standard's development enables the authors to impose their subjective views. It becomes possible to introduce in the standard certain units, that match their personal preference, so disciplines might be adopted without wide appraisal. Not only is this problem quite familiar for Russia's higher pedagogical school, but it can be classified as common for enacting federal regulations. One can find a lot of examples to the effect in the former practice of working out and adopting the state standard curricula, as well as new generation standards. Presently the situation is worsened by a much too-detailed obligatory minimum act of standards used to educate a specialist, as well as by the simplified order to adopt the standards.

Traditionally, one solution to the given problem has been to facilitate a certain time budget. This provides for studying the disciplines of the regional component and the disciplines chosen by a university; as a whole it equals to 20% of a student's total general education. In our opinion, the given measure, though necessary for vocational education variability, fails to overcome the influence of the negative factors under discussion. At best we can only claim a reduction in their impact.

We believe that the necessary thing to maximally democratize specialist-teacher's training at the university is the discipline's maximum integrity, stipulated by the standard obligatory minimum and by the model federal curricula. On the one hand, it ensures a common federal approach towards curricula; on the other hand, universities are granted the opportunity to develop their own structure of the respective educational courses.

The offered approach has been used to develop the structural pattern to train teachers of technology and entrepreneurship in respect to their subject. In general, the principal structure used in the former standard has been preserved, stipulating a student's training on cycles of general technical, technological, entrepreneurship, creative, design, and other disciplines. This approach corresponds to Russia's experience in educating teachers of technology and is continuously justified by pedagogical practice. Ambiguity of specific subject training for teachers of technology and entrepreneurship is largely determined by introducing federally mandated courses, namely, Applied Mechanics, Engineering Science, Info-Technology, Electro-Radio Engineering, Graphics, Fundamental Entrepreneurship, Fundamental Designing Disciplines, and Technological Practical Training. Amounting to 59% of a subject's training to become a teacher, the disciplines predetermine uniformity of the respective curricula. Simultaneously, they do not violate academic freedom of teaching because their interactivity ensures a wide range of their individual fulfillment within a certain university.

Finally, the last, but not the least essential, issue reflected in the standard is the necessity

of considering the peculiarities of Russian technological education. We mean separate training in engineering, housekeeping, farm-industry production, etc. Each direction can be pursued in variants depending on regional conditions and requirements, state of the teaching and material resources of educational institutions, wishes of the school children and their parents, etc. The mentioned multi-discipline (and multi-aspect) essence of technological training is complicated, over and over again, by the need to follow the federal requirement of uniformity towards acquiring minimum general technological knowledge and skills by the school children.

These peculiarities of technology have been envisaged in the standard by structural organization of the Subject's Training Disciplines unit, where the so-called "Disciplines of Specialization" are introduced. The required invariant constituent concerning the professional aptitude of the future teacher of technology and entrepreneurship is ensured by the above federal integrative disciplines, being basic to further education. The Disciplines of Specialization, multi-variant by their essence, lay down the guidelines for the in-depth professional specialization of a teacher to be, that is, a person capable of fulfilling this or that variant of technology.

As compared to the first generation standard, the new standard somewhat increases the time allocated for disciplines of specialization

up to 900 hours (amounting to 21% of the subject's training time, though even this may seem insufficient). Should it happen, we think it is worthwhile to refer to the standard in part, allowing for the use of time stipulated for the regional component as well as the so-called chosen disciplines (amounting to 20% of the subject's training) required to enlarge specialization disciplines.

By developing the new standard the authors didn't manage to realize all the ideas stated in some of their latest articles and submissions in Russian professional press (Karatchev & Kaplin, 2000; Karatchev & Lavrov, 2000; Karatchev & Yakobson, 2001; Lavrov, 1999, 2000). The main cause of it was the necessity of providing quite a high level of the uniformity of the standards for various pedagogical specialties. Notwithstanding this, we still hope that a new educational standard on the technology and entrepreneurship specialty shall make it possible to enhance training of specialists in Russia's pedagogical universities.

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## The Law and Technologists: Implications for the Technology Curriculum

Joan Forret

A general theme of technology education posits that participation in technology studies will result in outcomes and (hopefully) benefits for the wider society. Such an expectation is reflected in the New Zealand Technology Curriculum document where the aim of technology education includes enabling students "to achieve technological literacy through the development of: understanding and awareness of the relationship between technology and society." Although technology studies has developed as a distinct curriculum area in many countries, it is important to recognize that technology is not recognized as such by many of those in decision-making roles within our various societies. While educators have attempted to identify technology as a separate endeavor and knowledge system from science (Layton, 1993), that distinction is not necessarily perceived by those who may be very influential in making decisions that have important legal, economic, and social consequences. Research into the views of legal decision makers concerning science and scientific evidence has revealed a very wide spectrum of understanding and expectations of expert witnesses. Judges not only interpret expert technical opinion evidence differently from those within the expert community, they also interpret that evidence differently from each other. In addition, judges and other lay decision makers have various expectations of

the expertise and credibility of expert witnesses, and those expectations need to be met to ensure that appropriate consideration is given to their evidence. Technologists give crucial engineering, biochemical, and environmental opinion testimony that can have implications for the suitability of projects involving vast capital investment and the potential for serious environmental, social, and economic effects. Technologists also give evidence in criminal proceedings, and the credibility of that testimony will often be the difference between a guilty or not guilty verdict. Regardless of the type of legal system or social structure within a community, legal decision making will involve inquiry and an increasing reliance on expert opinion. Thus, it is crucial that in any program of technology education, lay perceptions and misconceptions are anticipated and accommodated so that technologists are taught how to effectively communicate their work and the importance of that communication as an aspect of the integration of technology into society (Jones, 1997).

### Research with the New Zealand Environment Court

In New Zealand the environment court hears all appeals from decisions made by local authorities under the provisions of the Resource Management Act 1991 (RMA). This act

provides that all local authorities must have planning documents that cover the management of natural resources. Any activity that is not expressly permitted by such a planning document must be authorized by a resource consent. Thus, the court hears a lot of appeals arising from the proposed contents of local authority planning documents and also from those aggrieved at the grant or refusal to grant a resource consent. The subject of appeals varies greatly and can range from relatively minor land use matters, such as approvals for a residential subdivision, to consideration of applications for marine farming or multimillion dollar mining developments that may involve serious environmental and engineering considerations. A failure by an expert witness to effectively communicate his or her opinion on any of the matters significant to a particular proposal may result in the failure of the project at a vast cost to the applicant or, conversely, the failure to prevent a project at a vast cost to the environment itself and also to the wider community.<sup>1</sup> (See also Ayd & Troeger, 1999.)

For most hearings that involve the presentation of scientific or technical evidence, the court sits as a panel of three members, comprising an environment judge and two environment commissioners. The judge is legally qualified; however, the environment commissioners come from a range of backgrounds. The RMA requires that the court has a mix of knowledge and experience including commercial, local government and community affairs, resource management, environmental science and engineering, surveying and mining, and cultural issues relevant to Maori being the indigenous people of New Zealand.

In order to canvass the views of the court regarding the role of science and scientific witnesses, I interviewed all eight judges and 13 of the 17 commissioners.<sup>2</sup>

## Classification of Expert Evidence

### *Technical Expertise*

Interview results show that the court could be divided into three unequal groups concerning their understanding of the nature of science. The largest group described science and scientific evidence to include the traditional physical sciences and technology in a wide range of forms, under a general umbrella of technical expert evidence. This group attributed all types of technical evidence to a general category of scientific evidence, including medicine and all aspects of engineering evidence. Many in this group, which comprised four judges and five commissioners, perceived the uniting concept of science to be the empirical basis of data.

Another theme within this technical expertise group was the notion of a methodological basis for the evidence. For example, when one judge who included engineering and medicine under the umbrella of science was asked about his categorization of sociological evidence, he answered affirmatively because “they are giving opinions based on analyses...conducted in, well what I would hope, would be...using the scientific method.”

His understanding of scientific method was further described as “the principle of, and gaining systematic formulation of knowledge and in a way that can be tested, tested by replication, I think.”

Another member of this group (a commissioner) described the features of pure science as “incontrovertible proof and by incontrovertible, the only proof that’s incontrovertible is proof that can be repeated and repeated and repeated and you come up with the same answer. Reproducibility of result. That’s pure science.” This interviewee had previously indicated that precise technical evidence could be categorized as scientific; however, she described the social sciences as “garbage” due to their “inexactness.”

<sup>1</sup> The approval of an application by the government to build a high dam at Clyde, which resulted in the flooding of a fertile valley in intensive horticultural production in the South Island in the 1980s, is such an example. The proposal was vigorously opposed at the time and has since been identified as contributing a significant cost to the country as the result of continued engineering expenses and debt burdens, and the extra hydro electricity produced is not ever expected to balance those costs.

<sup>2</sup> In order to maintain confidentiality, I have coded all of the interviewees as judge or commissioner only and my research findings refer to all of the judges as “he” and to all of the commissioners as “she.”

The third major theme uniting the technical expertise group concerned the nature of witnesses' qualifications. This view is well illustrated by the following comments from a commissioner in response to a question asking what makes evidence scientific: "[A] person with discipline...with academic skills and training, qualifications...of a scientific background. ...they have got to have a scientific training, academically, and...practiced in that field." Many of this group preferred to discuss evidence as either expert or not and treated all forms of technical evidence under the same umbrella as science.

### ***Hard Science vs. Applied Science***

The second group of six commissioners and two judges had a view that technology and technical evidence was different from what they described as "pure" or "hard" science. Most of this group had a view of "applied" versus "pure" science, although they often saw that categories, particularly within engineering, could be rather blurred depending on the evidence being presented. The following comments from a commissioner most clearly illustrate the approach of this group:

I suppose you really have to distinguish between science and applied science and medicine would have to be applied science, I would say, except for those at the vanguard of research. The same thing, engineers are applying science that somebody else has discovered for the main part.

### ***All Evidence Is Scientific***

The third group, comprising two judges and two commissioners, held the view that any expert evidence, and in fact any admissible evidence, was necessarily scientific. These interviewees answered with reference to expert, rather than scientific, evidence.

The "all evidence is scientific" group can be best illustrated by the following comments from a judge when asked if he perceived a difference between evidence and scientific evidence: "I don't quite. It's all evidence, but I think probably what you're getting at is whether it might be relevant in a certain situation." When the same interviewee was then asked what

makes expert evidence scientific, he continued: "It never addressed my mind, it would never occur to me. If what he is telling me is relevant to the case we've got before us. To me it's just evidence."

For this group the essential characteristic of the evidence presented to them, whether from a scientist, a technologist, or anyone else for that matter, was the expert nature of that evidence. This idea of expert evidence is important for technology educators. For the effective implementation of any technological development, the technologist must be able to communicate the essence of that development and persuade the relevant decision maker to invest in or approve of it. In a legal framework, that may mean that technologists will be required to proffer expert opinion evidence so that the decision maker or court can make an informed decision. Whether those outside technology education perceive technology or technologists to have a commonality of purpose or method that is different to science is not at issue. Clearly, there are a range of views and many of those prominent in decision making in our societies will have very different views from each other as well as from technology and science educators. However, within the courtroom framework there are some consistent themes that educators should address to ensure that technology students are appropriately prepared for possible future roles as experts.

### **Characteristics of a "Good" Expert Witness**

#### ***Independent Evidence***

When asked what were the characteristics of good expert witnesses there were some common themes identified by all interviewees as being essential. The most common, which was mentioned by all interviewees, was the requirement that experts, whether classified by the interviewee as a scientific expert or not, should be independent of the parties, but should proffer their opinion to the court objectively and without appearing to advocate for the instructing party in any way. Many interviewees noted that the duty of the expert is to inform the court using their own expert opinion, and the appearance of bias or advocacy was the most commonly described indicator of a "poor" witness.

The appearance of any advocacy or bias on the part of an expert witness could result in his or her evidence carrying considerably less weight, or being completely ignored.

Some interviewees also noted that while the lack of objectivity would damage an expert's credibility, the ability to concede a point would enhance that credibility. One judge described the characteristics of a good expert as follows: "A person who is prepared to concede a point. That's number one. You can pretty well pick... the expert who is going to dig his heels in and no way is he going to shift and that guy is useless..."

This reference to concession of a point was repeated by several interviewees as an indicator of an objective witness—possibly because to do so is almost antithetical to advocacy. However, and more seriously, if the worth of an expert's testimony is judged by how objective, in a non-partisan sense, the expert is, then experts should be taught how to communicate their evidence accordingly.

### **Presentation**

Another common theme among descriptions of good expert witnesses was the depth of understanding experts had for a particular situation and their ability to effectively communicate their evidence. In some situations effective communication may mean an interesting oral presentation. One commissioner commented:

...we do have some expert witnesses who...and it is not about their evidence... but they are boring and their voice is hard to listen to. ...the best ones are the ones that have a passion and they really believe in what they are on about and that is what they are presenting...and they are clear.

It was also important for the interviewees that experts were able to give their evidence in nonjargon language so as to "educate and inform the court." In some cases the interviewees preferred experts to use everyday analogies as part of their explanations and to use clear and simple diagrams and charts. This ability to clearly explain their evidence was also seen as an indicator of the expert's own knowl-

edge and understanding.

Personally, if a technical person or a scientist can't explain anything in terms that the person you are speaking to can understand, then I doubt whether they can understand it themselves, in that, they are just parroting terms that they acquired in their studies. Whereas if they really understand it they can explain, at least to an adequate extent. [Commissioner]

This ability to explain issues in language accessible to the lay members of the court does have its limitations, however. One interviewee commented that an expert should not appear to "talk down" to the members of the court or to give the impression that his or her evidence was necessarily superior to that of other experts. Likewise, the clarity and conciseness of evidence was seen by some members of the court to be relative to the type of expert. Those experts perceived to be scientific might have to give longer and more detailed evidence.

### **Qualifications**

When asked how the court measures the expertise of an expert witness, the most common response related to the expert's qualifications and also his or her list of previous publications. The importance of qualifications to some members of the court is particularly evident in the following comment from a commissioner who was describing the process for deciding between several different experts giving evidence on the same subject matter:

...we find out their commonality of agreement and where they disagree, highlight that...then you will line up the qualifications of the respective experts and that is what we go with. So if one has got an extra degree from Oxford, or something else from Cambridge, or whatever.

A judge also emphasized the importance of publications for the assessment of the credibility of scientific witnesses: "...a scientist has published papers. ...the fact that they've published papers in their curriculum vitae...is an important part of their evidence, because they have to qualify themselves as experts."



Given the scope of evidence perceived to be scientific, this latter requirement may be significant for many technical experts because they may not routinely produce articles for publication as part of their professional practice. Such witnesses would have to establish their expertise in other ways, such as giving details of their duration of professional practice or of experience with similar matters to the proceedings before the court.

### **Expectations Regarding Methodology**

When asked how expert witnesses obtained the substance of their evidence, there was no apparent pattern to the requirements for good practice. Some members strongly insisted that an expert must have personally obtained the substance of his or her evidence from measurement of data. Several commissioners commented that they had been personally admonished in court when in their earlier working lives they had appeared as expert witnesses and had proffered evidence that was not obtained under their direct supervision. Other interviewees accepted that in certain situations an expert may have sent an assistant to obtain the raw data but must have performed the analysis him or herself. This practice was commonly acknowledged in respect of acoustic engineers who may take noise measurements at intervals throughout the day and night. Some members were adamant that evidence could not be based on analysis of a literature search because the expert had no direct knowledge of the subject matter. This requirement is linked to common law rules concerning the admissibility of expert evidence, although these rules are not binding on the environment court (Freckleton & Selby, 1993). For other members, however, not only would a thorough analysis of literature be acceptable, but also an analysis of data proffered by an expert engaged by the opposing party. This diversity of expectation is worrying because there is no obvious way that a given expert could appreciate the requirements of the court regarding the expert's methodology. In addition, criticisms about methodology were not only leveled at newer experts. Sometimes very experienced experts were criticized for presenting their evidence in the same way that they had always done but with less personal involvement in the

collection of their evidence than another expert in the same field. In respect of methodology, it is clearly necessary that the court develops its own consistent policy, but that policy should be informed by the members of the various professional groups that represent scientific and technical experts. In turn, technology and science educators have a role in grounding students in sound research methods and practices and in contributing to the continuing education of those people who are outside the technology or science communities but who encounter the personnel and subject matter from those communities on a regular basis.

### **Implications for Technology Education**

The preparation and presentation of an expert opinion is an important and common aspect of the working life of many technologists. It is natural that decision makers in a range of different arenas will require expert technical advice concerning a multitude of different proposals and issues. I suggest that educators should have a role in preparing students to face a variety of situations in which their expert opinion will be under scrutiny. This view was also expressed by several members of the environment court as follows: "...the new, young planner straight from graduate school... isn't fully given to understand what is his or her role, and the failure is on the part of graduate schools." [Commissioner]

Technology education must emphasize the importance of effective communication at two different levels. First, students of technology need to recognize the importance of communication during all stages of their development. Effective communication requires recognition of the expectations of the intended audience (Nelkin, 1996). For many students of technology that audience may at times be a court of law. Although the environment court has differences in its expectations of experts, the qualities of independence, clarity, and depth of understanding were approved by all interviewees. Those qualities could easily be incorporated into technology education by encouraging students to present interactive seminars to explain their work. The notion of independent expertise could be developed by having students present interactive seminars based on each other's work. The notion of an interactive

seminar would promote the need for clarity, consistency, and depth of understanding, which were all valued qualities of expert witnesses.

At a second level, there is a role for technology educators to provide continuing education to those lay people who regularly assess information provided to them by experts. These lay people may be members of a legal forum such as the environment court or they may be members of local authorities, governmental organizations, or other decision-making bodies. While my research has focused on a relatively small court in New Zealand, it is likely that these results will be transferable to other courts and other countries. The environment court hears a lot of very technical evidence, and its specialist nature is part of the reason for a combined legal and lay composition. Thus decision-making bodies that are constituted without any specialist technical expertise are likely to be less familiar with the framework and methods of technology as a curriculum component. Most of these people will not have had the benefit of any technology education and their views will reflect their own personal educational and practical experiences. It is likely that they will use language in different ways to each other and may view the role and

experience of the experts who proffer advice quite differently from each other and from the experts. Thus, there is a role for technology educators to work with decision makers to develop appropriate criteria for assessing expert opinion evidence and to communicate the goals and methods of technology studies as distinct from science and other educational frameworks that may be familiar to those decision makers.

Modern legal decision makers regularly hear a large amount of expert evidence from a wide range of disciplines and in relation to a wide range of issues, including environmental, criminal, and commercial matters. Many of those experts proffer technical evidence that concerns aspects of design, manufacture, and use of technological developments. It will be a serious flaw in technology education if that evidence is not successfully communicated in the legal environment because of a mismatch between the expectations of decision makers with those of expert witnesses.

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# Recruitment Strategies for Industrial Technology Programs

Ron O'Meara and Mindy Carmichael

## Introduction

Today's competitive marketplace requires many colleges and universities to search for ways to maintain or increase their program enrollment numbers. One method is to focus on an enrollment management program with an emphasis placed on retention efforts for existing students. Although this is one important issue facing many colleges and universities, it is not the only method for maintaining or enhancing enrollment figures. The need is to focus on both retention efforts as well as the recruitment of prospective students to provide the foundation to build enrollment numbers.

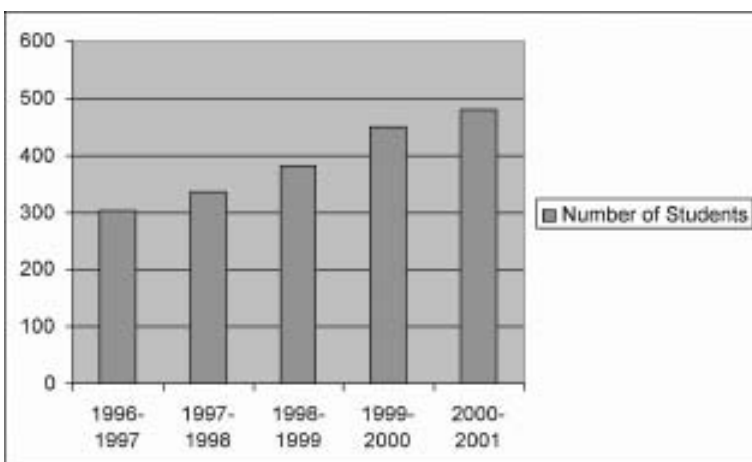
Competition in starting salaries of graduates from business and/or engineering programs can make it challenging to recruit students into industrial technology programs. Further, it is predicted that as technology continues changing at a rapid pace the new jobs created will require additional education (Brandon, 1997). Coupled with this are projections of a shrinking labor supply and increased competition among educators for their respective programs. The interest in the field of industrial technology is evident, but it is imperative to make students aware of both industrial technology programs and career opportunities. Educators need to be proactive in recruiting students to meet society's increasing employment needs and for maintaining or strengthening their enrollment numbers and even more so ensure the quality of the students.

In order to meet the challenging demands of student recruitment, industrial technology educators must leverage their recruitment strategies that specifically highlight industrial technology disciplines. The general focus of this article is to share a broad overview of several recruitment strategies that have proven effective at a regional university located in the Midwest.

## Departmental Enrollment

Enrollment in the Department of Industrial Technology at the University of Northern Iowa has increased at a steady rate over a five-year period. With a growth of 62.7% in five years, the department has gone from 295 majors in 1996 to 480 majors in 2001 (see Figure 1). With 97% of the 13,533 students enrolled in the university coming from Iowa high schools and community colleges, the enrollment increase is due in part to recruiting efforts from these educational institutions. A strategic recruitment plan was designed to generate students and gradually increase enrollment over a five-year period. The strategic plan was successful, and the increase in enrollment resulted from four different reasons: (a) an increasing number of incoming freshmen to the university, (b) transfer students from two-year programs, (c) an on-going recruitment effort by a full-time recruitment coordinator, and (d) the efforts of faculty, staff, and current students.

**Figure 1. Enrollment increases in Department of Industrial Technology at University of Northern Iowa.**



According to Zargari, Devier, and Schumm (1999), comprehensive transfer agreements between community colleges and universities need to be established to increase student enrollment. Administrators at two- and four-year institutions seeking articulation agreements can benefit through improved student retention rates and cost savings (McDuffie & Stevenson, 1995; Wattenbarger & Witt, 1995). One of the most important reasons for developing articulation agreements is to improve access by giving students more options and smoothed pathways to achieving degree completion (Bryant, 2001). The Department of Industrial Technology realizes the benefits of this partnership, and articulation agreements have been and will continue to be a vital asset to the enrollment increase in the department. In 1998 the Department of Industrial Technology created and approved 60 articulation agreements with Iowa community colleges. Three years later the department had a total of 317 different articulation agreements with all 15 of Iowa's community colleges. The university has a different agreement with almost every associate of applied science degree at the various community colleges in the state. In 1999, the university had a total of 1,114 transfer students with nearly 70% coming from Iowa two-year colleges (Carlson & Wyatt, 1999). Of the 1,114 transfer students, the Department of Industrial Technology had 58 students transfer into its programs in 1999-2000. Further, during the academic year 2001-2002, the number of transfer students increased to 76, and by the academic year 2003-2004, the transfer students increased to 114. The university expects to see additional increases in students transferring from Iowa community colleges as more departments generate articulation agreements for their programs.

### Enrollment Trends

To examine the enrollment trends of industrial technology programs within the state of Iowa, data contained in the *Industrial Teacher Education Directories* (Bell, 1997, 1998, 1999) were analyzed. The three-year period reviewed for this analysis is reflective of the University of Northern Iowa's departmental recruitment plan that was initiated in 1996. Edmunds (1990) established that the use of directories is germane

for quantitative analysis of such programs. The data reviewed are aggregate numbers for the state during the three respective years of the initiated marketing study. The aggregate numbers were compiled to use as a baseline for comparing the enrollment growth at the University of Northern Iowa to the growth in the industrial technology program at Iowa State University.

Based on the data reported in the *Industrial Teacher Education Directories* from 1996 to 1999, enrollment growth of industrial technology programs in Iowa experienced an increase of 11.6%. In 1997, the total number of degrees granted from four-year institutions having the degree discipline of industrial technology or technology education was 172. The number of degrees granted in 1998 was 169, and in 1999 the number increased to 192. It is important to note that these aggregate numbers represent all degrees granted in the disciplines including bachelor's, master's, and doctoral degrees.

There are limitations when using secondary data for analyzing trends in enrollment figures. However, this analysis was performed to establish a baseline for comparison of growth in industrial technology programs statewide as compared to departmental initiatives. It is worth noting that the growth in industrial technology programs appears to have occurred across all emphases within the discipline.

### Recruitment

Educational institutions have many strategies for recruiting students, but awareness of the program seems to be a key factor for industrial technology. When the department designed its recruitment plan in 1996, a vast span of recruitment programs was created to either bring students to the Department of Industrial Technology or to take industrial technology program information to them. After initial attempts in recruiting, the department focused on bringing prospective students on campus to highlight the department and programs. The plan has proven effective and enrollment has continued to increase.

One of the department's largest recruiting tools is the Industrial Technology Day. For one day each semester, the department brings in



about 125 students from Iowa's high schools and community colleges to view the department, receive program information, and gain hands-on experience. During this half-day event, students are able to see what industrial technology has to offer both from an educational and career opportunities standpoint. The sessions relate to the nine different emphasis areas to major in within the department, of which students can select three to participate in. A breakdown of student participants from a recent IT Day is shown in Figure 2. Faculty, staff, and college students coordinate the sessions and design them so the IT Day participants can view a variety of areas within the major. At the end of the day, questionnaires are given to each student for an evaluation and comments concerning the IT Day. The responses have been positive with students commenting on the benefits of the hands-on experience, viewing the labs, and being able to work directly with faculty, staff, and college students. They also appreciated working on and designing a project and having something to take home with them. This day has been an effective method in recruiting students by bringing them to campus to consider the department and learn the benefits of choosing a major area of emphasis in industrial technology.

### Survey of Impact

A multimedia recruitment survey was compiled in the spring of 1999 and sent to Iowa's 420 high schools and 17 community colleges. Guidance counselors were asked about video, CD-ROM, and Internet use by students to

acquire college and career information. When asked about videotape usage, 73% surveyed stated that their students use videos for this purpose, whereas 68% used CD-ROMs for college and career information. Internet use is the most effective tool; 96% of the counselors surveyed acknowledged this usage for their students because of easy access and availability.

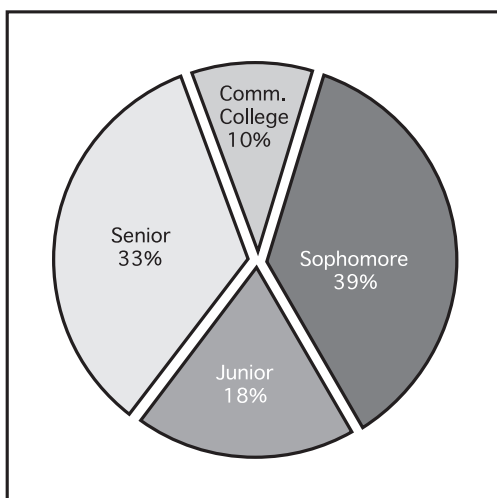
This survey helped to determine future recruitment tactics and proved the Department of Industrial Technology's hands-on method of recruiting highly effective in attaining our recruitment goals. Although schools suggested that students use the multimedia references, they still prefer to go to the college or job site for information. Before our recruitment push took place, videos were sent to requesting high schools and community colleges, but feedback was never received concerning interested students. However, when recruiting efforts started to bring students to campus, responses were positive and enrollment also increased. The multimedia survey was done to help determine if changes needed to be made on the recruitment strategy after four years or if the plan was still on track. Although the hands-on method of recruiting has been valuable, there are additional tactics utilized to strengthen the department's goal.

Scholarships are an important emphasis in our recruitment plan. The Department of Industrial Technology gives more than 35 scholarships yearly to freshman, sophomore, junior, and senior students. Many of these scholarships are full tuition and are used to recruit students and to reward current students. Other areas of importance relating to the recruitment goals are student organizations, high school outreach programs, the NAIT interactive CD-ROM, exhibitions at conferences, and advertising in magazines.

### Conclusion

There are many aspects impacting enrollment figures at the start of the 21<sup>st</sup> century. The tightening labor supply, new workplace skills, and increases in starting salaries for shortage areas influence students' choice of programs and the resulting enrollment numbers.

**Figure 2. Student breakdown for IT Day, Spring 2000.**



Enrollment figures for the state of Iowa are growing at a nominal rate within the field of industrial technology. The growth for the state during the period of this study was 14.2%. As a comparison, the growth realized at the University of Northern Iowa for the same period after implementing a strategic marketing plan was 62.7%. This increase in enrollment is a positive indicator of program viability and a strong commitment to a systematic marketing design.

To maintain existing enrollment figures and increase future enrollment numbers, educators will need to cast a wide net utilizing a cross-discipline marketing strategy. A commitment to perform continuous recruiting to provide growth

in enrollment figures and fully utilizing the resources at hand (i.e., faculty, staff, advisory boards, recent industrial technology graduates) is a key component of a successful recruitment strategy.

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## Is the Serpent Eating Its Tail? The Digital Divide and African Americans

Jacqueline Horton

The Internet is getting larger every day. Computers, through the Internet, are becoming a significant part of our everyday lives. More and more companies and organizations are using the Net to inform, educate, and entertain. As we travel the Information Highway, a growing number of the phases of our lives—identification, money, security—are being handled electronically.

The Digital Divide is alive and well in America. What this means is the technology haves and the have-nots are continually growing further apart. Due to the pace of change in the field of computer technology, this divide widens faster in less time. Playing catch-up becomes an increasingly more difficult game to endure, with the government, public, and private sectors trying to invent ways to level the playing field. However, according to the U.S. Commerce Department's National Telecommunications and Information Administration's (NTIA, 1999) paper "Falling Through the Net III: Defining the Digital Divide," many of those who are left behind (Blacks, Hispanics, Native Americans, those with education below the high school level, single parent families, those with income less than \$25,000/year) are trying to catch up themselves by accessing computers in community centers and libraries. Since parties on one end of the Digital Divide are using computers to get themselves to the other end, why aren't more online?

The purpose of this study is to look at racial overtones to Internet access. It is assumed that it is important to have both computer and Internet access to compete in both school and work. By looking at how the Web is being used, ways can be suggested to make computer access

easier and more convenient for African Americans, thereby increasing their interest in computer technology and information.

What follows is a discussion on content and the Internet. While cost is the dominant reason for discontinuance of online service, lack of interest ("don't want it") is the number one reason for not having Internet access at home (NTIA, 1999). If individuals can't perceive the importance of an object or how it could affect their lives, they will not go out of their way to try to learn to use it, or excel at its application.

### History of the Internet

Technology can indeed act as prosthetic extension of human powers and communities. (Brook & Boal, 1995, p. vii)

Welcome to the Information Age. The Information Age began when people turned their minds from using machines to manufacture goods to using machines to process information. Productivity in the Information Age is not due to more workers or longer assembly lines but to informed teams and smarter modes of work (Carnoy, Castells, Cohen, & Cardoso, 1993).

Because the Information Age is relatively new and has spawned a tremendous rise in, particularly, scientific information, I suggest that the Information Age began in 1968 with the formation of the ARPANET (Advanced Research Projects Agency - net), the Internet's predecessor (Zakon, 1993-1999), developed by the U.S. Department of Defense. The development of the ARPANET necessitated the creation of packet switching technology and the different but compatible platforms from which it would need to run consistently and reliably, important concepts on which today's Internet is based.

ARPANET and e-mail were first demonstrated publicly in 1972 (Zakon, 1993-1999). The Domain Name System (i.e., SFSU.edu) was introduced in 1984 (Zakon, 1993-1999). In 1991, the World Wide Web was introduced, and the NSFNET backbone was upgraded to T3 (44.736 mbps) and passed 10 billion packets per month (Zakon, 1993-1999). Ten billion packets at 44.736 mbps is a lot of information moving very fast.

### **A Brief History of the Effects of Technology**

In any case, for millions across the globe, there is no private phone, fax, or TV, let alone a computer or an automobile. *And there never will be.* This is not a question of progress or modernity delayed. (Brook & Boal, 1995, p. 11)

Obviously everyone is not keeping up with this increased flow of information. In 1994 the NTIA reported that while 27.1% of Whites had computers in their homes, only 10.3% of Blacks and 12.3% of Hispanics owned computers (NTIA, 1999). In 1998, four years later, the number of households with computers doubled for everyone; but in comparison with Whites, Blacks and Hispanics were even less likely to have household access to computers (46.6%, 23.2%, and 25.2%, respectively; NTIA, 1999). In fact, “Whites have more access to computers in the home than Blacks or Hispanics do from any location” (NTIA, 1999, p. xv). In 2000, 36% of Blacks had access to the Internet, in comparison to 50% of Whites who had access. While the difference between the two groups is getting smaller, it does not appear as if everyone will arrive in this Information Age at the same time (Spooner & Rainie, 2000).

Is this Digital Divide an anomaly, an unlikely case of an egalitarian product that exacerbates class struggles? Or is the Internet simply the product that affects us today, a system whose consequences are even more dramatic due to this 21<sup>st</sup> century globalization that we are experiencing? Several writers have noted that African Americans have routinely gotten the short end of the technology stick with computers and that the Internet is at the end of a long line of “firewalls” built to keep Blacks out.

One of the first major technological inventions to adversely affect African Americans was Eli Whitney's cotton gin. Whitney's gin allowed cotton to become an easy and cheap commodity.

Because more slaves were needed to aid in this new growing industry (Walton, 1999), there was a huge jump in the slave trade. The year 1865 saw the end of the Civil War and the beginning of the Reconstruction. African Americans were free technically, but being penniless and landless in an agrarian society, could not be economically or even physically emancipated. Most Blacks were uneducated after experiencing 200 years of slavery. What was the use of freedom without education? Not much. It would be akin to being given a boat with no oars. Blacks needed other avenues for growth. Slowly but surely they made gains in areas other than farming, where they had previously had the most experience.

After the Civil War, Blacks began the migration to the North. The Industrial Revolution spurred the need for many more industrial workers, and Blacks were allowed to fill the void—some in semi-skilled jobs but most in unskilled, domestic, and janitorial jobs in both the North and the South (Marshall, 1967). Automation in the late 19<sup>th</sup> century to early 20<sup>th</sup> century increased mechanization, which allowed more Blacks to be employed in jobs that previously required training and experience (Harris, 1982). Technology at this point helped Blacks in the workforce. The migration of Blacks to the North helped make up for the staunch immigrant labor pool during World War I.

The National Recovery Act of 1933 was an attack on urban poverty. This act shortened the workweek and instituted minimum wages for occupations. But instead of offering Blacks and Whites the same wage for the same work, employers classified the jobs differently, which allowed professions that were heavily worked by Blacks to be classified at a lower level or to be exempt from classification altogether (Marshall, 1967).

By the early 1940s African Americans, despite setbacks and opposition, had doubled their numbers as skilled craftsmen (Harris, 1982). The increase in the diversification of jobs continued at this time leading to a general increase in the number of African Americans employed. Unfortunately, 80% of the Black male working population still worked in jobs considered unskilled (Harris, 1982).

World War II saw further increases in the Northern migration and employment of Blacks. The number of Blacks employed in semi-skilled jobs grew, mainly because of the monies pumped



into the war effort and the drafting of White workers into the armed forces, which depleted the growing workforce (Marshall, 1967). Even so, Blacks were not given adequate chances in training programs and new jobs.

Negroes have faced a more serious unemployment problem than white workers throughout the postwar; the jobless rate for Negro workers has remained about twice that of white men and women since the early 1950s. The ratio persists at each level of educational attainment, with the differential even greater among workers with more schooling than among those with a minimal level of education. (Harris, 1982, p. 123)

In the 1960s job opportunities did not improve much for the Black male. Black gains in the 1950s were in semi-skilled jobs. However, when automation replaced semi-skilled workers in the 1960s, their employment declined to the level achieved in 1948 (Harris, 1982). Mechanical cotton pickers were used increasingly, which caused further unemployment among Blacks still living on Southern farms (Harris, 1982). Blacks were able to make gains in securing professional employment with the federal government, however. Even so, in 1961 72% of the lower ranked jobs (grades GS 1-4) were held by Blacks, while 35% of all employees were employed in those levels.

Technology increased in the 1970s and 1980s, and the economy shifted from manufacturing to low-paying and service-oriented jobs (Harris, 1982). The accompanying decline in the numbers of low-skilled manufacturing jobs did not help the standard of living for Blacks. "The socioeconomic status of Blacks was as depressed in 1980 as it had been in 1969" (Harris, 1982, p. 179).

And now in the 21<sup>st</sup> century, we have computers and the Information Age. How prepared and how well positioned is the average African American to move on the Information Highway?

### **The Digital Divide**

More than 100 million people around the world, most of whom had never heard of the Internet four years ago, now use it to do research, send e-mail to friends, make requests for bids to suppliers, and shop for cars and books. (U.S. Department of Commerce, 1998, p. 4)

While the Internet is thought to be an equalizer, it has never been thought of as a level playing field. Black entrepreneurs make the play, gaining footholds (Muhammad, 1999). Most of the Black Internet/computer users are between 24 and 48 years old and make more than \$40,000 (Hoffman & Novak, 1999). Though the numbers appear more egalitarian for Whites, they are still linked strongly to household income and education. The higher the income and education, the greater is the chance that a person will own or use a computer.

In the United States, the person who doesn't own a computer is more likely to be a person of color with little income and education. He or she will more than likely be either single or a single parent and live in the inner city or a rural area. If there were no Digital Divide, so accurate a picture of the have-not world could not be painted. But study after study shows the above to be the case.

You can't have the Digital Divide without the Digital, but is the Internet at fault? Remember that the Internet was not made for everyone to use but developed by the Department of Defense. Perhaps it has problems scaling up for general use. While technology can be seen as morally neutral, it cannot be assumed that the uses to which it is put are equally sanguine.

These uses seem to be either of no use or of no interest to most people. This creates an information disconnect, an information divide. This information divide is what is fueling the Digital Divide.

But the flight into cyberspace is motivated by some of the same fears and longings as the flight to the suburbs: it is another "white flight." (Brook & Boal, 1995, p.ix)

If the Internet is truly blind ("No one knows if you are a dog on the Internet" [Steiner, 1993, p. 61]), why isn't everyone on it equally? There are so many variables (education, income, age) to the information have-nots when you look at African Americans that it is hard to get a clear picture of what is happening and why, and what to then do about it. Let's look at the education variable for example. While this article does not focus on the effect of education on the Digital Divide, it should be noted that it mirrors the Educational Divide as it pertains to

Blacks who are, once again, on the wrong side of the line. It is no secret that Blacks and other minorities do not receive the best educations, particularly if they attend an urban school (Rist, 2000; Temple, 1998). It is the same forces at work in the Digital Divide as in the Educational Divide. Large class sizes and crumbling institutions, which characterize the urban public school to which many minority and poor students are sent, are but the physical harbingers of the differential yet lasting treatment afforded to people of color (Temple, 1998). All of these factors work together. How else do you explain the inability of Black high school dropouts to be employed at the same rate as White high school dropouts (Marshall, 1967)? There are many facets to the Black economy, and education is one of them; so is knowledge and manipulation of things digital. The idea here is to focus the issue of the Digital Divide on race in hopes that it will focus attention on all race-related items such as education and income and that the digital tide will aid in floating all such boats for African Americans.

Focusing on employment, do African Americans have jobs that do not require a computer and so are never exposed to one? Do they not go grocery shopping or use an ATM or go to the library? The sad fact is that if you are Black, you are more likely to live in an inner city, drop out of school, and earn a low income (Bolt & Crawford, 2000; Harris, 1982). So is the Digital Divide racial or is it education / income based? These items are so closely intertwined for African Americans that you cannot say either way. What we can do is take a look at what African Americans do when they are online. Perhaps this will shed some light as to why they are not online in greater numbers.

African Americans use the Net for online classes and job hunting (Hoffman & Novak, 1999; NTIA, 1999). African Americans shop online just like everyone else, but they do not search for product information as much as others (Hoffman & Novak, 1999).

So now we have a better idea, though not complete by any means, of what Blacks do online. It sounds like they know how to put the computer to good use, so why aren't they online more? Three suggestions: exposure, cost, and content.

### ***Exposure***

In 1999, Tom Joyner and Tavi Smiley threatened to sue CompUSA to get the retail giant to place ads with African American-oriented media (Associated Press, 1999; Wickham, 1999). Digital technology is not so abundant in the inner city as elsewhere. Schools are considered wired when they have one computer hooked up to the Internet; schools in wealthier areas have more computers hooked up to the Internet per student than those in poorer neighborhoods (Bolt & Crawford, 2000; Goslee, 1998).

### ***Cost***

While computers are coming down in price, it is the webTV versions that are readily available for under \$500. Otherwise, a quick perusal of newspaper ads shows most computers to be still at the \$1,000 mark (monitor not included). Computers are also a lump sum purchase, which is a large amount of money to pay all at once for an item with questionable usage and value. Then there are the monthly ISP fees to add to the expense.

### ***Content***

While there are hundreds of thousands of Web sites on the Net, there are only a few hundred of special interest to African Americans (Bolt & Crawford, 2000; Hoffman & Novak, 1999). But do you have to have Black-specific content in order to get African Americans online? Aren't they cat lovers and stock buyers and music aficionados as well? Perhaps what African Americans need in order to get on the Net is a "killer app" (a software program that drives up sales of computers)—e-mail isn't it and mp3 isn't it. What will it take to get African Americans to see that the digital life is useful for them?

Again, the three possible reasons for African American involvement on the wrong side of the Divide are exposure, cost, and content. Content will be further explored next.

### ***Content and City.net***

Despite the strong demand for labor, many workers are failing to realize the benefits of California's economic boom. (Yelin, 2000, p. 1)

There are many ways to bypass the cost issue. The U.S. government is doing its part in the reduction of the cost of computer equipment and hookups to the Internet. An E-rate

(NTIA, 1999) has been implemented that ensures discounted connection rates for schools and libraries, thus enabling more public schools to get wired. In addition, President Clinton's "Call to Action for American Education" allowed for all public schools and libraries in the U.S. to be wired for technology by the year 2000 (Novak & Hoffman, 1998). The other half of Clinton's "Call to Action" is to connect every U.S. home by 2007 (Novak & Hoffman, 1998).

Between the E-rate and the "Call to Action," most of our nation's children have access to computers. Free PCs given out by Internet service providers and subsidized PCs given out by employers presumably take care of any other cost concerns on the part of nonwired African Americans everywhere (Thierer, 2000).

What is more, computer prices are dropping. Some color TVs cost more than computers, and yet people still buy them (Thierer, 2000). Computers and other Internet technology will get steadily cheaper and cheaper until the issue of cost simply fades away.

Clinton's "Call to Action" will have every public school child exposed to the Internet. They will go home and spread the "tech-virus" to their siblings and other family members they come in contact with. Also, adults without access to children are working in places that are getting wired, exposing more adults to the technological wonders.

As more people buy computers, computer makers and retailers will have to consider seriously the untapped market of the unwired: the low-income, rural or inner-city dwelling minority. The unwired are ripe for saturated exposure through advertising.

What is more, government entities will increasingly put more information on the Internet. Therefore, people who require up-to-date knowledge of benefits, such as disability or Social Security, will find this information being put online more often in the future (U.S. Internet Council & International Technology and Trade Associates [USIC & ITTA], 2000). People will be forced to look to the Web for information that has a direct impact on their lives. In time, the exposure for African Americans will increase, slower than their ability to gain access, but it will increase all the same.

Content is the final piece of the puzzle.

Content is what will make people take their first steps onto the Internet and will make them stay online once they try it. Content is what is going to prepare America for the new "digital workforce" as described by the U.S. Department of Commerce. Increased interest will come from more significant content. Enlarged interest will reduce fear and allow Black people to take ownership of things digital (U.S. Department of Commerce, 1998).

But what content is needed to lure African Americans across the Digital Divide? As with any design problem, the best way to find out why the customer is not buying the product is to listen to the customer talk about the product. So one must either ask users directly or observe them during use (or nonuse as the case may be). This article does not contain results of interviews with African Americans nor does its author claim to have looked over the shoulders of African Americans while they used a computer or passed a computer store; that would be grist for a whole other article. However, from what has been read and researched about the Digital Divide and African American computer use, or lack thereof, I have come up with what might be an answer to the content question.

Access and exposure are good, but those two conditions do not make one computer literate. In *Newsweek* magazine, Alter (1999) stated that, in addition to having access to the Internet, people must use their creativity and initiative to get the most out of the computer. Being superficially introduced to the Internet or insufficiently exposed to software will not be enough to make one computer literate. The Digital Divide is not just about access; it is about what people do with a computer once they have one.

In *Digital Divide: Computers and Our Children's Lives* (Bolt & Crawford, 2000), B. Keith Fulton, director of Technology Programs and Policy with the National Urban League said, "In the Information Age, it is critically important to master the three basics: reading, writing and arithmetic...but also to have information literacy: the ability to access, interpret, and respond to information" (p. 114). Once again, access is important; but in our future and the future of the world, we cannot afford to leave anyone behind. Everyone should become acquainted with this information literacy. People should be unafraid to approach

technology and should have a general idea as to what can be done with it.

New studies suggest much the same thing—content is the way to get people online. The Digital Divide Network (2000), quoting the recent Stanford University (2000) study and National Public Radio (1999) study, stated that the Internet technology industry is building networks for users as consumers but not for people who want to make content themselves. The Children's Partnership's March 2000 report on online content suggested that people, in particular those with low incomes, would prefer to have local information on the Web. Items people would like to see more frequently are employment, educational opportunities, and business development prospects. The importance of producing content was also brought up by the Digital Divide Network (Lazarus & Mora, 2000; Twist, 2000). Even the U.S. Internet Council's (USIC & ITTA, 2000) "State of the Internet 2000" paper discussed the growth of "virtual communities" (p. 22). These virtual communities have local information and have grown from simple chat rooms to Web portals with news, weather, e-mail, and the like.

So even content is not a simple matter of just giving it away. People want information that is useful to them. If people don't want to go on the Internet, it is because the information is not useful and because it is hard to find and navigate. But if people make their own content, then it is as interesting and as easy to navigate as they make it (Goslee, 1998; Lenhart, 2000; National Public Radio, 1999).

My idea to closing the Digital Divide for African Americans is City.net, a portal where the residents create and edit the Web site. For example: San Francisco, California, has several different neighborhoods. Each neighborhood has its own character, its own main street, its own cultural flavor. Each neighborhood would have a Web site where each resident would have a login, e-mail if necessary, and access to the citywide portal. After being given computers, hookups, software, and training provided by a tech-savvy nonprofit, the neighborhood would have a technical town hall meeting where the design of the neighborhood's Web site would be created and decided upon. So, as an example: Chris Johnson, resident of Bayview would have an e-mail address of [cjohnson@bayview.sf.net](mailto:cjohnson@bayview.sf.net). This e-mail would allow access to Bayview's

site as well as any sf.net neighborhood's site. Chris also would be able, as a resident of [bayview.sf.net](http://bayview.sf.net), to add information to the neighborhood's site. Job availability, health risks, education opportunities in the near vicinity could all be posted on the appropriate neighborhood page. Chris could query neighbors about what classes or information they would be interested in and then they could arrange to have a class or speaker come and give a talk on that subject at the neighborhood center. The Web sites would be picture (graphic) heavy in order to make them easy to navigate and understand. The neighborhood could then have pages translated or even written in languages other than English based on the needs of the neighborhood.

How would people without much computer literacy (or whom may even be illiterate) be able to post things on City.net? Once format is developed, pages could be formatted so that adding information should be a matter of point-and-clicking or typing the information in. Important citywide announcements could then be broadcast to all residents. Federal and state information could also be given out in this way. But everyone must be involved or the City.net will not represent all of its people.

The City.net has been tested in other locales. It was documented in the Children's Partnership's *On-Line Content* (Lazarus & Mora, 2000) paper. Brooklyn, in New York, and Chicago's [www.northwest.com](http://www.northwest.com) are two examples of online community resources that base their content on the values and input of their neighborhoods (Anderson, Bikson, Law, & Mitchell, 1999; Lazarus & Mora, 2000; Schön, Sanyal, & Mitchell, 1999). While these virtual communities are like the City.net introduced above, the scale is smaller and the participation of all citizens is not as inclusive. That said, these online community resources have the capability of increasing interest in the Internet and other digital technologies for those who have been previously disenfranchised. City.net and like portals could be the "killer app" the Internet is waiting for.

In conclusion, one can hope that the Digital Divide will disappear as a result of the decrease in prices for computers and the increase in alternate methods of accessing the Internet. But content is the last key to the puzzle. Content will draw those not previously interested into the



fray. City.net, a portal that would combine home computer ownership with software training in order to have residents build a neighborhood's personalized site, is my idea to increase the African American presence on the Web.

## Conclusion

The Gartner Report on the Digital Divide (Smolenski, 2000) posited a three-stage Digital Divide in America: Stage One is lack of computer access; Stage Two is lack of experience with technology, which limits the use of important information and sites away from disadvantaged Americans; and Stage Three is lack of broadband access to the Internet. Throughout this article I have suggested three stages as well. The first stage is lack of computer access. The second stage of the Digital Divide is lack of access to the Internet (the first and second stages are sometimes addressed concurrently), and the third stage is lack of expertise. Expertise is the equivalent to Gartner's second stage of experience. However, expertise for this article not only includes experience with the Web and the Net, but with all digital things. The further development of information literacy is the reason that closing the Digital Divide is so important. The Digital Divide is not an issue simply because people do not have access to computers or the Internet; it is an issue because this lack of access breeds an unfamiliarity with the digital technology and information revolution that is so pervasive and necessary here at the turn of the century and beyond.

For African Americans the effects of this third stage of the Digital Divide is real. Blacks are less likely to have a computer in the home (NTIA, 1999). While they may be getting wired in record numbers, they are more likely to be new to computers and the Net, and therefore forever behind the experience curve (Spooner & Rainie, 2000). A whole generation will be too old for the wiring of the schools and too young to have been in the first wave of computer use. These people don't disappear. They move through their lives just a little bit behind everyone else. African Americans need a program that will jump start them and propel them quickly to the level of, if not beyond, their White and Asian counterparts. African Americans do not have time to wait for computers to get cheaper or schools to be wired or Net content to realize their worth as consumers. A program such as City.net, which would provide for training, access, and content production in a concrete package, driven by private industry and managed by nonprofits and the citizens themselves, would go a long way towards dismantling the Digital Divide.

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## Student Perceptions of Web-Based Supplemental Instruction

Steven A. Freeman and Dennis W. Field

### Introduction

Nearly every university and college in North America now has a Web presence (Saba, 1998). Approximately 70% of U.S. colleges and universities provide undergraduate applications online and nearly 77% provide their course catalogs online (The Campus Computing Project, 1999). The Internet is also changing the way in which education is delivered, and in fact, some predict that the Internet will become the dominant distribution system for distance education and training (Simonson, Smaldino, Albright, & Zvacek, 1999). Many faculty members are expanding their traditional delivery methods (lecture, laboratory, face-to-face discussion) to include educational options ranging from Web-based course supplements to the complete delivery of courses online. There are endless online choices that instructors may consider in this range, from simply posting a syllabus to creat-

ing Web-based content to enhance classroom instruction to full online delivery. In 1997-98, nearly 44% of all U.S. higher education institutions offered distance-based courses, an increase of one third since 1994-95, with most of the growth being primarily in Internet delivery (National Center for Education Statistics, 2000). The most recent Campus Computing Project (1999) survey identified that 45% of the 530 participating higher education institutions offered at least one full course online.

While the primary focus of Web-based delivery has been in the development of stand-alone Web-based distance education courses, more faculty members are beginning to use the Web to supplement and enhance on-campus instruction (e.g., Goldberg, 1997; Henson, Fridley, Pollock, & Brahler, 2002; Marks, 2002; Masten, Chen, Graulau, Kari, & Lee, 2002;

Mohtar & Engel, 2000; Patterson, 1999; Stith, 2000; Wallace & Weiner, 1998). Data collected by The Campus Computing Project (1999) revealed that 28% of higher education courses have an associated Web page compared to 9% in 1996. The authors have chosen to augment a traditional face-to-face on-campus safety course with an online supplement. This article describes the assessment process used to gauge student perceptions of this new online supplement.

### Setting the Stage

The course chosen for the online component was a new junior-level occupational safety course, *Safety in Manufacturing*, required for all industrial technology students at Iowa State University (ISU). This course covers broad topic areas in occupational safety and health from a management or supervisory role in a manufacturing setting. The Web-based supplement, developed using WebCT (see <http://www.webct.com/> for information on WebCT) consisted of outline notes for all course topics, online quizzes, a variety of communication tools, and access to course grades. The course calendar is used to keep students apprised of daily topics, reading assignments, field trips, and due dates for homework and projects. There is a main bulletin board that everyone in the class may access and private bulletin boards that are assigned to each base group to facilitate within-group interaction. WebCT allows students to forward their WebCT e-mail to a different e-mail address should they prefer to receive all of their e-mail at one address. In addition to the communication tools, WebCT was also used to post student grades so that students could access their current grade at any time. This online supplement was initiated the first time this course was offered during the Fall 1999 semester. Freeman and Embleton (2000) provide a more detailed description of the course, the online supplement, and WebCT.

### Methods

To gauge the reaction of students to the WebCT supplement for *Safety in Manufacturing*, a student survey instrument was administered. The survey was adapted from work done by the University of Missouri's WebCT Support Team (1999) to meet the authors' needs and address the specific WebCT components implemented. The questionnaire consisted of 13 questions divided into two sections. The first section addressed students'

previous experience with Web-based courses, computer competency, how often and from where they accessed the online supplement, and any problems they encountered. The second section addressed their perceptions of the online supplement. The questionnaire was pilot tested at the end of the Fall 1999 semester with the 34 students enrolled in the course. The questionnaire was distributed with student course evaluations. The completed questionnaires were returned anonymously. The primary purpose of the pilot study was to assess the clarity of the instructions and the usefulness of responses to the questions as written.

Several questions were changed to clarify issues identified during the pilot study. Additional questions were also added to address components of the supplement that were not yet implemented during the first semester (e.g., starting in the second semester, students were required to take an online quiz prior to each class meeting) and to more specifically identify those components of the supplement that the students found useful. In its revised form, the questionnaire consisted of 18 questions and the opportunity to provide additional comments. The questionnaire was administered at the end of each of the following semesters: Spring 2000, Fall 2000, Spring 2001, Fall 2001, Spring 2002, and Fall 2002. Participant responses were anonymous.

Participants completed the questionnaire using pen or pencil. The responses were then archived by coding them into a spreadsheet. Each semester, descriptive statistics of the student perceptions were analyzed as part of the process of preparing the course for the next semester. The data were transferred from the spreadsheet database to a statistical software package for the analysis presented here.

### Limitations of This Methodology

As with any self-reported survey, it is typically not possible to verify if the students completed the questionnaire accurately, or honestly. Pilot testing the questionnaire, which indicated that the questions were sufficiently comprehensible to allow the students to answer accurately, reduced some of the potential impact of this limitation. The question of honesty is harder to address. However, the responses were anonymous, had no impact on the students' grades, and were prefaced with a discussion of the need for honest feedback to improve the use of the WebCT supplement for future semesters.



## Results

During the six semesters of this study, 210 students completed this course. A total of 178 students completed the questionnaire for an overall response rate of 85%. During these six semesters, the class size ranged from 19 to 47. The response rate ranged from 70.2% to 100%. During the Spring 2000 semester, this class was the first Web-based course experience for over 76% of the respondents. The majority of the students for the next two semesters also had no previous Web-based course experience. Then starting with the Fall 2001 semester, the trend shifted in the other direction, and by the Fall 2002 semester, nearly 92% of the students had previous Web-based course experience. This clear demarcation between the percentage of students who had Web-based course experiences the first three semesters versus the last three semesters provided a natural split that was used in subsequent analyses.

The class met face-to-face twice per week, and in every semester over 90% of the respondents indicated that they accessed the course Web site two or more times per week. The locations from which students accessed WebCT most often were the departmental computer labs and their places of residence. However, the location used most frequently changed from the departmental computer lab (59% in Spring 2000) to the student's house or apartment (69% by Fall 2002). Again, a natural split existed between the first three semesters and the last three semesters. During the first three semesters, over half of the respondents (59%, 59%, and 54%, respectively) used the departmental computer labs as their primary location for accessing WebCT. During the last three semesters, 50% or more of the respondents (55%, 50%, and 69%, respectively) indicated that they most often accessed WebCT from their residence. It should also be noted that significant construction of "Internet ready" student housing was opening up during this time.

When ranking their computing and information technology proficiency on a scale from 1 = *novice* to 5 = *expert*, the industrial technology students responding considered themselves to be competent computer users with 86% giving themselves a rank of 3 or better in Spring 2000 and 100% giving themselves a rank of 3 or better in Fall 2002. As expected, they were able to quickly master the WebCT environment and indicated very few problems interacting with

WebCT. The most common problem during the first three semesters was logging in during the first two weeks of class (24%) and slow response time during the last three semesters (49%).

The WebCT course components considered most useful by the students were the course notes, access to grade information, and the online quizzes. Nearly all (99%) of the students who had previous Web-based course experiences indicated that they preferred this WebCT course to those used in the past. More than 90% of these students indicated that the online notes and quizzes helped them prepare for class. Similarly, 89% indicated that the WebCT component was valuable and improved their learning experience and 92% indicated that they were satisfied with their WebCT experience. The last question on the survey asked if they would prefer a class with a WebCT component to one without such a component, given a choice. Ninety-six percent indicated that they would prefer a class with a WebCT component.

## Correlations and Comparisons

The primary purpose of this study was to gauge student perceptions of their experience with the WebCT supplement to *Safety in Manufacturing* to help guide continuing development and use of the online supplement in future semesters. In addition, this study also explored potential differences between student subgroups based on (a) their self-reported computer competency, (b) the components of the supplement they considered useful, and (c) their perceptions of their WebCT experiences. All correlations where a significant ( $\alpha = 0.05$ ) difference between students was found in three or more semesters are presented below. The importance and/or implications of these findings are discussed in the next section.

In all but the first semester, students who indicated that the WebCT component was valuable and improved their learning experience were more likely to consider the WebCT quizzes helpful in preparing for class [the corresponding correlation and  $p$  values in parentheses for Fall 2000 through Fall 2002 were .632 (.000), .836 (.000), .525 (.002), .649 (.000), and .406 (.024)] and were more likely to be satisfied with their overall WebCT experience [the corresponding correlation and  $p$  values in parentheses for Fall 2000 through Fall 2002 were .561 (.002), .561 (.001), .788 (.000), .818 (.000), and .612



(.000)]. In four semesters, students who ranked their computer competency higher were also less likely to think that they spent too much time learning WebCT [the corresponding correlation and  $p$  values in parentheses were Spring 2000, .492 (.045); Fall 2000, .499 (.006); Fall 2001, .377 (.037); and Fall 2002, .461 (.009)]. Students who considered the WebCT course notes helpful in preparing for class were more likely to be satisfied with their overall WebCT experience in four of the six semesters [the corresponding correlation and  $p$  values in parentheses were Spring 2000, .553 (.021); Fall 2000, .707 (.000); Spring 2001, .502 (.003); and Spring 2002, .517 (.002)]. During the last four semesters, students who considered the WebCT quizzes helpful in preparing for class were also more likely to agree that access to their grade information prompted them to take action [the corresponding correlation and  $p$  values in parentheses were Spring 2001, .349 (.047); Fall 2001, .429 (.018); Spring 2002, .358 (.044); and Fall 2002, .427 (.017)].

In three of the six semesters, students who considered that the WebCT component was valuable and improved their learning experience were also more likely to consider it important to have experience using the latest technology applied to their discipline. During three semesters the students who considered the WebCT notes helpful in preparing for class were more likely to indicate that the notes also facilitated note taking in class. Also during three semesters the students who considered the WebCT notes helpful in preparing for class were more likely to indicate that the WebCT quizzes were helpful in preparing for class. Finally, students who indicated that the quizzes were a useful component of the WebCT course were more likely to indicate that the quizzes helped them prepare for class.

### Discussion

Less than 25% of the students enrolled in *Safety in Manufacturing* during the Spring 2000 semester had any previous experience with courses that utilized a Web site. While serious efforts are underway across the country to increase Web-based delivery of educational content, the early focus was on using the Web for complete online delivery—distance education. It was not surprising that relatively few resident students, even in a technology discipline, had been exposed to online components in their courses. Although underutilized at the time,

research was available documenting that students who received a combination of face-to-face instruction with a Web supplement performed better than their counterparts who received only traditional or only Web-based instruction and were much more satisfied with their learning experience (Goldberg, 1997, 2000). This may be particularly true for industrial technology students who are already competent computer users and, as the results confirmed, were able to quickly pick up the intricacies of online delivery even without previous experience. However, WebCT was becoming the standard Web-based instructional platform at ISU and its use across campus was expanding. By Fall 2001 over 60% of the students in *Safety in Manufacturing* had previous experience with a course that utilized a Web site. A year later over 90% of the student respondents had previous Web-based educational experiences. Since they were on-campus students, the majority of these experiences were likely to be Web-based supplements to traditional course delivery methods. It is clear that Web-based components are now common across the campus and in the industrial technology curriculum. It is also noteworthy that as the reliance on Web-based components increased (both through the number of previous courses and the number of access times per week) the students were more likely to utilize access from their residence than from departmental computer labs. However, the fact that more students were accessing their Web-based courses from off campus is likely the reason that more students complained of slow network response time in later semesters.

The three components of the online supplement—course notes, grade information, and quizzes—that were considered the most useful were the components that were used most often. The students did not have a choice in using the online quizzes. They were required to take a preparation quiz prior to each class on the topic to be discussed that day. Each quiz was available for the 48 hours prior to the start of the class covering that topic. The online notes were used by students to help prepare for the quizzes and to facilitate note taking in class. Although it was not encouraged or discouraged in any way, it was observed that by the second week of each semester the majority of the students were printing out the online notes and bringing them to class. These results were corroborated in that

more than 90% of the students agreed that the course notes and quizzes helped them prepare for class. Grades were not posted in hard copy or handed out in class. Instead, updated student grades were posted to WebCT. Since the students were accessing the WebCT component on a routine basis, they developed the habit of checking their grades frequently and letting the instructor know if grades were not accessible within a day of handing in assignments. Information that was accessible to the students included grades for all assignments, current data on overall percentage, class rank, and current letter grade. Having access to current grades at any time also received positive comments in the student course evaluations.

The other three major components of the supplement—bulletin board, calendar, and e-mail—received less enthusiasm. The bulletin board was used to provide general course announcements and provide private feedback to each group concerning group assignments and projects. During the first three semesters, homework assignments were posted to the bulletin board. However, during the last three semesters, the homework assignments were provided in the “Class Resources” section of the WebCT supplement. This seems to have affected the perceived usefulness of the bulletin boards as the ratings dropped more than 10% during the last three semesters. The calendar was probably not deemed as useful as some other components since it duplicated information that was provided in the syllabus; the syllabus was quite detailed and few changes were made to the schedule during the semester. The fact that few of the students considered WebCT e-mail to be useful is explained by the variety of responses to the question on whether they preferred to have the course-related e-mail separate from their personal e-mail. The vast majority of the students already had an e-mail account that they were actively using. The account they used most often was the one they tended to use to communicate with their group members and the instructor. WebCT allows students to forward their WebCT e-mail to a different e-mail address should they prefer to receive all of their e-mail at one address; however, it does not allow other e-mail to be forwarded to WebCT e-mail. Thus, students who wanted only a single e-mail system used one outside WebCT as their primary means of communication with other students and the instructor.

It should be expected that students who believed that the WebCT supplement was valuable and improved their learning were the most satisfied with their overall WebCT experience. If students considered the WebCT quizzes to be useful, it is logical for these same students to use the quizzes to help them prepare for class. If they were using the online notes to prepare for the quizzes, it follows that they would also consider the notes useful in preparing for class. It is therefore not surprising that the students who considered the Web-based supplement to be valuable also considered the quizzes to be helpful in preparing for class. As previously mentioned, the industrial technology students were already competent computer users and were thus able to quickly learn WebCT. It follows that the more competent their computer skills, the less likely they were to perceive learning WebCT as a time burden. What is encouraging is that only two students (of the 173 who responded to that particular question), regardless of previous experience or computer competency, indicated that learning and interacting with the WebCT supplement was a problem. In addition, it seems natural to expect that students who found the online notes useful while preparing for class would use the notes in class to facilitate their own note taking. Since the online notes helped them learn the material, it was expected that those who found the online notes useful would be the most satisfied with their overall WebCT experience. Although students’ response to the online notes is rewarding to the authors, an obvious goal for future semesters is to continue to improve the online notes until all the students find them useful and strongly agree that they help in class preparation.

A positive correlation existed between considering the quizzes to be useful in preparing for class and agreeing that access to grade information prompted them to seek assistance from the instructor or other group members. It may simply be that these students were more proactive in their learning and that the quizzes and seeking assistance from others were both viewed as active measures in learning the material. In addition, a positive correlation existed between regarding the WebCT component as valuable and considering it important to have experience using the latest technology applied to their discipline. This is probably due to the fact that the industrial technology students are competent

computer users and consider Web-based instruction as a “technology” process.

### Conclusions and Recommendations

Based on work to date and the results of this study, the following conclusions were drawn:

- Industrial technology students at ISU were already prepared and capable of learning WebCT as a supplement to classroom instruction quickly, regardless of previous experience in using Web-based courses or course components.
- Students appreciated the Web-based supplement to *Safety in Manufacturing* and considered it to be a useful and valuable component to the overall delivery of the course material.
- Students considered the online notes and quizzes particularly helpful to their overall experience in *Safety in Manufacturing*.
- Students considered the access to grade information to be a useful component of the WebCT supplement.
- Students accessed the Web-based material from where they had easy access to the Web—departmental computer labs or personal computers at their place of residence.

The authors believe there are opportunities for faculty members to enhance and improve the educational experience for on-campus students through the use of online course components and encourage all instructors to begin to explore these opportunities. Based on the findings of this project, the following recommendations are suggested for further inquiry:

- Studies need to be conducted to explore the relationships between student perceptions and educational outcomes (e.g., here it was found that students perceived that the online quizzes and notes helped

prepare them for class, but the anonymous nature of the questionnaire did not allow for an exploration of whether the use of these online components resulted in improved class performance).

- Studies need to be conducted to evaluate the use of specific online components (e.g., Why did some students put more value on the online notes? How were they using them? How could they be improved? Were students that valued them using them differently than students who placed lower value on them?).
- Similar studies need to be conducted with other types of courses to determine if student perceptions are consistent across technology curricula. The findings of such studies, if tied to student outcomes, may suggest broad-based curricula reform for on-campus technology courses.

In addition to the recommendations above, industrial technology faculty should also consider whether the lessons learned here and in future studies can be applied to asynchronous delivery of hands-on technology curricula that forms the basis of on-campus technology education.

Readers interested in details of this study in tabular form may contact the authors at [sfreeman@iasstate.edu](mailto:sfreeman@iasstate.edu).

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# PC-Based Virtual Reality for CAD Model Viewing

Abhishek Seth and Shana S-F Smith

Product design is a critical activity because it has been estimated that 70% to 80% of the cost of product development and manufacture is determined by the decisions made in the initial design stages (Kalpakjian & Schmid, 2001). During the design process, 92% of communications are graphically based (Bertoline, Wiebe, Miller, & Mohler, 1997). Graphics is a visual communication language, which helps designers understand their developing designs and to convey their ideas to others. Thus, efficient graphics communication tools can improve design and decision-making processes.

Most designers currently use traditional CAD tools to help communicate their designs to others. However, CAD tools only allow users to examine 3D models from *outside* flat computer monitors. In other words, the models and the viewers are in different realms. Using traditional CAD tools, the designers cannot view models with natural stereoscopic vision.

Recently, virtual reality (VR), as an emerging visualization technology, has introduced an unprecedented communication method for collaborative design. VR refers to an immersive, interactive, multisensory, viewer-centered, 3D computer-generated environment and the combination of technologies required to build such an environment (Aukstakalnis & Blatner, 1992; Cruz-Neira, 1998). VR technology breaks down barriers between humans and computers by immersing viewers in a computer-generated stereoscopic environment. VR allows users to experience a strong sense of presence in a virtual scene and enhances user interactivity. Using VR technology, depth cues provided by a stereo image help convey spatial relationships in 3D models, which enhances users' understanding of a design. Viewers can perceive distance and spatial relationships between different object components more realistically and accurately than with conventional visualization tools.

Usually, however, implementation of VR technology is not easy. It requires skilled technical people and highly specialized, sometimes costly, equipment. These requirements prevent the widespread use of VR in research and industrial communities (Olson, 2002). However, now,

most PC workstations have stereoscopic graphic display capability built into their graphics card chip sets. PC-based VR techniques, also called low-cost VR, bring VR to a usable level for people with basic technical computer skills and limited resources. Low-cost VR takes advantage of recent advances in low-end graphics systems and other inexpensive VR commodities. Thus, VR solutions are becoming more accessible.

## About This Article

This article introduces the current status of VR applications in industry and the technologies involved in the low-cost VR systems. The number of companies producing low-cost VR-related hardware and software is continuously increasing. New hardware and software technical terms are confusing or meaningless to people without any prior background in VR. Thus, choosing the right VR tool for a particular application is challenging for potential users. This article introduces different available stereo image rendering techniques, such as anaglyphic, page flipping, and sync doubling, and major low-cost VR hardware and software tools available for CAD model viewing. The purpose of this article is to help CAD users and product designers have a better understanding about VR technology so that they can develop their own VR systems to increase the efficiency of design communication.

## Status in Industry

In industry, VR has proven to be an effective tool for helping workers evaluate product designs (Kelsick, 1998). Using VR enables everyone on a design team to understand designs better, leading to more informed and meaningful communications. Such rapid and less-ambiguous communication greatly enhances the speed and accuracy with which decisions can be made and designs can be completed.

Several major companies have incorporated VR technology into their design or production processes. In 1999, BMW explored the capability of VR for verifying product design (Gomes de Sa & Zachmann, 1999). They concluded that VR has the potential to reduce the number of physical mockups needed, to improve overall product quality, and to obtain quick answers,



in an intuitive way, during the concept phase of a product. In addition, Motorola developed a VR system for training workers to run a pager assembly line (Wittenberg, 1995). They found that VR can be used to successfully train manufacturing personnel and that participants trained in VR environments perform better on the job than those trained for the same time in real environments. In 1998, GE Corporate Research developed two VR software applications, Product Vision and Galileo, which allowed engineers to interactively fly through a virtual jet engine (Abshire & Barron, 1998). They reported that the two applications were used successfully to enhance design communication and to solve maintenance problems early, with minimal cost, delays, and effort. They also reported that using the VR applications helped make maintenance an integral part of their product design process.

### Passive and Active Stereo Systems

Because a person's two eyes are some distance apart, upon viewing the same object the right eye sees a slightly different image from the left eye. Therefore, to see a stereo image on a PC screen, one needs to generate different images for the right eye and the left eye, respectively, and arrange the two images such that the right eye sees only the right view and the left eye sees only the left view.

PC-based VR systems typically use one of several types of special viewing glasses to selectively send the right- and the left-eye images to the correct eyes. Depending upon the type of glasses used, stereo systems can be classified into passive or active stereo systems. "Passive" systems use glasses without electronic components; "active" systems use glasses with electronic components.

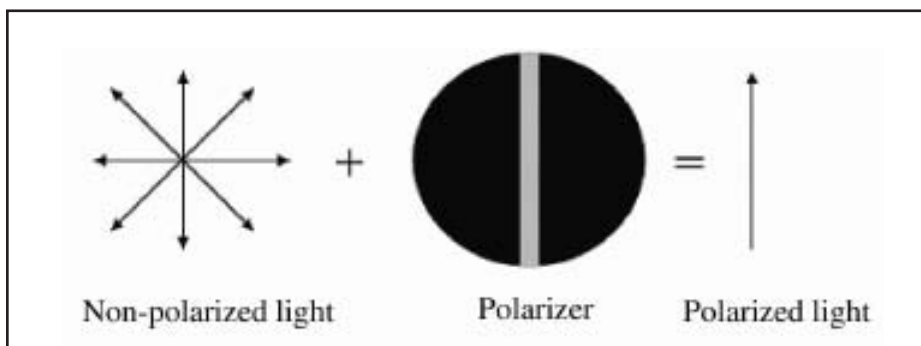
### Passive Stereo Systems

Passive stereo systems are the most common and basic type of stereo systems. They are popular because they are very inexpensive, and cost is often a critical factor in public environments. To the naked eye, passive stereo images appear to overlap and are doubled and blurry. However, when the stereo images are viewed with glasses made from colored or polarized filters, the images become stereoscopic.

Passive anaglyphic systems create a different colored image for the right and left eye. Users then view the colored images using anaglyphic glasses made from colored filters (e.g., blue for the right eye and red for the left eye). Anaglyphic glasses used for passive stereo cost about 80¢ per pair (VRex, <http://www.vrex.com>). However, image quality in passive anaglyphic systems is relatively poor, and colored views are not possible. The lack of colored viewing capability is one of the major drawbacks of anaglyphic passive stereo systems.

Another method for passive stereo viewing is based on the principle of light polarization. With oppositely polarized filters attached to two projectors and matching filters in a pair of glasses, right- and left-eye images can be separated and multiple colors can also be viewed. The theory behind polarized viewing systems is based upon the vibration characteristics of light (Barco, n.d.). Nonpolarized light waves can vibrate in any direction. A light wave vibrating in a single direction is called polarized light. The polarization of a light wave at any given moment is determined by the specific orientation of the wave at that moment. Nonpolarized light can be transformed to polarized light by passing the light wave through a polarizer (see Figure 1). The depth perception required for stereo images can be created by directing

**Figure 1. Polarizing light using a polarizing filter.**



**Figure 2. Double projector system with opposite polarizers.**



different visual information, using different polarization directions, to the right and left eye. Thus, such a stereo system uses two projectors, as shown in Figure 2. Polarizing light waves does not significantly degrade image quality because human eyes are largely insensitive to polarization. The cost for a polarized projector system is around \$20,000 (VRex, <http://www.vrex.com>; 3-D ImageTeck, <http://www.3dimagetek.com>).

If light is polarized in a single direction (north/south, east/west, or even diagonally), the light is linearly polarized. If a viewer changes the orientation of linearly polarized glasses by tilting his or her head, the resulting polarization orientation of the viewer's glasses will not match that of the polarization filters mounted on the projectors, and there will be a loss of stereo information, as perceived by the viewer (Barco, n.d.). Nevertheless, linear polarization is a cost-effective technology that can produce excellent right-eye and left-eye image separation for stereoscopic applications for which head tilting is limited.

Using circularly, rather than linearly, polarized light is an effective solution to the head-tilting problem. For circularly polarized light, head tilting does not result in a loss of stereo information, since the light is not polarized in a single direction. StereoGraphics Corporation's Monitor ZScreen series provides a stereoscopic panel, which mounts on a regular PC computer monitor, for circularly polarizing right-eye and left-eye images (StereoGraphics Corporation, <http://www.stereographics.com>). The cost of a Monitor ZScreen system is \$2,345. Polarized glasses range in cost from \$3.95 to \$50 per pair (StereoGraphics Corporation, <http://www.stereographics.com>; VRex, <http://www.vrex.com>).

One of the important advantages of polarized stereo viewing systems is that they can be driven by non-stereo-capable hardware. In addition, the polarizing method can provide colored and high-quality stereo images.

### *Active Stereo Systems*

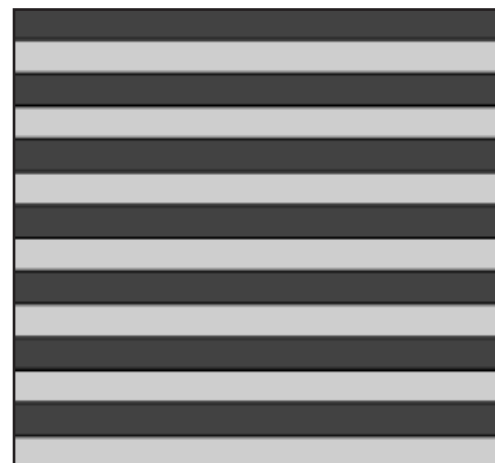
In active stereo systems, the viewing glasses used contain electronic components. Stereo images are presented by rapidly alternating the display of right-eye and left-eye images while alternately masking the right and left eye using synchronous shutter eyewear, such as LCD shutter glasses. Available LCD shutter glasses use various image switching techniques. The following three modes are most popular (Lipton, 1997):

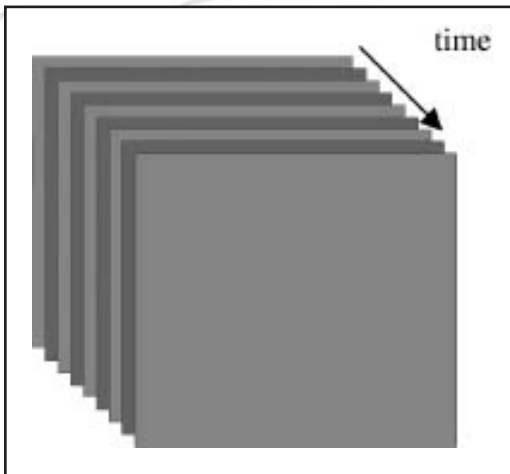
- Interlacing
- Page flipping
- Sync doubling

### *Interlacing*

Interlacing is used in existing television systems, such as NTSC, PAL etc., to transmit and broadcast signals. In interlace mode, a single frame is divided into two fields: the odd scan-line field and the even scan-line field. When the interlace mode is used for stereo imaging, the right-eye image and the left-eye image are divided into odd and even scan-line fields, or vice versa. First the odd scan-lines (1, 3, 5, 7, etc.) are presented, followed by the even scan-lines (2, 4, 6, 8, etc.; see Figure 3). When the right-eye frame is displayed on the screen, the left eye is covered by the glasses, and when the left-eye frame is shown on the screen, the right eye is covered by the shutter glasses.

**Figure 3. Interlacing.**



**Figure 4. Page-flipping.****Page-Flipping**

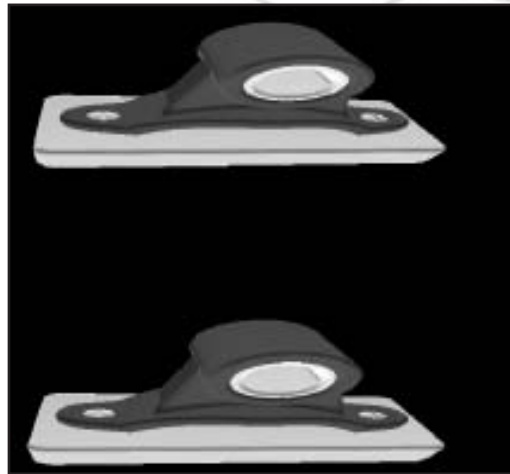
In page-flipping mode, the right- and the left-eye frames are shown alternately on the screen (see Figure 4). When the right-eye frame is shown on the screen, the left eye is covered by the shutter glasses, and when the left-eye frame is shown on the screen, the right eye is covered by the shutter glasses. In this mode, both the horizontal and vertical resolutions are kept the same, since the frames are displayed one by one on the entire screen.

For page-flipping, high-end PC hardware is typically required. A monitor that supports a 120 Hz or higher vertical scan frequency and specially designed hardware are often required. As mentioned earlier, page-flipping provides full resolution picture quality and, thus, provides the best visual effect among the display modes for shutter glasses. However, software and hardware dependence is a major drawback.

**Sync-Doubling**

With sync-doubling, the right-eye and left-eye frames of the image are scaled down in the vertical direction and arranged on the upper and lower half of the screen (see Figure 5). Sync-doubling differs from interlacing and page-flipping modes in that no specialized computer peripherals are required.

To create a stereo view, software designers only need to arrange the right- and left-eye images properly on the screen, as shown in Figure 5. An external circuit (called a sync doubler) is then used, which allows the right- and left-eye images to stretch to normal size and appear in an interlaced pattern on screen. The image quality is not as good as page flip-

**Figure 5. Sync-doubling.**

ping because the monitor's vertical frequency needs to be doubled to stretch the frames to full screen. Overall image resolution is therefore reduced by one half. However, the advantage of sync-doubling is that it is not limited by computer hardware capabilities.

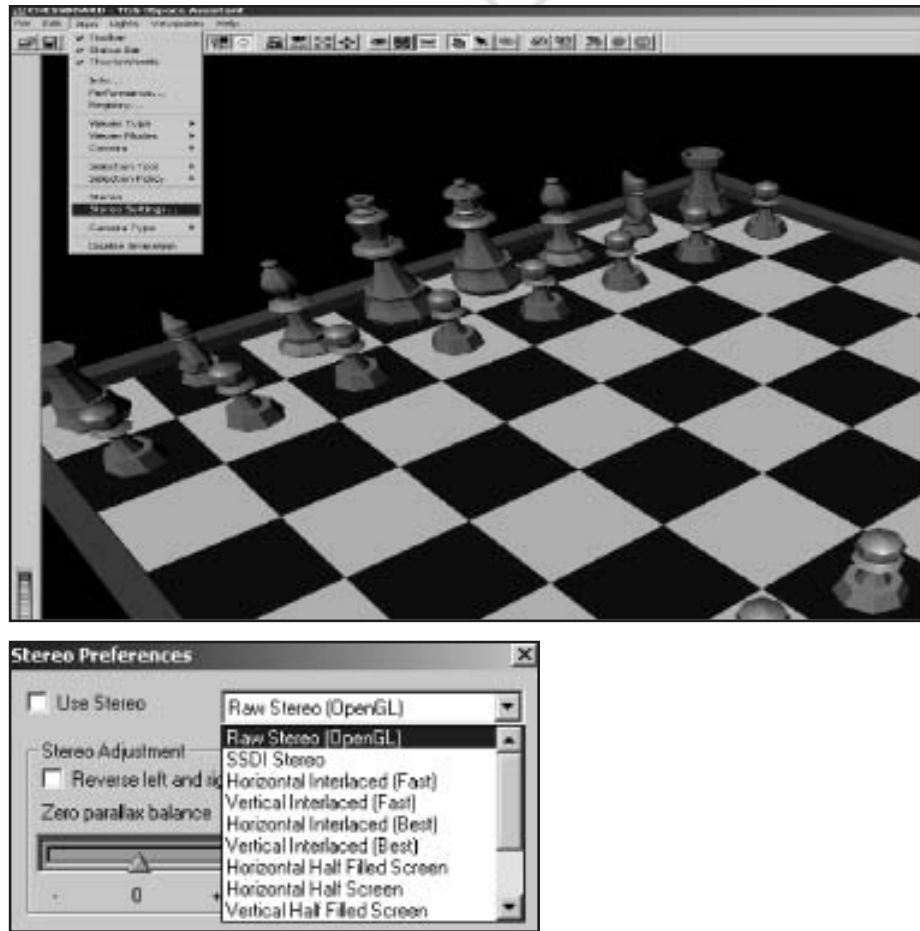
**Available Software**

Presently, there are a number of VR software tools available for stereoscopically viewing CAD models. For example, 3Space Assistant by Template Graphics Software (<http://www.tgs.com>) and Quadro View by Nvidia Corporation (<http://www.nvidia.com>) are well developed and very user-friendly.

For the available software tools, the computer system must have an OpenGL driver installed to activate stereo modes. OpenGL is a cross-platform, high-performance standard library for 3D graphics applications. If an OpenGL driver for the graphics card being used is unavailable or if the driver is not installed when the active stereo mode is used, the computer will display the message "No OpenGL driver installed on the computer," and the stereo image will not be shown on the screen. GL Direct, by SciTech Software Inc. ([www.scitechsoft.com](http://www.scitechsoft.com)), provides a solution to the above problem. After the software is installed, whenever any stereo application (e.g., TGS 3Space Assistant or Quadro View) starts, SciTech GL Direct will automatically start.

**TGS 3Space Assistant**

3Space Assistant from Template Graphics Software, Inc., is a stand-alone CAD model viewer. The advantage of 3Space Assistant is that it allows stereo viewing in a number of

**Figure 6. Stereo settings in the view menu of 3Space Assistant.**

stereo modes such as Raw OpenGL, Horizontal Interlaced, Vertical Interlaced, Red-Cyan Anaglyphic, and Blue-Yellow Anaglyphic (see Figure 6). If the active stereo mode is used, LCD shutter glasses are required. If the anaglyphic stereo mode is enabled, passive colored filter glasses (red/cyan, blue/yellow, or green/magenta) are required.

#### ***Nvidia Quadro View***

To use Nvidia's Quadro View, users need to purchase a quad-buffered graphics card or a computer system that already has a quad-buffered graphics card installed (Nvidia Corporation, <http://www.nvidia.com>; Redmond, n.d.). The stereo quality provided by Quadro View is very good, but the part handling features are not very user-friendly. Using Quadro View, 3D CAD models can be viewed using passive as well as active stereo modes. One of the unique features in Quadro View is its compatibility with other CAD design packages (e.g., AutoCAD, AutoCAD Architectural Desktop, and Mechanical Desktop), which makes it different from all other stereo viewers.

#### **Future Directions**

PC-based VR, in the future, will incorporate haptic and audio devices to give a better sense of immersion in the computer-generated environment and to provide a more intuitive interaction with design models. Haptic devices could provide realistic force feedback so users could feel objects that they touch or move. Audio devices could provide realistic sound effects for collisions between objects. In addition, because of the restrictions associated with manipulating 3D virtual objects with a keyboard and mouse, data gloves will be used to increase manipulation efficiency in low-cost VR systems. Handling computational workloads while providing real-time response is also a critical issue for realizing future low-cost VR systems.

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# Technology Profile: An Assessment Strategy for Technological Literacy

Charles W. Gagel

Given the scope of technology and the inherent difficulties of measuring such broad phenomena, this article explores two strategies for assessing technological literacy. One approach is drawn from a multiple measurement strategy often used to assess achievement, the test battery approach; the other is based on well-known interest inventories and personality type indicators, the typology approach. Shared between these approaches is the notion of a profile. One's performance or rating could be reported through a profile, that is, "a formal summary or analysis of data, often in the form of a graph or table, representing distinctive features or characteristics" (The American Heritage Electronic Dictionary, 1992).

While it is undeniable that the creation of such measures would be demanding given the conceptual scope of the undertaking, such efforts are called for in a report by the Committee on Technological Literacy—a joint committee of the National Academy of Engineering and the National Research Council, Center for Education (Pearson & Young, 2002). Specific recommendations were made for "the development of one or more assessment tools for monitoring the state of technological literacy among students and the public in the United States" (p. 12).

In principle, a technology profile could provide a means by which one's technological prowess or disposition could be indexed or classified according to a determined scale or system. Such a profile could aid in (a) the identification of potential students for a given program, (b) the comparison of one's capabilities to a known group, (c) the determination of one's technological knowledge and skill in a particular area of technology, or (d) the classification of one's disposition toward technology.

## The Test Battery Approach

The battery approach for a technology profile is based on a common method used by many measurement instruments when several

dimensions of a phenomenon are to be measured. A single instrument approach is usually avoided because to accommodate the breadth of the phenomenon the test instrument would need to be very large, and thus too time consuming and laborious to administer or complete. In these situations, a battery of tests are employed with each test measuring a specific area of the phenomenon.

The well-known General Aptitude Test Battery and Differential Aptitude Tests are two examples of such multiple test strategies. A more recent and related example can be found in the Technology and Internet Assessment (Ealy, 1999). This assessment battery is designed to determine one's strengths and weaknesses in eight areas related to computer, Internet, and information skills. The eight areas are titled (a) Use of Technology, (b) Specific Computer Skills, (c) Acquisition of Technology Knowledge, (d) Basic Internet Knowledge, (e) Internet Information Skills, (f) Adapting to Technological Change, (g) Impact of Technology, and (h) Ethics of Technology. Such a model could be adapted for measuring the broad spectrum of technological knowledge, skills, and disposition.

Given the array of content now being promoted for the technology education curriculum through the Standards for Technological Literacy document (International Technology Education Association [ITEA], 2000), it is difficult to imagine that a single test approach would adequately measure the intended literacy. In combination with the assessment standards set forth in the recent Advancing Excellence in Technological Literacy document (ITEA, 2003), a single test approach does not seem reasonable. It would seem that the development of a battery of tests would serve both the content and assessment standards better. Just how such a test battery might unfold is unknown; however, certain reports are conceptualized below to help guide an overall development process.

**Figure 1. Conceptual representation of a Technology Profile.**

Name: \_\_\_\_\_ Test Form: \_\_\_\_\_

## TECHNOLOGY PROFILE

### Individual Profile Chart & Cumulative Record

Record of Testing:

Date: \_\_\_\_\_ Date: \_\_\_\_\_  
Standard: \_\_\_\_\_ Standard: \_\_\_\_\_  
Score: \_\_\_\_\_ Score: \_\_\_\_\_

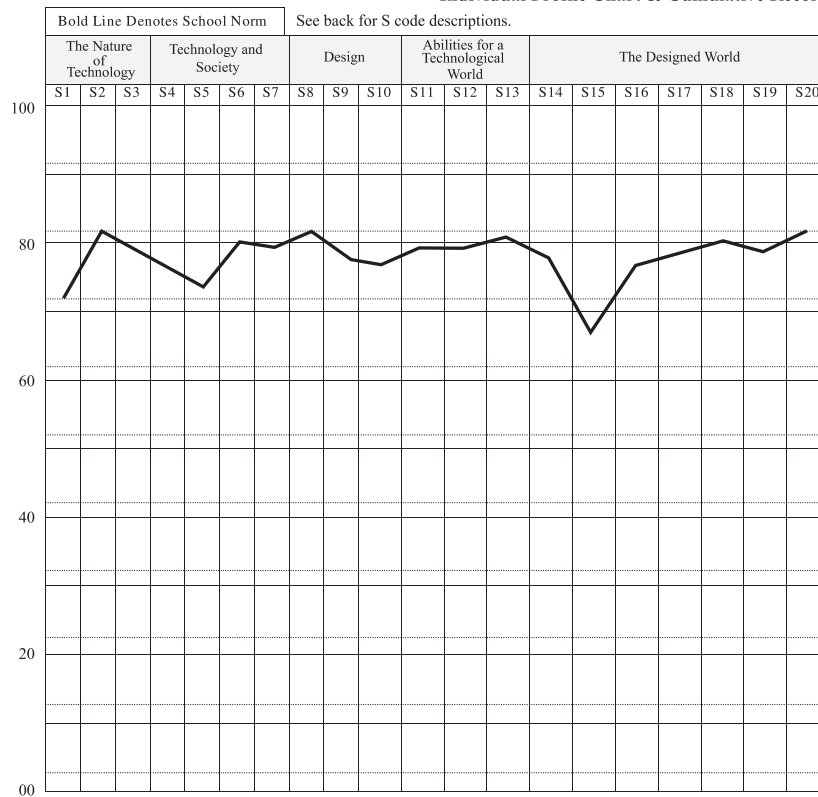
Date: \_\_\_\_\_ Date: \_\_\_\_\_  
Standard: \_\_\_\_\_ Standard: \_\_\_\_\_  
Score: \_\_\_\_\_ Score: \_\_\_\_\_

Date: \_\_\_\_\_ Date: \_\_\_\_\_  
Standard: \_\_\_\_\_ Standard: \_\_\_\_\_  
Score: \_\_\_\_\_ Score: \_\_\_\_\_

Date: \_\_\_\_\_ Date: \_\_\_\_\_  
Standard: \_\_\_\_\_ Standard: \_\_\_\_\_  
Score: \_\_\_\_\_ Score: \_\_\_\_\_

Date: \_\_\_\_\_ Date: \_\_\_\_\_  
Standard: \_\_\_\_\_ Standard: \_\_\_\_\_  
Score: \_\_\_\_\_ Score: \_\_\_\_\_

Date: \_\_\_\_\_ Date: \_\_\_\_\_  
Standard: \_\_\_\_\_ Standard: \_\_\_\_\_  
Score: \_\_\_\_\_ Score: \_\_\_\_\_



## S Code Descriptions

|   |
|---|
| <b>The Nature of Technology</b><br><i>Students will develop an understanding of . . .</i>                                     |
| S1: the characteristics and scope of technology.  |
| S2: the core concepts of technology.  |
| S3: the relationships among technologies and the connections between technology and other fields of study.                    |
| <b>Technology and Society</b><br><i>Students will develop an understanding of . . .</i>                                       |
| S4: the cultural, social, economic, and political effects of technology.  |
| S5: the effects of technology on the environment.   |
| S6: the role of society in the development and use of technology.   |
| S7: the influence of technology on history.   |
| <b>Design</b><br><i>Students will develop an understanding of . . .</i>   |
| S8: the attributes of design.   |
| S9: engineering design.   |
| S10: the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. |
| <b>Abilities for a Technological World</b><br><i>Students will develop the abilities to . . .</i>                             |
| S11: apply the design process.  |
| S12: use and maintain technological products and systems  |
| S13: assess the impact of products and systems.   |
| <b>The Designed World</b><br><i>Students will develop an understanding of and be able to select and use . . .</i>             |
| S14: medical technologies.  |
| S15: agricultural and related biotechnologies.  |
| S16: energy and power technologies.   |
| S17: information and communication technologies.  |
| S18: transportation technologies.   |
| S19: manufacturing technologies.  |
| S20: construction technologies.   |

*Note:* This page is the back of the Technology Profile.

**Figure 2. Conceptual representation of a Technology Profile and Summary Report.**

For: John J. Jones  
3546 Clearwater Creek Road  
Somewhere, USA 01010-3546

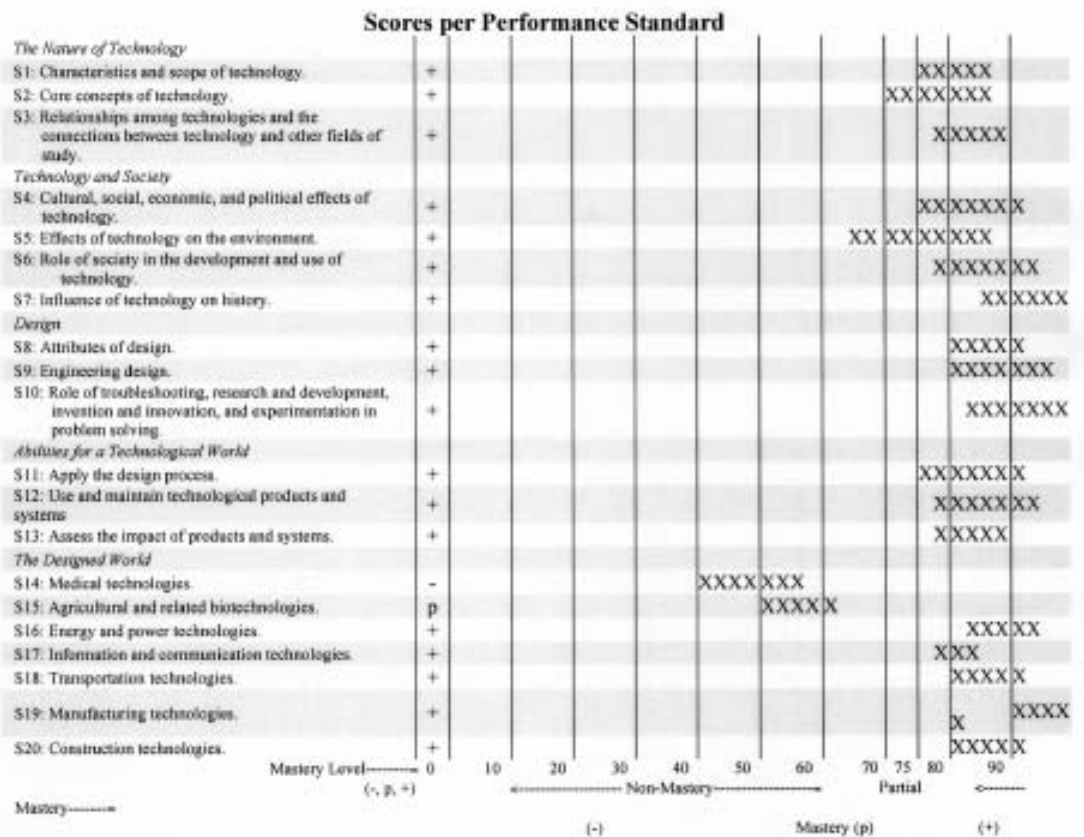
Date: November 14, 2004

Test Form: A Level: 10

| Test Cluster                        | Score      | Comparison Norms |          |          |
|-------------------------------------|------------|------------------|----------|----------|
|                                     |            | School           | Regional | National |
| The Nature of Technology            | <b>81</b>  | 80.6             | 78.2     | 82.5     |
| Technology and Society              | <b>84</b>  | 81.0             | 80.0     | 80.9     |
| Design                              | <b>87</b>  | 82.0             | 83.9     | 86.0     |
| Abilities for a Technological World | <b>85</b>  | 83.3             | 79.4     | 80.0     |
| The Designed World                  | <b>80</b>  | 80.8             | 78.4     | 78.3     |
| <b>Combined Score</b>               | <b>417</b> | 407.7            | 399.9    | 407.7    |

School: Mountain Crest High School  
7834 Mountain Crest Road  
Somewhere, USA 01011-7834

Class: TE 310/Wilson  
Room: 127



*Note:* On your profile, a bar of X's has been printed in the row for each performance standard. Your score is at the center of the bar. The reason for the bar instead of a single X is that a test is not a perfect measure of your knowledge, skills, or ability. You can be reasonably sure that you stand somewhere within the area covered by the bar.

## Technology Achievement Profile

In addition to the test battery design, the notion of a technology profile draws on certain data representation associated with various survey and inventory instruments. This aspect of the profile could serve to compare one's scores on the overall battery of tests with the characteristic scores of others. Scores on the individual tests of the battery (i.e., subtests) could be reported in such a way as to provide an overall portrait of one's performance or rating. Such reporting is often done in the form of charts or derived scores. Two possible models are described below. It should be noted that Figures 1 and 2 are conceptual representations only; the test to generate these reports has not been created or administered. All the data displayed in the profiles, therefore, are fictitious.

The first model, the *Technology Profile* (Figure 1), provides a graphic display of one's performance on 20 different subtests. For our purposes here, the subtests are based on the 20 content standards set forth in the Standards for Technological Literacy (ITEA, 2000). This model promotes the idea of an individual profile chart and cumulative record. The graphical depiction also provides a means for comparing one's scores to other established scores, for example, a cumulative overall school or school district's performance.

The second model, the *Technology Profile and Summary Report* (Figure 2), provides scoring bands for the 20 content standards in addition to grouped scores for the five divisions of the content standards: The Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and The Designed World. The scoring bands (bars of Xs) represent the confidence range for the given test score. Comparison norms for the individual school, region, and nation are also included. One's achieved level of mastery is incorporated into the report as well.

Given these two forms of reporting, one could compare an individual's score to those of his or her classmates or to much broader groups. It would allow for comparisons between the many subcategories of technology. Such an approach could provide a multidimensional portrait of technological literacy.

## The Typology Approach

A truly unique approach for a technology profile could come in the form of a typology indicator, that is, a depiction of one's attitudes toward technology. From a general education perspective, given the ephemeral nature of technological knowledge and skills, this approach could prove more meaningful over time. Such an instrument would have greater longevity (i.e., shelf life) and could provide information that a competency scale would normally overlook. The profile could be based on survey and inventory type instruments, for instance, the personality scales of the Myers-Briggs Type Indicator (MBTI) and the Keirsey Temperament Sorter (KTS). Here, one's knowledge, skills, and attitudes regarding technology could be used to sort and categorize individuals according to some scale of technological capacity, interest, or disposition.

The MBTI uses four dichotomy scales to produce 16 different personality types. Two of the four scales deal with mental functions (i.e., thinking/feeling and sensing/intuition) and two deal with attitudes (i.e., extraversion/introversion and perceiving/judging). The KTS divides these 16 types of the MBTI into four major categories (i.e., artisans, guardians, idealists, and rationals). Each of the four categories is then divided into four subcategories, each with its own descriptor (see Table 1). Using the MBTI and KTS as models, a technology disposition profile is discussed in the next section.

## Technology Disposition Profile

Developing a technology disposition profile would require the creation of dichotomous scales for a variety of attitudes and sentiments toward technology. In keeping with the MBTI (where the scales follow along mental and attitudinal lines), the scales for a technology disposition profile would follow the same logic, that is, mental and attitudinal. Mental functions could be viewed as the mental dispositions (i.e., habits of mind) of certain creators and users of technology; attitudes could be cast along the lines of application and consequences (e.g., Engineer : Utility :: Artist : Aesthetics or Environmentalist : Conservation :: Producer : Consumption). Such scales might resemble those shown in Table 2.



**Table 1. Types and Temperaments According to the Myers-Briggs Type Indicator and Keirsey Temperament Sorter**

| Artisans         | Guardians         | Idealists        | Rationals           |
|------------------|-------------------|------------------|---------------------|
| Promoter (ESTP)  | Supervisor (ESTJ) | Teacher (ENFJ)   | Fieldmarshal (ENTJ) |
| Crafter (ISTP)   | Inspector (ISTJ)  | Counselor (INFJ) | Mastermind (INTJ)   |
| Performer (ESFP) | Provider (ESFJ)   | Champion (ENFP)  | Inventor (ENTP)     |
| Composer (ISFP)  | Protector (ISFJ)  | Healer (INFP)    | Architect (INTP)    |

*Note:* E = extraversion, I = intuition, F = feeling, J = judging, N = introversion, P = perceiving, S = sensing, T = thinking.

**Table 2. Potential Dichotomy Scales for Attitudes Towards Technology**

| Creators / Users       | Applications / Consequences |
|------------------------|-----------------------------|
| Designers / Producers  | Products / Costs            |
| Producers / Consumers  | Services / Benefits         |
| Management / Labor     | Resources / Environment     |
| Government / Citizenry | Political / Economic        |

## Discussion

The notion of a technology profile, as just described, raises a number of questions. For instance, given the 20 content standards developed by the ITEA, is it conceivable that they could serve as the constructs for test development? If each standard was used for a separate instrument, 20 individual tests would likely be viewed as too cumbersome to develop and administer. Would it be more manageable then to use ITEA's five major divisions of the content standards to guide test development? Would five tests be adequate? Given the breadth of technology, five tests would seem limiting especially if one's everyday lived encounters with technology were to be included. Everyday lived encounters go beyond what can be expected from the typical classroom education. There are issues of learned versus acquired literacy here (Gee, 1989).

A possible compromise might draw on both the standards and their divisions. A combination approach may be comprised of 10 separate instruments; for example, the test titles

may be as follows: The Nature of Technology, Technology and Society, Design in Technology, Medical Technologies, Agricultural and Related Biotechnologies, Energy and Power Technologies, Information and Communication Technologies, Transportation Technologies, Manufacturing Technologies, and Construction Technologies.

The above discussion has addressed a few of the issues surrounding the more traditional test battery approach; the typology approach would have similar concerns regarding scope and size. Given the number of occupational interest inventories and scales that are available today, would developing a type sorting scale for technological dispositions add a meaningful dimension to our measurement of technological literacy? What might such a measure of beliefs and attitudes add to our understanding of technological literacy?

The typology scale, as conceptualized here, goes beyond occupational interest and fit. It seeks to investigate further than one's conscious

knowledge, skills, and motivation. The objective is to gain an understanding of one's dispositions toward technology—those beliefs and attitudes that have both conscious and unconscious origins. It can be argued that one of technology's most serious liabilities as a legitimate domain of knowledge is its growing invisibility. There are two dimensions to this invisibility. First, there is one's familiarity with technology; that is, as one interacts with technology on a daily basis, one's awareness of that interaction is dimmed. This is often explained as a level of *automaticity*, a state in which one acts without attending much conscious effort. In this dimension, the more one interacts with and is dependent upon technology, the less one realizes and appreciates the interaction.

The second dimension of technology's invisibility is based on technology's own evolution. As technology advances, it becomes more invisible. In today's computerized world, we talk about a seamless interface. Essentially, this means an invisible blending of multiple components. This invisibility masks the real complexity of what is transpiring; it simplifies the technology for the human user. This phenomenon of simplification often results in a lack of awareness and appreciation of the technology. The simplification masks many of the implications or impacts of technology on the individual, the society, and the environment.

### Closing Thoughts

There remain numerous questions regarding the viability of a profile approach for technological literacy. The test taker's own mental endurance (potential boredom, for instance) must be considered when determining the size and number of tests in a battery. Like many other test batteries, the individual tests can be spread over a period of days, weeks, or perhaps months. Since each test would address a specific area of content, boredom and a sense of repetition could be minimized.

Another consideration must be one of *perception*. How will these tests be viewed by teachers, administrators, parents, or the general public? In our era of high-stakes testing, adding another layer of testing would likely be met with resistance. Consequently, as mentioned earlier,

technology's misunderstood nature is one of the greatest challenges when it comes to perception. At the school level, devoting time out of the school day to measure technological literacy will ultimately be gauged against its perceived value with mathematics, language arts, science, and other school subjects. Hence, it must be acknowledged that technology still struggles for a place in the greater sociology of knowledge.

The notion of a technology profile has other entanglements with perception as well, for instance, the negative image of *profiling*. Could one's technology profile be used in a negative way? Could it be used to unfairly stereotype individuals? While one must admit that such an outcome is possible, it is certainly not the intent.

Whether a test is required or elective holds still other perceptual concerns. The technology profile is not envisioned as a mandatory test unless, perhaps, the study of technology achieves a required status in the total school curriculum. It should be further understood that a technology profile may not necessarily be part of the K–12 schooling experience at all. A profile could have value in both school and non-school settings, as with many other tests related to technical or workforce matters.

Perhaps the most difficult challenge for developing a technology profile, whether for the test battery approach or the typology approach, would be the creation of the test items or statements. Validity, and perhaps reliability, will indeed be a challenge. Even though every human being encounters technology everyday, it is the diversity, combined with a certain level of competency, that is problematic. Here, we can take a lesson from the field of artificial intelligence (AI).

At one time, AI held much promise for aiding complex decision making. It was believed that if we could create a large enough database and access it with an appropriate algorithm that AI would be able to answer almost any complex question. In reality, the diversity of the human knowledge base and the complexity of human situations have proven much more difficult than originally recognized. AI has given us many very useful problem-solving tools but mostly in

very restricted environments (e.g., selected medical and engineering applications).

The AI lesson for measuring technological literacy is twofold: (a) context must be limited and (b) multiple, more narrowly defined tests produce better results. Validity hinges primarily on the first point; namely, validity must consider the background and/or setting of the one being tested. Thus, it could be argued that with technology's diversity across human culture, it would not seem unreasonable to design a given test for a particular region of a country or, perhaps, even for urban versus rural encounters with technology. While this may seem to further complicate the issue, its intent is to draw attention to the matter of application. Technology is fundamentally an applied subject by nature. Test items and statements will be valid to the extent that they measure what one *knows about* technology and what one is *able to do* with technology within a given context. To not include these

aspects of technology will yield an incomplete measure of technological literacy and thus limit the validity of the overall test.

Finally, the technology profiles conceptualized in this article are intended to promote our thinking about the assessment of technological literacy. With the growing emphasis on standards and their assessment, the technology profile may provide an alternate means for documenting one's achievements and dispositions toward technology. While such an approach would surely require an extensive development effort, it would seem that the complexity and scope of technological literacy warrants such an approach.

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## Author Note

Figures 1 and 2 in this article are based on the reports used by the Iowa Tests of Basic Skills and the Comprehensive Tests of Basic Skills.



# A Comparison of Industrial and Academic Perceptions of Quality Control Education

R. Neal Callahan and Shawn D. Strong

Effective quality control is easily recognized as a key component in successful manufacturing operations. Companies place a high priority on establishing a strong quality management team and sound quality procedures, yet many employers find newly hired technical graduates unprepared to apply quality control concepts learned in the classroom. Companies realize that the success of their quality program has a substantial influence on their bottom line. Quality program effectiveness is directly related to profitability through its impact on productivity, product cost, customer satisfaction, product image, and, ultimately, attainable product price. Considerable resources are spent on either training existing employees or hiring additional ones who are well versed in quality control principles.

Educators in technical programs share in this concern for developing well-trained graduates who are competent in a variety of quality related topics. Technology-based programs typically include one or two courses focused on quality topics. As in industry, educators spend a great deal of resources and effort developing appropriate quality related courses, faculty, and facilities.

The purpose of this study was to investigate the perceptions of both industry professionals and faculty members of technology-based programs concerning the preparedness of recent graduates as they began a quality related position. To gain this information, surveys were administered among managers and technical leaders in industry and compared with surveys of faculty members from four-year industrial technology and engineering technology programs. Recent graduates were evaluated with regard to both theoretical knowledge and applied skills. By analyzing survey results, recent literature, and in-depth conversations with industry professionals, recommendations are made for improving quality control curricula and better serving industry needs.

## Background

Quality control on the plant floor is practiced much differently than it is presented in the

classroom, with numerous opportunities for inaccurate data collection and unclear conclusions (Schenck, 1993). Experienced quality professionals often find that newly hired graduates have difficulty with issues such as gaging, data interpretation, and conforming to a production and cost-oriented environment. While many of these issues are a matter of experience, both industry professionals and the related literature indicated that applied quality concepts should be added to basic quality control curricula at the college level. Every effort should be made to strengthen students' skills by combining theoretical knowledge with practical situations (Kemenade & Garre, 2000).

Successfully applying quality control concepts on the shop floor requires the ability to overcome common problems such as incomplete data, inaccurate measurements, and non-normal distributions. Dealing with these types of problems can be challenging for those who have been exposed to rigid statistical standards for quality analysis in the classroom. Wheeler and Chambers (1992) indicated that many techniques can be used even when less than perfect conditions such as non-normal distributions and unstable processes exist. In addition, an understanding of the ways in which the process and product impact the analysis of quality data is critical in making correct judgments (T. Dorsey, personal communication, June 6, 2003). Familiarity with basic data collection procedures and protocols, along with an understanding of quality standards and reference material, is also expected. These requirements may seem overwhelming for those in entry-level positions, but exposure to a few key concepts before graduation can make the transition much easier. Demanding production schedules and cost constraints can be additional complications for the quality professional to overcome. The key to success is an ability to understand and address these problems without abandoning basic quality theory and standards.

## Previous Work

Previous studies have investigated methods for improving quality control skills of employees. Rungtusanatham (2001) surveyed



production personnel to assess the impact of quality control training. His findings indicated an improvement in motivation and job performance as quality control skills increased. Improved quality control practices by employees also have an impact on customer satisfaction according to Nilsson, Johnson, and Gustafsson (2001). Suleiman and Yourstone (1998) investigated the effects of training, performance evaluation, and rewards on the successful implementation of a quality management program. Developing a sense of value for quality among workers is of particular importance. Deming (1994) concluded that external monitoring or bonuses are not the basis for an effective quality system. Instilling a value of quality for its own sake based on the pride and self-esteem of the workers results in long-term success. A survey conducted by Rao, Raghunathan, and Solis (1997) indicated that quality assurance performance was affected by length of quality experience in organizations.

Folkestad, Senior, and DeMiranda (2002) explored service learning as a method for developing students' social attitude toward work along with strengthening technical literacy. This method does hold some promise for strengthening practical skills by increasing exposure to real projects with real problems. However, caution should be exercised to assure that the technical content of the project is demanding enough for the particular course of which it is a part. Focusing on social development in a technical course could reduce exposure to and comprehension of specific skills that will be needed later. Plaza (2004) proposed an integrative approach to technology education in which core courses are developed around a topic involving many disciplines and many instructors. This approach could be successful at the introductory or capstone levels, but could also trend toward an excessive number of survey courses that would reduce the focus and depth of the program.

Bhote (1991) concluded that 90% of U.S. industry is not successful in solving chronic quality problems. He promoted the teaching of very powerful, but simple, statistical tools for dealing with persistent problems.

The previous studies have indicated that quality control training can have a positive impact on employee performance. With a grounding in these findings, this study sought to

determine specific quality skills employers expect in entry-level professionals. A comparison of what is expected by employers versus what is emphasized by academia was then investigated.

### Survey Methodology

Both industry professionals and college faculty members were surveyed to gauge and compare expectations concerning quality control education. A questionnaire survey instrument was developed and a pilot test was conducted with colleagues and industry professionals who had significant roles in quality control. The pilot test was conducted to check the validity of the questionnaire, identify and eliminate any ambiguity, and make appropriate changes identified by respondents' suggestions. Recommendations from the pilot test were incorporated into the final version of the survey and included issues concerning specific topics covered, wording of certain questions, and the form of the survey itself (see Figure 1 for the final version of the survey questionnaire).

Two populations were targeted for the survey. One population consisted of a database of industry professionals maintained by the college department conducting the survey. This database was made up of production and quality assurance professionals who maintained contact with the department and had involvement in applying quality control concepts in the national or international manufacturing environment. A second population consisted of college faculty who were members of the engineering technology listserv, which included technology-based faculty across the United States. A qualifying statement with the survey narrowed this population to faculty of four-year industrial technology or engineering technology degree-granting institutions who were involved in teaching quality control. All surveys were sent via e-mail.

The survey employed twelve 5-point Likert scale questions and one rank order type question. The 5-point Likert scale design consisted of: (1) strongly disagree, (2) disagree, (3) undecided, (4) agree, and (5) strongly agree. The achievement of new technology graduates was evaluated with respect to six knowledge areas in quality control: basic statistics, statistical process control, measuring equipment, non-normal distributions, gage control, and documentation standards. Each knowledge area was evaluated using a paired format consisting of a

### Figure 1. Survey questionnaire.

The following survey questions relate to recent college graduates from four-year Industrial Technology or Engineering Technology programs entering the industrial workforce. Assume that the graduates will be significantly involved with the quality control function in their first assignment.

Do recent graduates from technology based programs possess the following knowledge and skills?  
Check one of the five boxes for each knowledge or skill listed.

|  | Strongly Agree | Agree | Undecided | Disagree | Strongly Disagree |
|--|----------------|-------|-----------|----------|-------------------|
| Graduates have adequate knowledge of basic statistical theory                          |                |       |           |          |                   |
| Graduates have adequate skills in applying basic statistical concepts                  |                |       |           |          |                   |
| Graduates have adequate knowledge of statistical process control theory                |                |       |           |          |                   |
| Graduates have adequate skills in applying statistical process control concepts        |                |       |           |          |                   |
| Graduates have adequate knowledge of basic measuring equipment                         |                |       |           |          |                   |
| Graduates have adequate skills in using basic measuring equipment                      |                |       |           |          |                   |
| Graduates have adequate knowledge of non-normal distributions                          |                |       |           |          |                   |
| Graduates have adequate skills in applying non-normal distributions to analyze data    |                |       |           |          |                   |
| Graduates have adequate knowledge of gage control concepts                             |                |       |           |          |                   |
| Graduates have adequate skills in applying gage control concepts                       |                |       |           |          |                   |
| Graduates have adequate knowledge of data collection and documentation standards       |                |       |           |          |                   |
| Graduates have adequate skills in applying data collection and documentation standards |                |       |           |          |                   |

Of the following quality related areas, rank the top three items (1, 2, 3; 1 = highest priority) that you feel most need **additional** attention in technology based programs. If an item is not listed please write it in the space provided. **Only select the top three items – leave all others blank.**

- |  |                                 |                           |
|--|---------------------------------|---------------------------|
| ___ Statistical Process Control                  | ___ Gage Control                | ___ Design of Experiments |
| ___ Basic Statistics                             | ___ Capability Studies          | ___ Measuring Equipment   |
| ___ Data Collection Standards                    | ___ Economic Aspects of Quality | ___ Hypothesis Testing    |
| ___ Non-Normal Distributions                     | ___ Rational Subgrouping        | ___ Sampling              |
| ___ _____ (list an additional item if not given) |                                 |                           |

statement relating to theory and a second statement relating to applied skill.

The rank-order portion of the survey listed 12 items for the participants to consider. A blank was provided that allowed an additional item to be added if it was not already listed. Participants were asked to rank the top three quality control items (1, 2, 3; 1 = highest priority) that they felt most needed additional attention in technology-based programs. This portion of the survey was evaluated by applying a number score to the ranked responses. For clarity this priority scale was then inverted. Quality control items rated with the highest priority were assigned a score of 3 followed by 2 and 1 for lower priority rankings. In this way graphical priority ratings may be more easily interpreted.

A total of 28 useable questionnaires out of 64 were returned by industry professionals for a response rate of 44%. Three industry questionnaires were discarded due to incomplete responses. A total of 32 faculty members returned surveys from an original population of approximately 175 for a response rate of 18%. One faculty questionnaire was discarded due to improper ranking of items in the rank order portion. The faculty response rate was approximated based on the engineering technology listserv membership of 1,396 for four-year colleges. A spot check of five institutions revealed that about 1 out of 8 faculty members from technol-

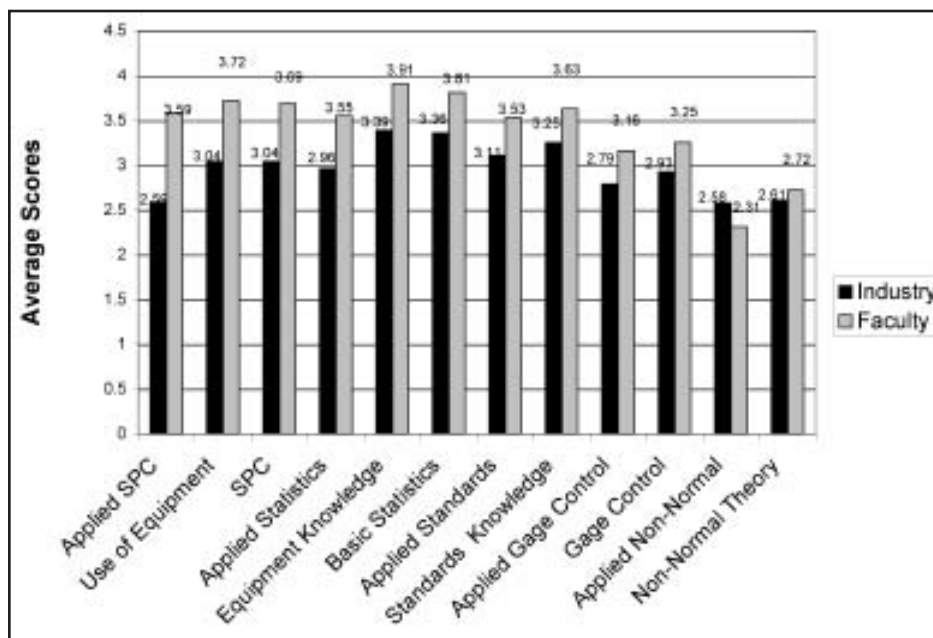
ogy-based programs were involved in teaching quality control courses. This reduced the target population to approximately 175.

The Likert portion of the survey strongly indicated the rejection of the null hypothesis associated with the means test indicating the sample sizes were sufficient to identify differences between the two groups (see survey results). The rank order portion of the survey revealed that approximately half of the respondents chose the top three ranked items. According to Cochran (1977), a minimum sample size of about 30 is needed to ensure validity if the population proportion is approximately 0.50. Based on the above guidelines, we would classify any conclusions drawn from the study to be cautiously valid.

### Survey Results

The survey was intended to evaluate the abilities of recent graduates from two different perspectives: industry and academia. The first part of the survey consisted of 12 statements that were rated according to the Likert scale previously described. In comparing the two survey groups, we examined which knowledge areas exhibited significantly different responses between industry professionals and college faculty. To illustrate this comparison, data from both groups were summarized in a single bar graph and listed in descending order of differential magnitude (see Figure 2).

**Figure 2. Combined bar chart for knowledge area ratings.**



The greatest difference between ratings scores occurred in the applying SPC category. A large difference in ratings also occurred in evaluating knowledge of SPC. This is surprising considering the attention and effort expended on this topic by both industry and academia. Other areas that showed a large difference between the two evaluation groups include knowledge and use of equipment, statistical theory, and applying basic statistics. The overall evaluation of recent graduates' knowledge and abilities is noticeably lower from the industry professionals averaging 2.97 compared to the college faculty group which assigned an average score of 3.41. In order to determine whether the differences in

ratings between industry and academia were statistically significant, a means test ( $t$  test) was performed for each knowledge area. The results of these tests are shown in Table 1.

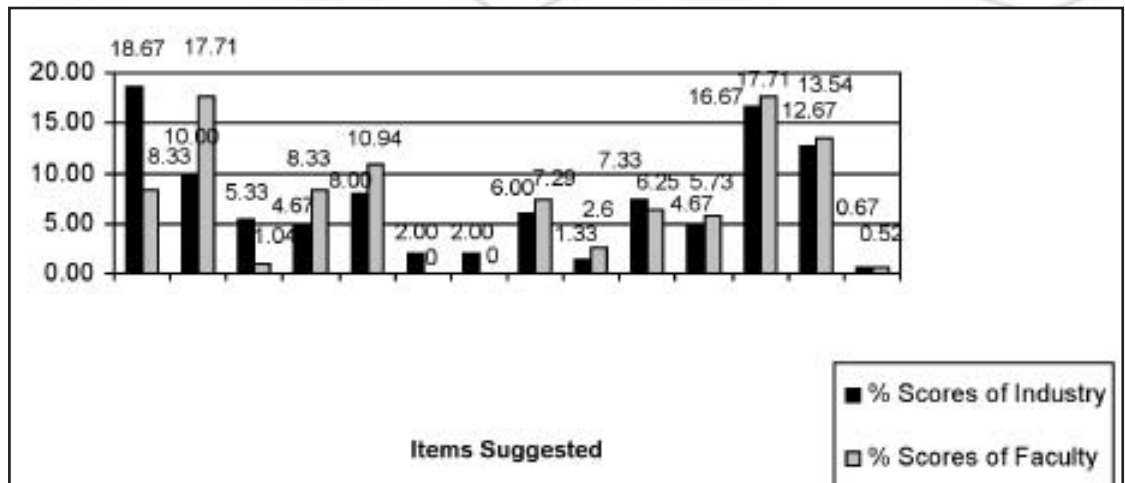
Table 1 indicates a statistically significant difference between industry and academic ratings for SPC theory and application, equipment knowledge and use, and applying basic statistics. In all of these categories the faculty ratings were significantly higher than the industry ratings.

The rank order portion of the survey was designed to identify the most crucial topics that

**Table 1. Means Tests for Theory Versus Academic Ratings**

| Knowledge Area  | Means    |         | $t$ Value | $p$ Value |
|---|----------|---------|-----------|-----------|
|   | Industry | Faculty |           |           |
| Applying SPC  | 2.59     | 3.59    | -4.16     | .000*     |
| Use of equipment                                      | 3.04     | 3.72    | -2.88     | .006*     |
| SPC theory  | 3.04     | 3.69    | -2.51     | .015*     |
| Applying basic statistics                             | 2.96     | 3.55    | -2.13     | .037*     |
| Equipment knowledge                                   | 3.39     | 3.91    | -2.32     | .024*     |
| Basic statistical theory                              | 3.36     | 3.81    | -1.82     | .074      |
| Applying standards—data collection and documentation  | 3.11     | 3.53    | -1.63     | .111      |
| Standards knowledge—data collection and documentation | 3.25     | 3.63    | -1.41     | .166      |
| Applying gage control concepts                        | 2.79     | 3.16    | -1.47     | .148      |
| Gage control theory                                   | 2.93     | 3.25    | -1.24     | .222      |
| Applying non-normal distribution theory               | 2.58     | 2.31    | 1.08      | .287      |
| Non-normal distribution theory                        | 2.61     | 2.72    | -0.43     | .669      |
| Note: $t$ test of mean differences = 0 (vs. = 0).     |          |         |           |           |
| *Meets significance level with $\alpha = 0.05$ .      |          |         |           |           |



**Figure 3. Combined chart for areas needing further attention.**

should receive additional attention in technology-based programs. A bar chart was constructed to illustrate the difference in responses for industry professionals compared to college faculty. The chart shown in Figure 3 lists response differences in descending order of magnitude for all rank order data. The scoring for areas of study needing further attention was noticeably different between industry and faculty responses. Industry scored capability studies and SPC highest (most in need of further attention) while faculty members indicated SPC and design of experiments (DOE) should receive the highest priority. Both groups listed basic statistics among the top three items. Due to the scoring method and an unequal number of participants in the two groups, the raw score was converted to a percentage of the total possible score for each group. A means test was not feasible for the rank order portion of the results due to the complicated scoring method.

### Analysis of Survey Results

The fact that recent graduates' overall skills in quality control were rated significantly lower by industrial professionals than by faculty members may indicate a disconnect between the two groups. Increased interaction and communication between the groups could be helpful in bridging this gap. The greatest differential was assigned to applying SPC skills. SPC is taught as a part of most technical programs and has been recognized as a key quality concept for decades. With great focus on this topic, it is troubling that such a gap exists between industry and faculty perceptions. Applying knowledge to industrial situations requires judgment

and experience that students often do not receive in the classroom. Although this reality is inevitable to some degree, additional classroom projects and laboratory exercises could help address the problem. Perceptions concerning graduates' understanding of SPC theory, knowledge of common equipment, ability to apply basic statistics, and ability to use equipment all indicated a statistically significant difference between industry and faculty ratings. Most of these abilities require the application and practice of theory. The survey results indicate that faculty members may need to focus much more on developing the practical, applied skills of students in order to meet industry expectations.

The rank order portion of the survey identified differences in ratings concerning areas of study needing further attention. Both industry and faculty strongly indicated that SPC and basic statistics should receive more attention in technology-based programs. Industry professionals identified capability studies as the most crucial area for additional coverage whereas faculty members' evaluation of this topic was much lower. The ability to perform and understand capability studies is a critical part of most quality control functions. Industry professionals seemed to indicate that specific, practical skills such as this are very valuable and need much more attention in the academic environment.

Faculty members indicated that DOE should receive much more attention in academic programs whereas industry professionals rated this area much lower. DOE has been touted, and used to a lesser extent, in industry for many

years. Being a more complex area of study, it requires a strong statistical background to be fully utilized. Many in industry who have taken DOE training may still lack the statistical skills to apply it effectively. This may explain the lower ranking assigned by industry; however, the importance of DOE has been clearly established. Montgomery (2001) and Roy (1990) have demonstrated the practical value of applying DOE in industry using various factorial techniques.

### Analysis of Industry Concerns

The results of the survey reveal industry concerns and needs that should be further explored. If academic programs are to be improved, specific experiences and abilities that are lacking must be identified and integrated into industrial technology and engineering technology curricula. To address these issues, in-depth discussions with industry professionals were conducted. The issues identified during these discussions were very similar to those highlighted by the survey. In addition, a review of recent literature and teaching strategies was conducted. The conclusions drawn from these efforts follow.

*Capability studies:* The survey identified capability studies as a major area for improvement. An understanding of how to conduct and interpret these studies is a crucial basic skill in industry. Students are often exposed to the formulas and methods for calculating  $C_p$  and  $C_{pk}$  without gaining a clear understanding of the meaning and importance of the numbers being generated. Exposure to one-sided specifications, non-normal distributions from specific processes, and data collection methods as a part of process capability studies can help strengthen students' skills (T. Dorsey, personal communication, June 6, 2003).

*Statistical process control:* Both faculty and industry surveys indicated that SPC should receive more attention in technology-based programs. Most quality control courses include a study of SPC involving theory and textbook problem solving. This level of exposure may not require enough practice or development of applied skills as the industry survey indicated. Addressing applied skills in SPC provides an excellent opportunity for faculty members and students to interact with local industry. Student projects that involve interaction with local manufacturers and data collection from real process-

es can greatly increase applied skills (K. Hubbard, personal communication, March 10, 2004).

#### *Relating process and product to quality:*

Before any quality control study begins, a clear understanding should exist of the process and product from which the data are to be drawn. Most quality control training in the classroom includes statistical analysis, control charting, and basic procedures without emphasizing how characteristics of the particular process and product can influence the results. Without making this important link, opportunities for error and misinterpretation are endless. Errors involving incorrect subgrouping of data are particularly common in industry (Wise & Fair, 2001). Non-normal distributions are common among many processes such as the wear cycle associated with drilling processes (Oberg, Jones, Horton, & Fyffell, 2000). Exposing students to realistic process characteristics such as this example can strengthen their skills as they begin their careers (T. Dorsey, personal communication, June 6, 2003).

#### *Gage repeatability and reproducibility:*

When collecting data for analysis, assuring that accurate gages and gaging methods are used is a critical first step. Incorrect use of common measuring devices such as calipers and micrometers can be a particular problem (Hewson, O'Sullivan, & Stenning, 1996). Measuring equipment and processes must be well controlled and suited for the particular use in order to assure valid data collection (Little, 2001). Students who receive little or no practical experience with measuring devices have difficulty in understanding the seriousness of this issue. Given that inaccurate gages and gaging methods are common problems in industry, a strong argument can be made for strengthening gage control coverage at the college level (N. Anderson, personal communication, June 4, 2003). Hands-on projects involving gage repeatability and reproducibility (R&R) studies and gage control allow students to integrate knowledge with practical situations, strengthening needed skills in the process (Kemenade & Garre, 2000).

#### *Standards for data collection and sampling:*

Complying with appropriate sampling procedures and documentation practices is critical in most quality control studies. The sampling method should contain enough data to conduct a

complete analysis without the collection of unneeded information that distracts when drawing conclusions (Carey, 2002). An introduction to quality standards and procedures can help better prepare students to address issues such as correct sample size and sample identification, appropriate sampling procedure, and documentation requirements (N. Anderson, personal communication, June 4, 2003).

### Recommendations

Based on the survey results, discussions with industry professionals, and literature review, the following recommendations are made concerning the improvement of quality control education:

- *Improve interaction between industry and academia.* The survey indicated a significant difference in responses from industrial professionals as compared to those from faculty members. Improved communication and exchange of ideas between the two groups is needed. By implementing an industrial advisory board, technology-based programs can take an important step toward this goal. Advisory boards made up of local and regional industry leaders can provide invaluable information concerning what is needed and expected of graduating students. This forum also allows faculty members to introduce ideas and methods that are not well known to industry. Other contacts with industry through student internships and funded research can be quite helpful in keeping the communication lines open. Industry interaction with student organizations through plant tours, guest speakers, and assistance with student projects can also prove beneficial.
- *Increase coverage of statistical process control and capability studies.* The survey strongly indicated that both industry and faculty recommend additional coverage of SPC and process capability analysis. Industry evaluation of recent graduates' applied SPC skills was particularly low. To compensate for this lack of applied skills, additional theory coverage should be combined with a "hands-on" laboratory component requiring process monitoring and interpretation. Realistic problems and complications associated with SPC and process capability that are likely to be experienced in industry should be discussed and included in assignments.
- *Emphasize the combination of practical application with theory.* The industry survey indicated significantly lower ratings for equipment knowledge, equipment use, applying basic statistics, and applying SPC as compared to the faculty survey. These applied skills appear to be lacking as graduates begin their careers. This shortfall can be improved by further emphasizing applied skills and practical application in combination with theory. Examples presented earlier that can lead to the development of applied skills include dealing with complications such as one-sided specifications, using common equipment to measure and collect data, conducting capability studies, SPC monitoring, performing gage R&R studies using real parts and data, and locating and using data collection and sampling standards. These few examples are representative of numerous opportunities for gaining practice and experience in applying theory. Many of these activities can be implemented in the classroom. If additional laboratory time is needed, it should be added into the curriculum.
- *Promote the introduction of new methods and techniques in industry.* New techniques and methods of analysis are often developed and perfected in academia, not industry. More complex methods of analysis and process improvement may not easily be introduced into industry. Although DOE techniques have been used for many years, they are still valued much more in academia than in industry according to the survey. These more advanced methods may require additional support and interaction with industry from college faculty, and may be further introduced by supplying graduates with significant training in these areas. Comments and opinions should not only flow down from industry to academia, but also flow up as education develops new or complex ideas and methods that can benefit industry.

### Summary

Industry respondents evaluated recent graduates' knowledge and abilities in quality control

significantly lower than the same evaluation provided by college faculty. Industry professionals and college faculty have different opinions concerning which areas of study should be further emphasized to improve quality control education. By improving the dialogue and interaction between industry and academia and implementing a more applied education, the quality control component of industrial technology and engineering technology programs can be greatly strengthened.

### Future Research

An important finding in this study was the disconnect between industry and academia concerning which quality control skills most need further emphasis in technology-based degrees. A comparison of student skills after completing

a more traditional lecture-based course versus a more applied course as suggested by this study would be of interest. This information could help determine the potential for improving quality control skills by revising course content and structure.

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## Student Behaviors in the Context of Computer Aided Learning in Design and Technology Teacher Training

E. Stephanie Atkinson

### Introduction

This article discusses the relationship among an individual's cognitive style, attitude to learning, and his or her achievement in the context of computer aided learning (CAL). The results of a small-scale study involving 32 students (18 male and 14 female) studying their first electronics module during an Initial Teacher Training (ITT) Design and Technology degree program at a university in England are reported. Data concerning cognitive style, gender, attitude to CAL, appropriate prior knowledge, and the test results from a unit of work that used a CAL package as the main teaching strategy are analyzed and the relationship between selected variables are discussed. Conclusions pertinent to the students in this study are then drawn.

### Background

In all sectors of higher education (HE), there has been an increasing professional concern with the processes of teaching, learning, and assessment and their management, at a time when economic and technological changes have had a major impact (Dillon, 1998; Somekh, 1998). With the rapid growth in the power and functionality of modern computing and network systems, HE has been encouraged both at a national level and by locally driven initiatives to

embrace technology-assisted teaching and learning strategies (Boucher, 1998). In the context of this article, the technological changes referred to by Dillon (1998) are centered on the developing use of CAL packages to meet both lecturer and student needs within electronics modules in an ITT Design and Technology degree program.

The broad objectives for developing technology-assisted teaching and learning were first set out in 1996 after the Higher Education Funding Council for England (HEFCE) commissioned a six-month research study of information technology-assisted teaching and learning (ITATL) in HE. Primarily these objectives were to make teaching and learning more productive and efficient, to enhance the learning experience of students, and to widen access to HE through its delivery in new and different locations (Tearle, Davis, & Birbeck, 1998).

During recent years, a great variety of educational software has been designed that would support students' learning. Pedagogical advantages and disadvantages of such materials have been well researched (Alexander, 1995; Boucher, Davis, Dillon, Hobbs, & Tearle, 1997; Dillon, 1998; Ford, 1999; Lee, 1999; National Council for Education Technology [NCET], 2000; Pillay,

1998; Steurer, 1992). Benefits have been reported in terms of individualized learning that can be self-paced, self-accessed, asynchronous, synchronous, provide nonsequential based delivery, include positive motivational interactive features, while affording access to more accurate appraisal and documentation of learners' progress. Research has indicated that the hierarchical linking arrangements that facilitate browsing can also act as an aid to learning. The merging of formally separate media in a manner that allowed associations or links between the various elements (Ebersole, 1997) and under certain circumstances the modification of the form of the material being presented, by the learner themselves, have also been cited as positive features of CAL resources (Pillay, 1998; Steuer, 1992). At a time of considerable expansion in HE, the hope that Information and Communication Technology (ICT) could deliver a more cost effective teaching and learning environment has also played a significant role in its development (Somekh, 1998). However, there have been expectations without due regard to the difficulties that are an inevitable part of any technological innovation in education. Disadvantages have been cited (Ferris, 1999; Mak, 1995) in terms of the teachers' deficiency in understanding the differences between the pedagogy and philosophy underpinning the use of CAL and traditional learning materials in a university environment (Jones, 2001). There is also the lack of training for lecturers to exploit its potential (Oliver, 1994), and the need for appropriate technical support. In the context of the CAL materials themselves, many of the interfaces employed at present have been confusing and opaque to many users. For example, the absence of personal contact and clarity of message due to the nonexistence of physical presence, voice intonation, gesture, and other tacit cues (Harasim, 1989; Moore, 1992), together with the difficulty in conveying humor, irony, and subtle nuances of meaning (Feenburg, 1989), have all been shown to be disadvantageous for certain types of learners. It has also been shown that the nonlinear organization of information highlighted by many as an advantage has proved to be a distinct disadvantage for other users (Edwards & Hardman, 1989). Gygi (1990) referred to a lack of "discourse cues," whereas Shum (1990) talked of the

need to reduce cognitive overload for the user by designing better cognitive maps that would aid the user's navigation through the CAL materials.

Ebersole (1997) described designing effective interactive media as a daunting proposition. He explained that in addition to the collection and organization of useful content the designer of CAL materials must create a user interface that facilitates access to the content. He and others (Lord, 1998; Pillary, 1998; Recker, 1995) all believed that learning materials should be crafted with careful attention to the mental processes and learning style that the user was likely to employ. Learners have been seen to waste valuable time navigating an erratic course through the complex structure of the materials provided for them often because they have been unable to acquire the original author's structure and map it on to their own learning style (Alexander, 1995; Shum, 1990). It would therefore seem important that all learning materials, whether they are for traditional or CAL environments, should be cognitively well designed.

Just as an ergonomically designed chair is well adapted to the physical requirements of its user, so a cognitively ergonomic learning resource is well adapted to the learning requirements of its user. (Ford, 1999, p. 188)

The terms *cognitive style* and *learning style* have been widely used by educational theorists for the past 60 years. Terminology has varied from writer to writer (Curry, 1983; Dunn & Dunn, 1993; Riding & Cheema, 1991). On some occasions the terms have been used interchangeably, while at other times they have been afforded separate and distinct definitions (Cassidy, 2003). However, many (Biggs & Moore, 1993; Goldstein & Blackman, 1978; Riding & Pearson, 1994; Tennant, 1988; Witkin, Oltman, Raskin, & Karp, 1971) have agreed that cognitive style is a distinct and consistent way for an individual to encode, store, and perform, and one that is mainly independent of intelligence, whereas learning style "is adopted to reflect a concern with the application of cognitive style in a learning situation" (Cassidy, 2003, p. 81).

As the relevant research base on cognitive style has grown, so has the number of terms

used to describe cognitive style groupings. Riding and Rayner's (1998) analysis of the multiplicity of constructs concluded that the terms could all be grouped into two principal cognitive styles and a number of learning strategies. They referred to these cognitive style dimensions as a "Wholist-Analytic Cognitive Style Family" and a "Verbalizer-Imager Cognitive Style Family." The Wholist-Analytic style they defined as the tendency for individuals to process information in wholes or in parts, whereas the Verbalizer-Imager style they defined as the tendency for individuals to represent information during thinking verbally or pictorially. They believed that these dimensions were totally independent of one another.

Many notable investigations have been carried out concerning the relationship between cognitive style and ability. Witkin et al. (1977) differentiated between cognitive style and ability by emphasizing the bi-polar nature of cognitive styles, unlike intelligence and other abilities. They suggested that each pole of cognitive style had adaptive value under specified circumstances, whereas having more of an attribute such as intelligence was better than having less of it. This difference was well defined by Riding (1996). He explained that the basic distinction between cognitive style and ability was that performance on all tasks would improve as ability increased, whereas the effect of style on performance for an individual would either be positive or negative depending upon the nature of the task and the way in which it was presented to the learner.

In traditional teacher-led, paper-based environments, learning in matched conditions (instructional style matched to the student's preferred learning style) has been demonstrated to be significantly more effective than learning in mismatched conditions in many instances (Ford, 1999; Pask & Scott, 1972). Research findings using a sample of school children indicated that this was especially the case for young pupils and those of low ability. Conversely, more able pupils, who were given the opportunity to use mismatched learning materials at times, were shown to develop learning strategies that coped with a wider range of materials and experiences on future occasions (Riding & Rayner, 1999).

In the context of CAL environments, Ford (1999) suggested that it would be tempting to think that the potential navigational freedom inherent in such systems meant that mismatched education was a thing of the past, although he believed that the potential for navigational freedom was frequently not recognized by the learner nor were they always able, or willing, to use such freedom optimally, or even effectively, in relation to their preferred style of information processing.

Traditionally, learning materials in a university environment have been presented mainly in a text format. However, with the shift from an elite to a mass higher education system (Rumble, 1998) it has become increasingly important that materials are provided in a variety of forms that are able to match individual student learning style preferences. CAL packages, if designed to do so, have the potential to provide materials that can meet this need and be more sensitive to style differences.

The CAL package "units of learning" under consideration in this article were part of a suite of mixed media, blended learning materials developed over the past 25 years by LJ Technical Systems ([www.ljgroup.com](http://www.ljgroup.com)). These materials have been successfully and extensively used in schools and further education colleges across much of the world, particularly in America, the Middle East, and the United Kingdom (UK), although this was the first time a university in the UK had used these materials as part of one of its degree programs. The CAL package used in this instance had four primary objectives:

- Understanding electrical quantities and the use of instrumentation for their measurement.
- Identification of individual components and measurement of their characteristics.
- Synthesis of simple circuit building blocks based on components investigated.
- Location and identification of computer inserted "faults" within the investigated circuits.

The software was linked to a dedicated electronics base unit, and various subcircuit modules were connected to this for the investigations. All connections were by removable wires and link

pins, so no circuit construction skills were required. The tasks were presented in the form of an “on screen” manual but copies of this could be printed and retained by the students as a log-book of activities. The answers were entered in a separate window and took a variety of forms. These were predominately multiple choice, or yes/no question formats, but in some instances numeric answers were required. In the case of calculations, the system required the exact value for a mark to be awarded, but when entering measured quantities, any value within a certain range would be accepted because of component and instrumentation tolerances. Within a particular group of questions, the student was free to go back and alter an answer as often as necessary. However, students were unable to proceed to the next group until that section was submitted and marks allocated. Failure to achieve a certain minimum score would also prevent progression to the next stage and tutor intervention was then required.

The educational theorist would hope that the fundamental purpose of assessment is to give feedback to learners and thereby enrich their learning experience. In the past the culture and traditions of universities have been deeply rooted in enriching learning. However, recently there have been indications that the purpose of assessment in HE has changed. Factors such as government interventions, the massive increase in the numbers of students entering higher education, the change in the character and needs of the student population, the worsening staff-student ratios, the requirement for accountability, and clarity in the relationship between learning objectives, learning outcomes, and assessment criteria have all led to the development of a predominantly categorizing assessment culture within many universities.

Most of the investigations into the advantages of assessing students using ICT have assumed the educational theorists’ point of view, yet the use of CAL in university environments has brought the tensions between enriching learning and the need to categorize students into sharp focus. By their very nature, CAL-based systems are designed to facilitate the maximum number of positive outcomes for a cohort of students—be this by allowing repeated attempts

until the correct outcome is achieved, by offering unlimited time for grappling with the issues in hand before offering a response, or even by allowing group discussion of a problem before arriving at a consensus viewpoint. However, the very process of accommodating these differing learning strategies in this manner can generate relatively undifferentiated results for a cohort of students, with all of them achieving fairly high mark levels.

With the rapid growth in the use of CAL within university environments, and the research evidence to suggest that various factors could affect learning and achievement within that context, it seemed pertinent to the authors of this article to design a small-scale research project that could examine the relationship among attitude, cognitive style, learning, and achievement in the context of a CAL package that was being used to teach electronics.

## Methods and Procedures

### *Sample and Components*

The purposive nonprobability sample referred to in this article comprised the total 32 students (18 male and 14 female) studying their first electronics module during an ITT Design and Technology degree program at a university in England.

The following components were used:

1. **Cognitive Style.** A well-established cognitive styles analysis (CSA; Riding, 1991), which was computer presented and self-administered, was used. This indicated a student’s position on both the Wholist-Analytic (WA) and the Verbal-Imagery (VI) dimensions of cognitive style (Riding & Rayner, 1998) by means of an independent ratio for each. Every member of the sample carried out the CSA in the manner prescribed in the CSA administration documentation.
2. **Attitude to CAL.** The attitude of individual members of the sample to working with and using computers as a tool for learning was tested by means of a 58-item summated rating scale. Each of the items on the scale was subjected to a measurement of its discriminative power (DP). The 35 items with the highest DP



indices were selected to establish an attitude score for each student.

3. **Achievement.** One set of test results was used in this study. The test used was designed by LJ Systems and embedded in the CAL material. The overall mark for the module was calculated using the marks awarded for each task as described earlier in the article, together with a posttest which provided alternative scenarios that once again tested the learning that had taken place. As explained earlier, all the tests were computer generated and marked although they also required practical skills in creating the physical circuits and cognitive skills in linking the literature to the associated schematic diagrams, interpretation of instrumentation data, and the development of deductive reasoning to identify faults. The results were automatically summated and stored directly onto the computer managed learning (CML) system database. In line with university quality assurance requirements, all assignments were then both internally and externally cross-moderated to assess validity and reliability of both the marks and the materials being used. The students completed the module test before any of the other data for the study were collected.
4. **Prior Knowledge of Computing and Electronics.** A questionnaire that requested information regarding the previous computing and electronics experience of each student was used. Questions concerning computing and electronics were asked separately and involved examinations taken in computing and electronics prior to starting the degree program and any school or work experience in industry utilizing computing or electronics skills prior to starting the degree program. The answers were separated for scoring purposes into those that concerned previous experience in electronics and those that concerned previous experience in computing. A student who had studied an examination and had school or industrial experience in electronics or computing was given a score

of 2, whereas a student who had only experienced one of those situations was given a score of 1. A student with no experience of either situation was given a score of 0.

A student's perception of the newness of electronics and computing skills required to complete the module successfully was established through a second part of the questionnaire. This provided students with two statements, one regarding the newness of the electronics skills required in the module being studied and one about the newness of using computers for learning. These both needed a summated scale response. These were scored between 0 and 2. A score of 0 was given to those who indicated that all the materials were new to them, and also to those who said that they had not used a computer for learning before. A score of 1 was given to those who indicated that most of the materials were new to them, and also to those who said that they had sometimes used a computer for learning before. A score of 2 was given to those who indicated that little of the materials were new to them, and also to those who said that they had often used a computer for learning before.

5. **End of Module Feedback.** In line with all university modules, anonymous written feedback was collected from students using an optically read questionnaire. This feedback is primarily used to monitor the educational health of the module. However, it also provides the module leader with data on aspects of the module that students perceived as particularly helpful and areas of the module in which they believed their learning could have been enhanced if things had been approached differently.

## Results and Discussion

### *Cognitive Style*

Recent debate into the stability and internal consistency of many cognitive/learning style models (Coffield, Mosely, Ecclestone, & Hall, 2003; Peterson, Deary, & Austin, 2003; Riding, 2003) was taken into consideration when

methods of analyzing the collected data were designed. Initially, the data were analyzed using the raw CSA ratios as suggested by Peterson et al. (2003). However, no linear correlation with any of the variables under discussion was found, so it was decided to group the sample by the well used cognitive style categories defined in the CSA administration documentation, as these labels seemed appropriate to this research project. The WA ratios of the total sample ranged from 0.700 to 2.910 with a mean of 1.412 ( $SD = 0.463$ ). The male and female means were, respectively, 1.392 ( $SD = 0.475$ ) and 1.436 ( $SD = 0.459$ ). The gender difference was not significant ( $p = 0.7408$ ). The VI ratios ranged from 0.750 to 1.430 with a mean of 1.094 ( $SD = 0.148$ ). The male and female means were, respectively, 1.096 ( $SD = 0.143$ ) and 1.091 ( $SD = 0.157$ ). The gender difference was not significant ( $p = 0.9104$ ). The correlation between the two cognitive style dimensions was -0.153, attesting to the orthogonality of the two dimensions (cf. Riding & Cheema, 1991; Riding & Douglas, 1993). In comparison to the CSA standardization sample ( $N = 999$ ) referred to by Riding (2000), the sample reported in this study had very similar mean scores on each dimension, both as a total sample and when divided by gender. However, the sample in this study did not have subjects at the extremes of either dimension. This was particularly noticeable at the Wholist end of the WA dimension and the Imager end of the VI dimension.

This later result was initially very surprising, as it had been expected that many of the sample would have been “strong” imagers because these students were training to become design and technology teachers where the need to be able to manipulate images in the mind during design activity was recognized as a valuable skill. However, as prospective teachers, the need to be able to work equally competently with both text and diagrams and be able to communicate with pupils at the extremes of a dimension would suggest that being at the center of a dimension could be an advantage. In this study, the categories on the VI dimension were fairly evenly divided into 9 Verbalizers towards one end of the dimension, 13 Bimodals around the center, and 10 Imagers towards the other end of

the dimension.

With regard to the WA dimension, in both the task of being a successful teacher and a successful design technologist, the authors would suggest that being strongly Analytic or Wholist could be an advantage at certain times and a disadvantage at others. Data from this study indicated that the sample on the WA dimension was unevenly balanced. It was predominantly Analytic ( $n = 20$ ) with only 7 Intermediates around the center of the dimension and 5 Wholists at the other end of the dimension. It was therefore recognized by the researchers that this skewed distribution could affect results and needed to be borne in mind during data analysis.

### *Attitude to Using CAL*

The data concerning student attitude to CAL was scrutinized using descriptive statistics. The maximum score that could have been achieved was 165 and the minimum was 35. The actual maximum score achieved was 153 and the minimum score was 69. The distribution was negatively skewed (skewness = -0.251) with an overall mean score of 117.281 and a standard deviation of 22.036.

When individual student scores for attitude were placed in rank order and split into equal sized quartiles (top, 2<sup>nd</sup>, 3<sup>rd</sup>, bottom) there was the expected significant difference between the mean attitude scores for each quartile.

There were no significant differences between the attitudes of male and female students to using computers for learning.

### *Achievement*

The pass mark for the test was set high at 60% in order to try to overcome the problem highlighted earlier in this article concerning CAL's ability to facilitate the maximum number of positive outcomes and the need to differentiate between students' achievement within the electronics module. All students in the sample took the test and achieved a mean score of 73.938 with a standard deviation of 17.212. Six students failed and 10 students achieved scores of 90% or over. There was no significant difference between male and female students, although in both attitude to using computers as a

learning strategy and in the test results, females achieved lower mean scores than their male counterparts.

### ***Previous Experience***

All members of the sample provided their answers to the questionnaire regarding previous experience and newness of computing and electronics as described in the methods section of this article. In analyzing the data regarding previous computing activity, everyone in the sample had some previous experience of using computers although only six of the students had studied for an examination and used computers in an industrial context. It was therefore not surprising that 16 of the sample did not believe that they had had to learn any new computing skills in order to use a computer as a learning tool in this instance, whereas nine suggested that they had had to learn some new skills and seven had found that learning using a computer was very new to them.

With regard to previous electronics experience, a significant 28 students had no previous experience of electronics prior to starting their degree program, two had taken an examination or had industrial experience, and only two students had taken an examination and had industrial experience of electronics. It was therefore not surprising that a significant number of the sample believed that the electronics material was either entirely new to them or mostly new to them. Only four students believed there was little new material to learn.

### **The Relationship Between Variables**

It was the intention of the authors to discuss the relationship between and among all the variables in the study. However, during analysis it became apparent that in certain combinations of the variables the cell size became too small for meaningful analysis to be carried out. The relationship between cognitive style and attitude to CAL; cognitive style and achievement; attitude, prior experience, and achievement were found to be statistically feasible. These are discussed in the following paragraphs. Issues associated with gender have also been included whenever the cell size permitted.

### ***Cognitive Style and Attitude to CAL***

When the two separate cognitive style dimensions were scrutinized in relation to attitude to CAL, there was found to be a significant difference between the mean scores for the three categories on the two dimensions ( $p = < 0.0001$  in both instances). On the VI dimension, the largest difference was between Imagers and Verbalizers. Imagers were the most positive and Verbalizers the least positive. On the WA dimension, Wholists were the least positive and Intermediates, at the center of the dimension, the most positive. When comparing the two dimensions, it could be seen that Wholists were even less positive than Verbalizers in their attitude to CAL while Imagers were more positive than Intermediates.

This result would suggest that poor attitude to CAL may be influenced more by the segmented nature of the CAL materials than whether those materials were biased towards the use of images or text. However, it must be remembered that the skewed distribution of the sample on the WA dimension may or may not have influenced this result.

### ***Cognitive Style and Achievement***

When the two cognitive style dimensions were scrutinized separately in relation to test scores, there was found to be a significant difference between each category on both dimensions ( $p = < .0001$  in both instances). Intermediates achieved a high mean score, while Wholists achieved a much lower mean score. On the other dimension, Verbalizers achieved the highest mean score and Bimodals, at the center of the dimension, the lowest. When the rank order for both attitude and achievement in the test were compared, it could be seen that on the WA dimension there was a positive relationship between the two variables. However, on the VI dimension Verbalizers were ranked lowest in attitude to CAL while they managed to achieve the highest mean score in the test.

Some explanation for the unexpected inverse relationship between Verbalizers' attitude and achievement was sought. An analysis of the CAL materials indicated that the balance between the pictorial and text based material remained relatively constant throughout and it

was felt that neither had a preponderance of sufficient significance to skew the outcomes. The explanation was thought to lie not so much in the way that the tasks were presented but more in the way that the content was organized. Quite complex text based instructions were designed to become much clearer when linked to their corresponding diagrams. The Verbalizer, in avoiding use of image and remaining focused on text, may have needed to read and re-read the material before gaining sufficient understanding to proceed. Such difficult and time consuming tasks may perhaps explain the resulting low CAL attitude scores, but this very investment of time in a task that they perceived as difficult may have led to a deeper understanding of the requirements and therefore the higher level of achievement.

Further examination of the VI data led the researchers to examine the possible reasons for the low mean score of Imagers in the context of their high attitude score. Such individuals could have been expected to have higher levels of satisfaction resulting from their focus on diagrams and the relative ease with which they were able to correctly build circuits from the visual information. Such activity one expected could have engendered the more positive attitude to CAL. However, the assessments required careful reading of accompanying text, which explained settings required before measurements could be taken and answers given. Those Imagers who were not as thorough in their attention to reading the text could therefore expect significantly lower scores as a result.

#### ***Attitude to CAL, Prior Experience and Newness of the Materials, and Achievement***

When data concerning attitude to computing and previous experience and newness of electronics were combined, a positive relationship was found. Students who believed that there was little new electronic materials to learn had the most positive attitude to using computers in their quest for knowledge, while students who believed that all the material they had to learn was new to them were the least positive. The difference in attitude between the top and bottom groups was found to be significant ( $\chi^2 = 61.350$ ,  $p = <0.0001$ ). The anonymous "End of Module Feedback" supported a possible explanation for this outcome. Although the whole sample indi-

cated that they recognized the advantages that independent learning using CAL could offer, there was still a general feeling of resentment that the lecturer had not been "on call" for support when needed. Those with more experience of electronics naturally had a more secure mental "scaffolding" to support the leaps of intuition needed for progress beyond an impasse and such success seemed by its nature to have led to a degree of comfort in working with information technology (IT). Conversely, those with little electronics experience had no background to draw from to help maintain progress. Being unable to converse with the computer for the help needed led to an inevitable frustration with IT and the poorest attitude score.

When the test results were scrutinized with the student perception of the level of new electronic materials present in the CAL program as a second variable, it was found that the mean scores for those who found the materials new to them followed the expected pattern; they achieved the lowest mean marks. However, the mean marks for the other two groups were not as expected. Those who believed that there was little new material did not achieve as high a mean mark as those for whom the electronic materials were mainly new knowledge. Observation of the students while they were using the CAL materials suggested a reason for this. Many of the students who had not studied electronics before recognized their deficiencies and were prepared to invest the substantial amount of time needed to become cognizant. Their newly learned knowledge and understanding then led to success in the tests. Whereas many of those who believed that they already knew much of the electronics needed were seen to bypass the supporting materials available on the computer, moving directly to the tests. The weaker score for this group indicated that this confidence was generally misplaced.

When data from the questionnaire concerning students' personal level of computing experience prior to taking the electronics modules were analyzed in conjunction with attitude to CAL, the result once again indicated a significant positive linear correlation between the two variables (Fisher's  $r$  to  $z$ ;  $p = .0032$ ). Those with previous computing experience were the most positive



and those with little computing experience were the least positive about having to use CAL to gain their electronic knowledge and understanding.

A further scrutiny of the data also indicated that there was a positive linear relationship between test results and the level of previous computing skills. Those with the most previous computing experience achieved the highest test results and those with little previous computing experience achieved the lowest result. In fact, when compared to the achievement data split by levels of prior electronic knowledge, it could be seen that levels of computing skills prior to the start of the module had a more marked effect upon achievement than the amount of electronics knowledge known before studying the module.

### Conclusion

The evidence for this study was collected using a small purposive nonprobability sample. Consequently, it was not statistically possible to generalize to a larger population. However, the data gathered provided a useful picture of the relationship that existed between CAL materials, appropriate prior knowledge, cognitive style, and attitude to using computers as a learning tool, as well as ability to achieve when using such materials, for this specific cohort of students.

The data indicated that those students who had no previous electronics experience were significantly less positive in their attitude to using computers as a learning strategy in comparison to those who had prior skills in electronics. It was also found that there was a linear correlation between previous computer experience and attitude to using computers as a learning tool and previous computer experience and levels of achievement in the electronics test. The data from this study also indicated that computing skills were possibly more important for achieving high marks within the CAL situation under

consideration than the level of previous electronics knowledge.

With regard to gender differences, there was found to be no significant difference between male and female students in either their attitude to computing or in their levels of achievement when using the CAL materials under scrutiny, although in both instances males achieved a higher mean score than females.

With regard to the relationship between attitude, achievement, and cognitive style, it was unfortunate that the sample was not evenly distributed between the three categories on one of the two cognitive style dimensions. However, the results on the VI dimension, where the distribution of the sample was evenly spread, provided evidence to suggest that there was a different relationship between students' attitudes to using a computer as a learning strategy and their ability to achieve using such materials depending upon their cognitive style. The authors of this article suggest that CAL packages designed to present materials in a different manner to learners with different learning style preferences may well help those learners to achieve their full potential in terms of learning and achievement in comparison to software that does not have this facility.

The results of this research have also provided the stimulus for the authors of this article to continue collecting data from subsequent groups of students to see if these findings are replicated with a larger sample size that can add credence to the conclusions drawn from this initial small-scale study.

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## The W. E. B. DuBois and Booker T. Washington Debate: Effects upon African American Roles in Engineering and Engineering Technology

Keith V. Johnson and Elwood Watson

The messages of Booker T. Washington and W. E. B. DuBois could not have been more diverse. The philosophical rivalry between Washington and DuBois has deep historical roots. To be on the same side fighting for the same purpose, progress, and uplifting of the Black race, these two Black intellectuals harbored radically divergent views on how to assist African Americans to free themselves from their often subhuman conditions. Both men were aware that technological advancement was of foremost importance to the advancement of African Americans. Washington's (1901) *Up From Slavery* and DuBois' (1903) *The Souls of Black Folks* were immediately hailed as classic commentary due to their efforts to address the then "Negro" problem in America. There were a number of Black Americans who made a valiant effort to mitigate poverty, illiteracy, racial discrimination, high mortality rates, and other des-

olate conditions that plagued many African Americans, particularly at the turn of the century. However, due to their influential appeal among certain constituencies, both Washington and DuBois garnered ample attention from many segments of the American intelligence, many of which were European in ethnic origin. Thus, acknowledgment from the White power structure (this was particularly true in the case of Washington) provided both men a platform to promote their message.

Washington was a student at Hampton Institute and became convinced that vocational education was the only means by which Blacks would become successful in America. In 1881 Washington went to Alabama and founded Tuskegee Institute, where he put into practice his belief that the ultimate solution to the race problem was for Blacks to prove themselves

worthy by becoming reliable and superior laborers, eventually making themselves indispensable to the economic well-being of the country. In order to accomplish this, Blacks needed the right form of education: an education that would be beneficial in an economic sense. Given his experience at Hampton, Washington felt that industrial education was superior to academic education for achieving his goal of Black social improvement (Spivey, 1978). As quoted in Franklin (1973), Washington believed that Black education “should be so directed that the greatest proportion of the mental strength of the masses will be brought to bear upon the everyday practical things of life, upon something that is needed to be done, and something which *they will be permitted to do* (emphasis added) in the community in which they reside” (p. 285). The basic philosophy of industrial education as practiced at Hampton and Tuskegee was quite simple. The training in various domestic and trade skills within an authoritarian and religiously based environment would produce a Black who would fit into the lower end of the occupational structure and, more important, know his or her place among Whites and come to accept that place as proper.

Such a form of education was just what White society sought. For Southerners, it would keep Blacks subservient and exploitable. For Northerners, it would serve as a way of calming racial tensions and providing a well-trained laboring underclass that could be used in the effort to industrialize the South. For these reasons, wealthy philanthropists in both the North and the South were willing to give large grants to institutions that adopted this vocational model while ignoring those institutions that remained academically oriented (Franklin, 1973; Quarles, 1969; Winston, 1971).

The results were as dramatic as they were devastating. The ideology of vocational education became the panacea for the race problem in America. Except for a few institutions of higher learning (Fisk, Atlanta, and Howard), Black colleges took the financial windfalls and adopted the vocational curriculum. Educationally, vocational training was a failure: It not only failed to prepare Blacks to move up in society, but it also guaranteed that they would move down. The emphasis on manual training and the trades served to destroy the educational aspirations that had been aroused during Reconstruction and wiped out the hope that education could

provide a way out of poverty. By 1930 industrial education was seen as a “cynical political strategy, not a sound educational policy” and proved to be the “great detour” for Blacks from which they are just beginning to return (Winston, 1971, p. 683).

Booker T. Washington was born a slave on the plantation of James Burroughs near Hale’s Ford, Virginia (Harlan, 1970). During the period of Washington’s prominence, from the 1890s until his death in 1915, probably the leading ideological orientation of American Negroes centered on the development of Negro business enterprise through a combination of thrift, industry, and racial solidarity, or Negro support of Negro business (Kusmer, 1991). Although the philosophy of “self-help” has largely been credited to Washington, this was a message that was very much in vogue as far back as the 1850s. It experienced a renaissance during Reconstruction, particularly among educated African Americans. The advocates of this progressive form of African American empowerment argued that African Americans, despite facing rampant discrimination, disenfranchisement, Jim Crow laws, and other forms of oppression, must turn from being defensive toward the capitalist system and adopt proactive methods of combating such a system. Once African Americans had proven their ability to help themselves and to acquire wealth and respectability, it was believed that prejudice and discrimination would disappear. During the mid 20<sup>th</sup> century, there were Black academics such as the late E. Franklin Frazier who argued that there were African American businessmen who were not above exploiting the masses of Blacks to augment their own economic welfare (Frazier, 1957).

At the close of the 19<sup>th</sup> century, the entrepreneurial class in the Black community depended in considerable part upon the support of White customers. Though the range of occupations varied from city to city, this group was composed primarily of blacksmiths, tailors, barbers, and other skilled artisans, hackmen and draymen, grocers, and less frequently meat dealers, hotel owners, caterers, real estate dealers, and contractors (Kusmer, 1991). Along with civil servants, teachers, pullman porters of upper class status, domestic servants in the most elite White families, the more eminent and better educated ministers, a few doctors, and an occasional lawyer, the more successful among



these entrepreneurs composed the upper echelon of the African American community in the late 19<sup>th</sup> century (DuBois, 1899).

By about 1900, however, significant economic and social changes were well under way. A growing antipathy on the part of Whites toward trading with Black businessmen coupled with rapid changes in technology and business organization forced many of these small entrepreneurs out of business. At the same time, the increasing urbanization of African Americans provided an economic base for professional and business men who were dependent on the services of African Americans (Meier, 1963). These services included banks, cemetery and realty associations, insurance enterprises, and numerous retail and service establishments (Meier, 1963). Previously established businesses such as newspapers, morticians, and retail merchants had depended upon the money that the upper middle class African American community had spent for their goods. By this juncture this economic class had increased in size. It was during the first two decades of the 20<sup>th</sup> century that two of the largest Black fortunes—that of R. R. Church, real estate magnet in Memphis, Tennessee, and Madame C. J. Walker, creator of the straightening comb and the first Black female millionaire—were created (Pierce, 1947). Walker was a profound example of early 20<sup>th</sup> century Black technological genius. It was the combination of the aforementioned factors of Black entrepreneurship that both Booker T. Washington and, to a lesser degree, W. E. B. DuBois attempted to espouse to the African American bourgeoisie (Meier, 1963).

Throughout American history, the Black upper class had an easier time obtaining an economic and technological based education than their brethren in the lower class. Because of this fact, they tended to be more acquainted with current scientific technology. Depending upon the city, the members of this socioeconomic class varied. In New Orleans the Black upper class consisted of free people of color. In Charleston, South Carolina, artisans, contractors, barbers, and postal employees represented the African American upper middle class. In cities such as Atlanta and Durham, there was a substantial entrepreneurial class that DuBois called the group economy. In Washington, DC, the situation was unique due to the large number of government workers and politicians. For many years (this was the case in many African

American communities, both urban and rural), ministers, teachers, and a few small businessmen (particularly after the Civil War) were the African Americans who were more inclined to gravitate toward technological pursuits (Meier, 1963).

Because of their diverse views on how to reduce the reductive circumstances of African Americans, both Washington and DuBois had viewed technology from different perspectives. Washington was a Southerner who harbored deep suspicion about the Black intellectuals who dwelt in the northern cities or attended the southern colleges that he never attended. He dismissed their arcane knowledge as too much from books and too little from life.

Washington was different than most Southerners in the fact that he was astute to the fact that in a capitalist society that it was pertinent for African Americans to become skillfully adept to the ever-changing economy. He knew that becoming technologically efficient was one such way to do so. This Black man who was the offspring of former Virginia slaves founded Tuskegee Institute in 1881. This was only four years after the Hayes/Tilden Compromise that officially ended Reconstruction in the South in 1877. Beginning with a few ramshackle buildings and a small sum from the state of Alabama, he built Tuskegee Institute into the best-known African American school in the nation. While not totally negating academic training, the school's curriculum stressed industrial education, training in specific skills and crafts that would prepare students for jobs. Washington built both his school and influence by tapping the generosity of Northern philanthropists, receiving donations from wealthy New Englanders and some of the leading industrialists and businessmen of his time, such as Andrew Carnegie, William H. Baldwin, Jr., Julius Rosenwald, and Robert C. Ogden.

Thus his establishment of Tuskegee Institute was the cornerstone for future goals that he harbored for African Americans. Washington's reputation as the principal of Tuskegee Institute grew through the late 1880s and 1890s; his school was considered the best exemplar of industrial education, viewed as the best method of training generations of African Americans who were either born into slavery or were the sons and daughters of freed slaves. His control of the purse strings of many of the



Northern donors to his school increased his influence with other African American schools in the South.

It was his legendary Atlanta Compromise speech that firmly defined Washington as a man who was deeply immersed with economic and technological advancement. It was during this speech that Washington urged African Americans to refrain from adamantly attempting to integrate with White America. Rather, he advocated a gradual emancipation of African Americans through hard work, economic improvement, and self-help (Washington, 1901). Technological advancement was an integral part of his message. His rhetoric gained universal acceptance among many Whites and a large number of Blacks.

What distinguished Washington from DuBois and many other African American leaders of the early 20<sup>th</sup> century was his philosophy that Black Americans had to keep ever faithful to the virtues of sacrifice, discipline, delayed gratification, and most important, economic salvation for their own communities.

The wisest among my race understand that agitation of social equality is the extremist folly, and that progress in the enjoyment of all the privileges that will come to us must be the result of severe and constant struggle rather than of artificial forcing. No race that has anything to contribute to the markets of the world is long in any degree ostracized. It is important and right that all privileges of law be ours, but it is vastly more important that we be prepared for the exercise of these privileges. The opportunity to earn a dollar in a factory just now is worth infinitely more than the opportunity to spend a dollar in an opera house. (Franklin & Starr, 1967, pp. 85-87)

Washington argued that business and technological acumen were paramount. This was the means by which the African American masses would prosper. He believed that cultured-based education was secondary and could be pursued at a later date.

DuBois concurred with Washington that progress among the Black race had to occur, but he believed that it would be more aptly served through a trickled down means. DuBois was born to a white French father, Alfred DuBois,

and Mary Burghart DuBois, a Black woman, in Great Barrington, Massachusetts, in 1869. He was what many people referred to in those days as “mulatto” or in contemporary terms, biracial. Unlike many Americans (Black or White) of the time period, his stellar educational opportunities afforded him a national platform for him to espouse his message. He earned his BA at Fisk University in 1888, another BA at Harvard in 1890, and later his doctorate in 1895. He was the first African American to earn a PhD at the institution (Aptheker, 1951). Ever determined to uplift Black Americans from poverty, he focused on how the skills of the Black professional class could be utilized to achieve this goal.

It was during this time period that the North was experiencing a large number of immigrants from Europe as well as a large number of African Americans migrating from the South. This fact provided for potentially volatile relationships between the newly arrived immigrants and the native born Black population. White Northern businessmen, primarily due to more familiarity and comfort with Europeans who shared their ancestral lineage, mores, and customs, began to align themselves with Jews, Greeks, Italians, and other White ethnics which, in turn, either marginalized or prohibited Black Americans from being able to provide services to their communities (Butler, 1991).

With regard to this problem, DuBois engaged in a major study of the city of Philadelphia. His work focused on four social classes within the city. The top 10% he called an upper class or aristocracy. These people included entrepreneurs and professional people. These people had decent jobs and their children attended the best schools. Group two was the respectable working class. These individuals were primarily made up of servants, waiters, porters, and laborers. This was a class that was eager to engage in upward mobility. The third group of African Americans was referred to as the poor. It was made up of recent immigrants who could not find work, unreliable persons, widows, and wives of broken families. The lowest class (about 6% of the Black population) was labeled as criminals (DuBois, 1899).

Because of the great discrepancies that existed between the two groups, upwardly mobile African Americans were able to successfully distinguish themselves among other

classes in the city. Class has often been used as a distinguishing feature of American society, especially among White Americans. However, it is also true that similar situations were commonplace among Black Americans as well. Upon his conclusion of studying African Americans in Philadelphia, DuBois decided that the only way that African Americans could advance was through the leadership of the upper classes. Thus the term talented tenth was adopted. DuBois was adamant in his belief that intellectual guidance from the best and brightest among the Black race was the means by which to advance African Americans. A number of years after Washington's death, DuBois (1940) reiterated his belief:

Since the controversy between myself and Mr. Washington has become historic, it deserves more careful statement than it has had hitherto, both as to the matters and the motives involved. There was first of all the ideological controversy. I believed in the higher education of a Talented Tenth who through their knowledge of modern culture could guide the American Negro into a higher civilization. I knew that without this the Negro would have to accept white leadership, and such leadership could not always be trusted to guide this group into self-realization and to its highest cultural possibilities. Mr. Washington, on the other hand, believed that the Negro as an efficient worker could gain wealth and that eventually through his ownership of capital he would be able to achieve a recognized place in American culture and could then educate his children as he might wish and develop his possibilities. For this reason he proposed to put the emphasis at present upon training in the skilled trades and encouragement in industry and common labor. (p. 70)

There was no doubt that by the early years of the 1900s that Washington's influence among the White elite was considerably stronger than DuBois'. There was no gainsaying his influence in the highest places, his manifold services to his people, and, above all, the radiating influ-

ence of Tuskegee's good works (Lewis, 1993).

Washington's leadership ultimately gave way to new forces in the 20<sup>th</sup> century, which placed less emphasis on individual leadership and more on organizational power. The founding of the National Association for the Advancement of Colored People (NAACP) in 1909 with W. E. B. DuBois as its first president and the National Urban League in 1911 challenged Washington's power as a dispenser of political patronage as well as his technological and economic message. Nevertheless, he remained active as a speaker until his death in 1915 at Tuskegee.

DuBois had a phenomenally prolific career as a writer and scholar. Over time, he became more disillusioned with America, particularly the Black elite—the group that he dubbed as the Black upper class—believing that they had failed on their obligation to lead the masses of African Americans out of retrograde circumstances. In October 1961 he moved to Ghana. In 1963 he renounced his American citizenship and officially became a citizen of Ghana. He died there on August 27, 1963, at the age of 95 and was buried there (Rampersad, 1976).

Both men were aware that the need for African Americans to become technologically literate was paramount. However, whereas Washington advocated a hands-on external approach, DuBois promoted a paternalistic form of advancement of the Black race. Both men's philosophies are still being argued and applied in the technological arena today.

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# A Multiple-Regression Model for Monitoring Tool Wear with a Dynamometer in Milling Operations

Jacob C. Chen and Joseph C. Chen

## Introduction

A major goal of the manufacturing industry is increasing product quality. The quality of a product is strongly associated with the condition of the cutting tool that produced it. Catching poor tool conditions early in the production will help reduce defects. However, with current CNC technology, manufacturers still rely mainly on the operator's experience to operate and monitor machines to avoid defects from poor tool conditions. Since operator experience can be unreliable, recent research has focused on integrating a tool condition monitoring system within the machine to allow online, real-time monitoring to reduce the dependence on human judgment.

Any effective monitoring system must be able to sense tool conditions, allow for effective tool change strategies when tools deteriorate, and maintain proper cutting conditions throughout the process (Lee, Kim, & Lee, 1996). Among the many possible machining conditions that could be monitored, tool wear is the most critical for ensuring uninterrupted machining.

The traditional process for predicting the life of a machine tool involves Taylor's (1906) equation  $VT^n=C$ , where  $V$  is cutting speed,  $T$  is tool life, and  $n$  and  $C$  are coefficients. This equation has played an important role in machining tool development (Kattan & Currie, 1996). Since advanced machining was introduced in the mid-1900s, various tool wear monitoring methods have been proposed to expand the scope and complexity of Taylor's equation. However, none of these extensions has been successfully adopted in industry universally due to the complex nature of the machining process. Therefore, there have been many attempts to explore other more promising methods for monitoring tool wear online using computers and sensing techniques (Atlas, Ostendorf, & Bernard, 2000; Li & Tzeng, 2000; Pai, Nagabhushana, & Rao, 2001; Roth & Pandit, 1999; Wilkinson, Reuben, & Jones, 1999). Again, none of the in-process monitoring systems has ever been applied in any form in industry because research is still at the estimation stage; the systems are too immature to implement for monitoring (Waurzyniak, 2001).

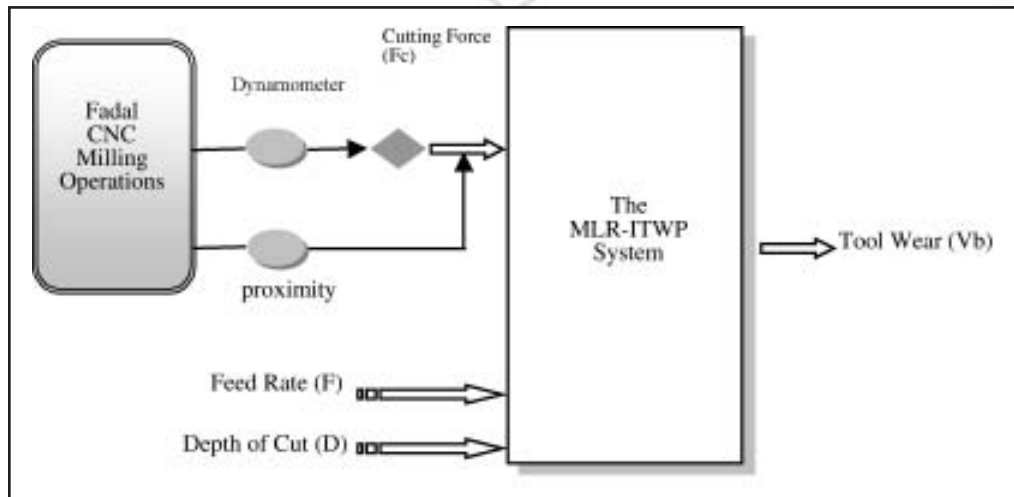
Therefore, researchers saw a need to explore an experimental and statistical approach in developing an in-process tool wear monitoring (ITWM) system. In order to accomplish this goal, this ITWM system requires an integration of sensing and decision-making techniques. For any in-process machining monitoring system, the sensing techniques are used to give the machine the capability of "seeing" that is equivalent to the human's eyes. However, the signals from the sensor have to be processed in order to determine whether or not something abnormal has occurred. The decision-making techniques are developed for the purpose of processing the signals from the sensors and data from other resources to determine whether or not the machining is satisfactory. Therefore, the decision-making techniques function like the "brain" of machines to make them intelligent.

Studies in the past have shown that the dynamometer sensor was much more effective than any other sensors in the field of tool wear (Dutta, Kiran, & Paul, 2000; Wilkinson et al., 1999). However, cutting force is very complex—it varies in different directions and varies throughout the whole revolution of the spindle. As a result, when tool wear occurs, it is sensible to conduct a cutting force analysis experimentally and statistically to find the cutting force representation that best predicts tool wear.

There is no doubt that the dynamometer is the most effective sensor available for monitoring tool wear. However, past studies of building tool wear prediction systems have used different decision mechanisms—either classic mathematical equations (Cho, Choi, & Lee, 2000; Sarhan, Sayed, Nassr, & El-Zahry, 2001) or expert systems (Dutta et al., 2000; Susanto & Chen, 2002)—based on different interests. In this study, a multiple regression approach was used as the decision mechanism in the proposed ITWM system.

## Purpose of Study

The purpose of this study was to develop an ITWM system using cutting force as a sensing signal and integrating the multiple regression approach as the decision mechanism. In order

**Figure 1. The architecture of the MLR-ITWP system.**

to develop the proposed ITWM system, the following two research outcomes were expected:

1. Identify the cutting force representation that could best predict tool wear.
2. Build and test an in-process tool wear prediction system, which was a multiple-regression model in this study, with the cutting force identified from the first task.

#### Architecture of In-Process Tool Wear Prediction System

In this study, the ITWM system that integrated multiple-linear regression can be named the multiple-linear-regression-based in-process tool wear prediction (MLR-ITWP) system. The input variables were feed rate ( $F$ ), depth of cut ( $D$ ), and cutting force ( $F_c$ ), while the only output variable was tool wear ( $V_b$ ). The architecture of the MLR-ITWP system is illustrated in Figure 1.

In the MLR-ITWP system, the three inputs entered the system as follows: both feed rate and depth of cut were controlled and programmed into the Fadal machine, while cutting force signals were collected through a dynamometer and converted to digital format through an A/D (analog/digital) converter. The digitized cutting force data per revolution of the spindle were simplified to a representative value, which was selected based on the force analysis. The following section shows the experimental setup for the study.

#### Experimental Setup

The experimental setup is illustrated in

Figure 2. The dynamometer sensor was mounted on the feeding table of the Fadal vertical machining center with the workpieces/tool holder on top of the sensor. The proximity sensor was mounted on the spindle and connected to a power supply. Through an A/D converter, the signals from both sensors were collected and converted into digital codes on the computer.

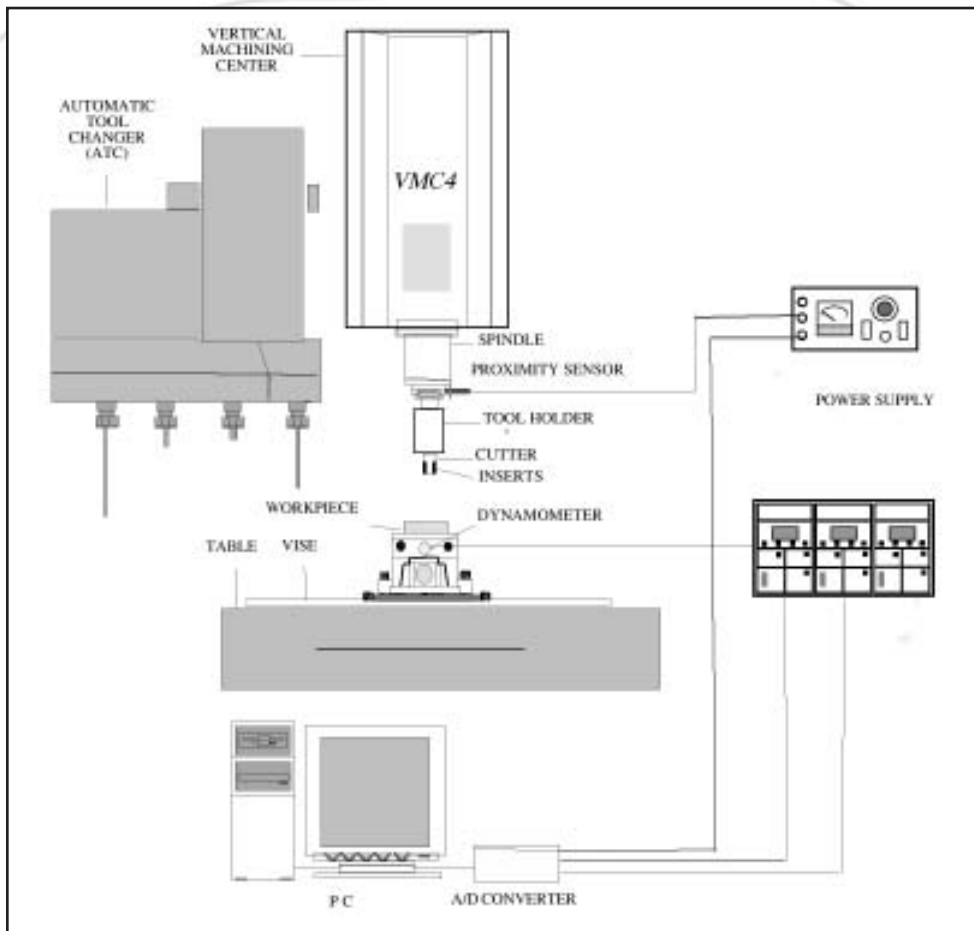
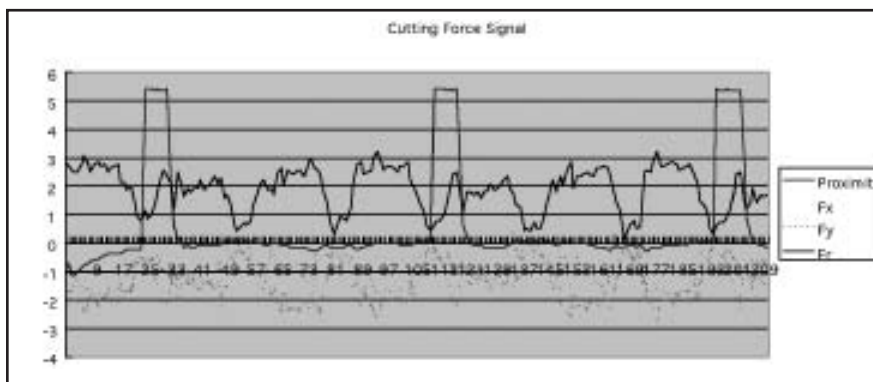
#### Hardware

Two sensors were used in the study: a Kistler 9257B type dynamometer sensor, which is capable of detecting force signals in three orthogonal directions ( $F_x$ ,  $F_y$ , and  $F_z$ ), and a Micro Switch 922 series 3-wire DC proximity sensor, which is used to determine the starting point of each revolution of the spindle in the force diagram (see Figure 3). Together, these two sensors were used to determine the cutting force magnitude.

An RCA WP-703A power supply was used to provide about 2.5V of electromotive force to operate the proximity sensor. A Kistler Type 5010 amplifier was used to amplify the force signals from the dynamometer to the maximum of 10V. An Omega CIO-DAS-1602/12 A/D converter was used to convert cutting force data from analog to digital. A P5 133 personal computer was used to collect data from the A/D converter, which originated from the proximity sensor and the dynamometer sensor.

The workpiece material used in the study was 1018 steel. A VNE90-1250C 3-insert mill with 1.25" cut diameter was used to hold inserts. APKT 160408R coated carbide inserts



**Figure 2. Experimental setup.****Figure 3. An example of cutting force signal converted as collectable digital data.**

were mounted on the tool holder for the milling machining. A Meiji EMZ-5TR Zoom Stereo Microscope was used to observe and measure the flank wears on the inserts.

### Identifying the Best-Predicting Cutting Force Representation

The goal of the first experimental run and data analysis was for force analysis, in order to identify the best cutting force representation for predicting tool wear.

### Force Analysis Experiment

The first part of the study included determining the cutting force representation to be recorded and entered into the prediction system in the second part of the study.

Past experiments have revealed that in end-milling operations, the Z direction (the vertical direction) of the cutting force can be ignored because it is insignificant relative to tool wear

monitoring compared to the X and Y orthogonal directions. Therefore, the selection of the force directions was limited to the forces in the X and Y directions and the resultant force of the two:  $F_x$ ,  $F_y$ , and  $F_r$ , where  $F_r = \sqrt{F_x^2 + F_y^2}$ .

For each of these three directions of cutting force, one could identify two possible cutting force representations: average force ( $\bar{F}$ ) and average peak force ( $\hat{F}$ ). Therefore, six cutting force representations were identified:

$$\bar{F}_x = \frac{\sum_{i=1}^m |F_x^i|}{m}$$

$$\bar{F}_y = \frac{\sum_{i=1}^m |F_y^i|}{m}$$

$$\bar{F}_r = \frac{\sum_{i=1}^m F_r^i}{m}$$

$$\hat{F}_x = \sum_{k=0}^{n-1} \left\{ \text{Max}\{|F_x^i|\} \mid i = \lambda\left[\frac{m}{n}\right] + 1, \lambda\left[\frac{m}{n}\right] + 2, \dots, \lambda\left[\frac{m}{n}\right] + \left[\frac{m}{n}\right] \right\} / n$$

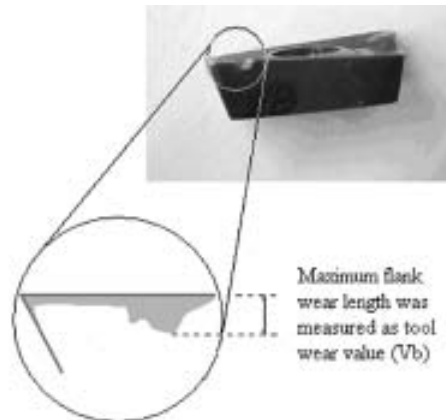
$$\hat{F}_y = \sum_{k=0}^{n-1} \left\{ \text{Max}\{|F_y^i|\} \mid i = \lambda\left[\frac{m}{n}\right] + 1, \lambda\left[\frac{m}{n}\right] + 2, \dots, \lambda\left[\frac{m}{n}\right] + \left[\frac{m}{n}\right] \right\} / n$$

$$\hat{F}_r = \sum_{k=0}^{n-1} \left\{ \text{Max}\{F_r^i\} \mid i = \lambda\left[\frac{m}{n}\right] + 1, \lambda\left[\frac{m}{n}\right] + 2, \dots, \lambda\left[\frac{m}{n}\right] + \left[\frac{m}{n}\right] \right\} / n$$

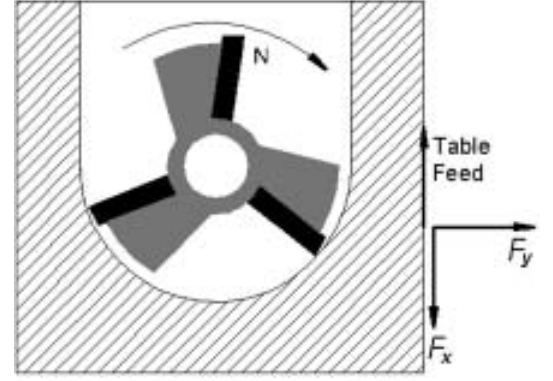
In the equations,  $m$  is the total number of cutting force signals collected in a revolution, and  $n$  is the number of the mill inserts (in the study,  $n = 3$ ).

To decide the best cutting force representation for predicting tool wear, the only independent variable was the flank wear ( $Vb$ ) of the tool, and the only dependent variable was the cutting force. The remaining cutting conditions were set to fixed values: feed rate = 5 in/min, spindle speed = 1800 rpm, and depth of cut = 0.05 inches.

**Figure 4. A typical flank wear geometry on an edge of an insert.**



**Figure 5. Definition of cutting force directions.**



### Correlations of Six Cutting Force Combinations and Tool Wear

One of the easiest ways to identify the best cutting force representation out of the six was to compare the correlations of these cutting force combinations and tool wear. The correlation coefficients were determined using Microsoft Excel, and the formula for the correlation coefficients is:

$$1) \quad \rho_{Vb-Fc^k} = \frac{\sum_{i=1}^n (Vb_i - \bar{Vb})(Fc_i^k - \bar{Fc}^k)}{\sqrt{\sum_{i=1}^n (Vb_i - \bar{Vb})^2 \sum_{i=1}^n (Fc_i^k - \bar{Fc}^k)^2}}$$

where  $\rho_{Vb-Fc^k}$  is the correlation coefficient between tool wear ( $Vb$ ) and cutting force combination  $k$  ( $Fc^k$ );  $Vb_i$  is the tool wear value of the  $i^{th}$  cut, while  $n$  is the total number of the training data sets. In this study,  $n = 13$ ,  $\bar{Vb} = \sum_{i=1}^n Vb_i / n$  and  $\bar{Fc}^k = \sum_{i=1}^n Fc_i^k / n$ .

With six cutting force combinations, six different correlation coefficients were obtained:  $\rho_{Vb-\bar{F}_x}$ ,  $\rho_{Vb-\bar{F}_y}$ ,  $\rho_{Vb-\bar{F}_r}$ ,  $\rho_{Vb-\hat{F}_x}$ ,  $\rho_{Vb-\hat{F}_y}$ , and  $\rho_{Vb-\hat{F}_r}$ . The largest correlation coefficient among the six indicates that the correlation is the greatest and the cutting force combination in that correlation is the best to predict tool wear.

### Results of Force Analysis

From the analysis (please contact the authors for the details), it can be concluded that the average peak forces in one revolution in the Y direction had the greatest correlation coefficient (0.78) with a  $p$  value of 0.002. However, the Y direction here is from the dynamometer, which is oriented differently from the machine. Therefore, the Y direction in this study is better defined as the direction perpendicular to the direction of the table feed (see Figure 5). The theoretical reasons, although not included in the study, definitely merit further study in the future.

## Developing the MLR-ITWP System

After the best cutting force representation for predicting tool wear had been identified as the average peak forces in one revolution in the Y direction ( $\hat{F}_y$ ), all the input values for the MLR-ITWP system were clearly defined. The second run of experiments and data analyses were then conducted.

## Tool Wear Monitoring Experiment

### Cutting Condition Selection

General cutting conditions usually refer to three major cutting parameters: feed rate, spindle speed, and depth of cut. From the body of research concerning tool wear (Lin & Lin, 1996; Susanto & Chen, 2002), spindle speed was not a significant factor in predicting tool wear. To simplify the study, spindle speed was therefore fixed in the study; only feed rate and depth of cut varied. The values of the cutting conditions were as follows:

Feed rate (x4): 5, 7, 9, 11,  
and 13 inches/minute

Depth of cut (x3): 0.02, 0.03,  
0.04, 0.05, and 0.06 inches

Spindle speed: 1,200 rpm

### Tool Wear

In the beginning of the experiment, all of the tool wears of the industry-used inserts were classified into five range groups (0.20-0.29, 0.30-0.39, 0.40-0.49, 0.50-0.59, and 0.60-0.69 mm), with the first group considered the lightest wear and the last group the heaviest wear. During the experiment, two sets of the inserts in the 0.60-0.69 mm group were worn out quickly and fractured in the third cut, which was quite different from the other inserts (which remained almost intact during the experiment). For this reason, it could be concluded that the tool life ends for this kind of coated carbide insert when it reaches the wear range of 0.60 mm.

Because many more industry-used inserts broke during the experiment with no replacements available, the researchers decided to artificially grind new inserts to the appropriate level of wear. In the study, the inserts were finely ground to even artificial tool wear with values of 0.25, 0.35, 0.45 and 0.55 mm (the 0.60 mm tool wear limit was observed).

### Experimental Design

With two factors from the cutting condition and one factor from the tool wear, the experimental design was a factorial design with three

factors: feed rate (x5), depth of cut (x5), and tool wear (x4). Therefore, 100 experiments were needed for the purpose of training the monitoring system. The data to be collected were the cutting forces (that is, the best predicting cutting force representation concluded from the first part of the study: the average peak forces in the Y direction).

## Results of Monitoring Tool Wear

The multiple-linear-regression model of tool wear, the MLR-ITWP system in Figure 1, was built with the help of the statistical software package JMP. The regression model considers the interactions among these three factors in the analysis, according to the following equation:

$$Vb = \beta_0 + \beta_1 F + \beta_2 D + \beta_3 Fc + \beta_4 F*D + \beta_5 D*Fc + \beta_6 Fc*F + \beta_7 F*D*Fc$$

Where  $Vb$  = tool wear (flank);  $F$  = feed rate;  $D$  = depth of cut;  $\hat{F}_y$  = cutting force (the most significant force representation revealed previously); and  $\beta_i$  ( $i = 0, 1, \dots, 7$ ) = the coefficients to be decided.

Using the JMP software, all the coefficients  $\beta_i$  in the model were decided, and the following regression model was obtained:

$$Vb = 0.1615 + 0.0454*F + 5.965*D - 0.0429*Fc + 0.1397*F*D - 0.0781*F*Fc - 8.2053*D*Fc + 1.3551*F*D*Fc$$

The analysis of variance of the regression model showed that the  $F$  ratio was smaller than .0001, which shows that this model is very significant for predicting tool wear.

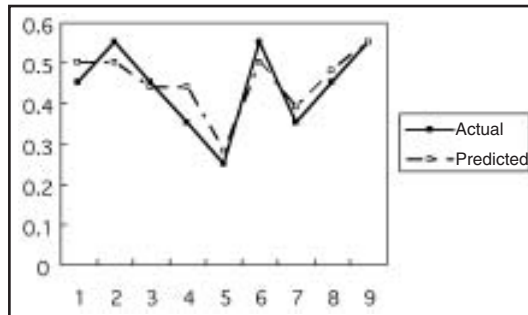
## Verification of the MLR-ITWP System

Once the regression model was formed, the MLR-ITWP system was built. To evaluate the performance of the developed system, nine sets of data were used for testing. The testing data sets were different from the 100 sets of training data used to produce the regression models.

The actual tool wear and the tool wear predicted with the testing data through the regression model were then compared. Nine sets of testing data were used to compare the actual wear with the predicted wear. The average error is  $\pm 0.039$  mm.

Figure 6 compares predicted and measured tool wear magnitude for all nine test cuts. The results suggest that the proposed MLR-ITWP system reasonably predicted tool wear in an online, real-time fashion.

**Figure 6. The comparisons of the actual and predicted tool wears.**



### Conclusions

A new in-process tool wear prediction (MLR-ITWP) system in milling operations has been set up, developed, and examined. The system showed the capability of predicting tool wear during the machining process.

The conclusions of this study are summarized as follows:

1. The average peak forces in the Y direction in a revolution best predict the tool wear among the force directions and the modes considered in the current study.
2. This proposed MLR-ITWP system can predict the tool wear value to have average error of  $\pm 0.039$  mm compared with the actual tool wear.
3. The proposed ITWP system has some limitations, which suggest the following possible directions for further research:
  - a. The tool wear used for developing the system was changed from industry produced to artificially ground. The difference between the two wears needs further study.
  - b. During the experiment, the researchers found that tool wear prediction is strongly affected by

the existence of tool chatter.

Therefore, the study of chatter prediction and control is also necessary for the development of automated machining.

- c. A MLR model has the limitation that it lacks the capability to learn—it does not allow any future data inputs. It is valuable to explore tools such as SPC, EMP, and DOE to assist in overcoming the problem in the future research.
- d. A MLR model is limited in its ability to simulate complex, nonlinear phenomena. Other ITWM systems that employ expert systems as decision mechanisms have value for future research.
- e. This research is limited to one type of tool insert and one type of workpiece material. Enlarging this system to include more cutting tools and materials for workpieces could make the results of this line of research more practical for implementation in industry.

In summary, this study provides the authors with a better position in continuing the tool monitoring system to enable an automated machining process for more efficient manufacturing in the future.

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# Holistic Assessment of Students in Undergraduate Industrial Technology Programs

Dennis W. Field, Steven A. Freeman, and Michael J. Dyrenfurth

“External constituents are demanding not only that departments say they are doing good things and not only that they measure how hard they are trying, but also that they measure outcomes” (Walvoord et al., 2000). “[Colleges] should be focused on the ‘value added’ of the student experience. In today’s society, the need to educate for understanding—not just grades—has never been more important” (Morrow, 2004). “What counts most is what students DO in college, not who they are, or where they go to college, or what their grades are” (Edgerton as cited in Morrow, 2004).

As evidenced by these quotations, the nature and assessment of education is changing significantly, and the assessment trajectory is away from sole reliance on the traditional perspective of student grades. Technology faculty must respond to the changing requirements of student assessment and ensure that graduates of the program meet both the expectations and standards of the institution as well as those of other stakeholders, particularly the private sector that typically employs those graduates.

We are reevaluating ways in which students in their departments are assessed. The three-step “backward design” process recommended by Wiggins and McTighe (1998) has served as a conceptual framework and useful design perspective. Broadly, these steps condense to (a) identify desired results, (b) determine acceptable evidence, and (c) plan learning experiences and instruction. Wiggins and McTighe offered a number of practical guidelines to the design and development of curricula, including the assessment process. They stated that “the backward design approach encourages us to think about a unit or course in terms of the collected assessment evidence needed to document and validate that the desired learning has been achieved, so that the course is not just content to be covered or a series of learning activities” (p. 12).

We have identified a number of elements driving assessments at the departmental level as well as those that address the degree candidates’ needs. We have explored non-classroom-cen-

tered assessment methods and have collected and analyzed preliminary data towards reaching the goal of more holistic assessment of student progression. The planning, work, and outcomes to date that support the learning goals and expected outcomes set forth by stakeholders follow. However, a point of reference must be set prior to any attempt to address the dual issues of student and program assessment by industrial technology faculty in higher education. For example, consistent with both our experiences and the recommendations outlined in step one of the three-step “backward design” process, one must have a fairly specific vision of the knowledge, skills, and attitudes a technology student should develop prior to embarking on his or her career before formulating an assessment plan. In other words, what is to be assessed? This might include such things as knowledge of technology and its associated processes; practical skills associated with materials, tools, processes, and systems related to technology; ethics related to technology development and application; attitudes toward technology; and issues impacting student learning.

A clear understanding of the reasons for assessing technology students is also critical. These reasons may originate in basic requirements to uncover information regarding students’ knowledge, skills, or attitudes. One may wish to verify that students can demonstrate practical technology skills and related professional skills, or one may desire to motivate and enhance learning. Ultimately, it is a goal of the faculty to have more than just course grades to reflect student performance. As noted by Wiggins and McTighe (1998), “Too often as teachers, we rely on only one or two types of assessment, then compound that error by concentrating on those aspects of the curriculum that are most easily tested by multiple-choice or short answer items” (p. 65). A well-structured program should include assessment by a variety of methods and from a more holistic perspective than is often currently employed. An ancillary benefit of a more holistic assessment may be a more positive student attitude toward the discipline.

From the departmental perspective, improved student assessment allows faculty to do a better job evaluating and adjusting the technology curricula and program options (e.g., manufacturing and occupational safety) to meet educational objectives. Improved assessment also increases faculty credibility with other stakeholders in the educational process, such as administration, parents, and employers. Given a clear understanding of the overall educational objectives and forces driving the need for assessment, one may turn to questions of available assessment strategies and benefits they provide for the learner and the instructor.

We three authors formed an action research collaborative with the central goal being to develop, implement, and evaluate innovative forms of assessment that document student growth in a holistic manner. The alternative forms of assessment that we advance are not envisioned as wholesale replacements for existing knowledge-based tests; rather, we suggest they supplement existing grade data with assessments targeted toward technological capability and problem solving. Outcomes of an improved assessment process allow faculty to make adjustments to both curricula and extracurricular activities with greater clarity regarding the impact of such changes on the industrial technology program and students. Ultimately, the faculty hope to accelerate the students' learning more effectively and efficiently and "jumpstart" them into their profession.

### **Technology Learning Community**

Changes to assessment processes are complicated by simultaneous changes to the program. For example, the context for our action research is a Technology "Learning Community" (TLC) that we established within the industrial technology curriculum at Iowa State University. Learning communities are relatively recent additions to the landscape of American universities. Research by Lenning and Ebbers (1999) has indicated improved student retention and satisfaction with the academic experience through the use of learning communities. The TLC is an induction and support activity for freshmen and transfer students in the industrial technology program. The purpose of the TLC is to help entering students (regardless of their academic stage) maximize their educational experience and begin their professional acculturation within the discipline of industrial tech-

nology. TLC participants are organized into small groups of students. Each student group works with a peer mentor, an industrial mentor (an industrial technologist practicing in industry), a graduate assistant, the academic advisor, and industrial technology faculty members. In addition to more formal assessments, TLC students evaluate their experience each week in reflective summaries. Below are some comments selected from TLC students' summaries:

- This was a very helpful class since it provided to me a strong idea of what I can expect, and in turn what is expected of me. Peer mentor groups met in class and we exchanged phone #'s and E-mail addresses.
- Last class we had speakers come in from SME [Society of Manufacturing Engineers], ASSE [American Society of Safety Engineers], and SPE [Society of Plastics Engineers] clubs who talked about what their organizations do and how to get involved in these clubs. I think this was a very good class day because most people are unaware of how they can get involved in something like this and what they actually do in these clubs. I am very interested in SME and hope to join next fall. I would have liked to join this semester but with my current schedule and obligations this is impossible.
- Last week our group met with our peer mentor for half an hour. We talked about our schedules and how classes are going. Our peer mentor suggested that we do our resumes and turn them in to him the next time we meet. We discussed how important it is to go to Career Day on Feb 19th. He wants our resumes so he can go over them and make possible corrections so we can have them with us for career day. We have assigned a day and time for our meetings, which is Wed. at 5 p.m. in the TLC room.
- Last week's class helped me to more fully understand the full potential that an Industrial Technology major could provide for me in the future. In our group meeting we talked about how to improve our resumes and how to sign up for ECS [Engineering Career Services].

At the end of each semester, TLC students were asked to evaluate the ability of the TLC experience to meet the goals of the TLC initiative using *excellent*, *good*, *fair*, or *poor* ratings. When questioned about their experiences with respect to the goals of “Orientation to the industrial technology discipline and profession” and the “Process of developing realistic self-assessments, career goals,” 93% of the students reported *good/excellent*. The responses were even more positive regarding the goals of “Connections with faculty, other students, and industry professionals” and the “Process of introducing the variety of professional roles available through an industrial technology degree,” with 96% of the students reporting *good/excellent* experiences.

The experiences within the introductory course were crafted to establish both the small group cohesiveness and interaction with peers that is so essential to effective team-based technological problem solving that employers demand of industrial technology (ITEC) graduates. Another key to the success of the TLC is the use of industrial mentors. ITEC students are very pragmatic—most have their sights set firmly on a career in industry. Hence, inputs from industrial mentors are highly valued and persuasive. They convey high expectations while demonstrating realistic practice and applications in industry.

Student learning has been enhanced through cooperative interaction with their TLC group members and mentoring team. The industrial and peer mentors have increased the TLC students’ understanding of the discipline and the importance of curriculum components beyond what individual faculty members can accomplish in the classroom. The TLC students have a better understanding of their personal learning styles and how that impacts their studying habits and classroom interactions. By the end of the semester, TLC students have generated or updated their resumes, started professional portfolios, and set the foundation of team building and awareness of technology that they will continue to enhance and build upon throughout their academic career and beyond. Additional information regarding the Iowa State University TLC may be found in Freeman, Field, and Dyrenfurth (2001).

### **Student Outcomes Assessment**

Desired student outcomes include enhanced

capability with technology, increased student satisfaction, higher academic performance, refined career goals, and a greater awareness of one’s learning style and how to most effectively utilize that information. When students conclude their studies within technology programs, it would be desirable for them to have indicators of capability to demonstrate academic proficiency, beyond just course grades.

In order to assess student outcomes in a more holistic way, appropriate instruments must be available. Efforts are underway to identify and evaluate such instruments for use in the undergraduate industrial technology curricula. In addition to the qualitative and quantitative analyses related to the TLC, activities include an evaluation of the use of Dyrenfurth’s (1991) technological literacy instrument based on the work reported in Dyrenfurth and Kozak (1991), the ACT Work Keys employability skills exams, and the National Association of Industrial Technology (NAIT) certification exam; reviews of each student’s portfolio by faculty and an industrial team; and comparison of participant satisfaction and academic performance with other students not participating in TLC activities.

A number of other key targets have been included as initial assessment areas. These targets include student demographics, academic performance, learning styles, technological understanding and capability, and ethical dimensions of technology.

With these assessments, faculty hope to benchmark both the initial and exit competence of students, document students’ progression over the course of their academic experiences, document differences among groups and types of students, and investigate implications arising from these differences for program design and development. The assessments are also designed to focus attention on the various components of competence (e.g., technical, managerial, foundational, personal) and to increase attention to the assessment process in order to strengthen its validity and reliability.

The faculty has synthesized a set of targeted industrial technology competencies for students at Iowa State University through the efforts of individual instructors responsible for specific courses, the departmental curriculum committee, and other stakeholders

(e.g., Industrial Advisory Council and NAIT). It would be advantageous for faculty to be able to collect a wide variety of demographic data and longitudinal data for tracking student performance, as well as data indicating performance against desired outcomes; however, they recognize that constraints exist on the amount of data that can be collected and analyzed.

The NAIT accredits industrial technology programs. Department missions are expected to be compatible with the approved definition of industrial technology. The mission, as listed in the 2002 *NAIT Self Study Report* (Department of Industrial Education and Technology, 2002), states: "The Department of Industrial Education and Technology at Iowa State University prepares technically oriented professionals to provide leadership in manufacturing technology and occupational safety through an undergraduate industrial technology program" (p. 6.2-2).

A second necessary, but not sufficient, condition for accreditation listed in the 2002 *NAIT Self Study Report* requires that competencies shall be identified that are relevant to employment opportunities available to graduates. While the accreditation process serves as one driving force for curriculum review and outcomes assessment, there are others. Apart from the expected continuous improvement efforts of the faculty, the department retains an Industrial Advisory Council to assure that the industrial technology curriculum addresses the current and future needs of business and industry. The Council recommends and reviews curriculum and program changes that will enable the department to be responsive to business and industry (Department of Industrial Education and Technology, 1998). The department faculty, NAIT, and the Industrial Advisory Council all play an important role in defining and refining the competencies expected of industrial technology graduates.

Ultimately, a reevaluation and alignment of course content offered in the programs was needed to ensure that the competencies expected of industrial technology graduates were realized. This involved a comparison of curricular content with required NAIT objectives. Gaps and/or superfluous material were identified and addressed. Faculty members led this effort, but they were not without guidance with respect to the process. The aforementioned three-step design process by Wiggins and McTighe (1998)

and work by Kenealy and Skaar (1997) offered useful frameworks. Kenealy and Skaar suggested an interesting outcomes-defined curriculum renewal process that has continued to influence this effort. Kenealy and Skaar described a multi-step "action planning" process that has been adapted so that a large number of diverse faculty and students could contribute cooperatively and with a sense of ownership. The needs of clientele groups led to the definition of major educational outcomes for the program, which in turn formed the foundation for learning experiences that would serve to meet student needs. Kenealy and Skaar stated that by grouping learning experiences, course titles and objectives are defined for a renewed curriculum. Subsequently, courses are defined by specific learner competencies, which are edited for proper sequencing. They also examined cognitive learning skills to ensure that upper level skills were represented throughout the curriculum.

### Assessment Instruments

Assessment instruments exist that are appropriate and readily available and for which validity and reliability studies are already well documented. We entered into discussions with ACT, Inc., regarding the use of the Work Keys® system at the undergraduate level. This is a system designed to quantitatively measure certain employability skills. It includes job profiling and work-related assessments and serves a variety of needs in the industrial and educational arenas. For example, the test component of the Work Keys system is designed to assess personal skill levels in important areas of employability skills (ACT, 1997). There are currently eight tests: (a) applied mathematics, (b) applied technology, (c) listening, (d) locating information, (e) observation, (f) reading for information, (g) teamwork, and (h) writing. ACT (1997) stated that educators can use the Work Keys information to develop appropriate curricula and instruction that target skills needed in the workplace. The Work Keys instruments have extensive reliability and validity studies completed (ACT, 1997) at the secondary level, but little information was available demonstrating that its use could be extended to the baccalaureate level. Our preliminary research results with undergraduates would seem to warrant additional investigation of the Work Keys system. Five of the eight tests were administered to undergraduates, including (a) applied mathematics, (b) applied technology, (c) locating information,



(d) teamwork, and (e) writing. Our primary concern was that a majority of the students would score at the highest scale level of the exams, thus diminishing the usefulness of the exams for assessment purposes at the baccalaureate level. This did not prove to be the case as only 9.1% ( $n = 33$ ) achieved this level in the Applied Technology exam, 14.8% ( $n = 27$ ) achieved this level in the Locating Information exam, and no students achieved the highest level in the Teamwork and Writing exams ( $n = 26$  and  $n = 22$ , respectively). Applied Mathematics yielded the only exam where significant numbers of students (45.2%,  $n = 31$ ) scored at the highest level.

The ITEC program enrolls numerous transfer students from engineering. Many of these students have not had a great deal of academic success in the engineering program, but most seem to thrive in the industrial technology program. It has been posited that a mismatch between instructional style and learning style has been a leading cause of at least some of these students' previous academic problems and that a change to a more "hands-on" curriculum has allowed them to flourish. While there may indeed be systemic differences in the instructional approaches taken by engineering and industrial technology faculty, a recent study undertaken to investigate this question found that there were no statistically significant differences in learning styles between groups of engineering students and industrial technology students at either Iowa State University or North Carolina A & T State University (Fazarro, 2001). Fazarro used the Productivity Environmental Preference Survey to evaluate learning style differences (Dunn, Dunn, & Price, 1996).

A number of other planned assessment instruments require some additional development prior to their wholesale use. Some are lacking sufficient reliability and validity data, whereas some offer only partial coverage of desired content areas. For example, the NAIT certification test currently covers only four technology categories: (a) production planning and control, (b) safety, (c) quality control, and (d) management and supervision. There are other topics that fall under the technology umbrella such as materials and processing, industrial training and development, energy, instrumentation and control, and information technology. Rowe (2001) suggested an updated test blueprint for the NAIT certification exam. Rowe

used a modified Delphi technique to identify core content, subject areas, and competencies. Thirteen core competency areas were identified including (a) leadership skills for supervisors, (b) teamwork, (c) fundamentals of management, (d) safety management, (e) technical graphics/CADD, (f) quality, (g) electronics, (h) human resource management, (i) technical writing, (j) written communication, (k) verbal communication, (l) computer integrated manufacturing, and (m) manufacturing automation. Rowe's findings indicated a need for expanding the use of written and verbal information, particularly with respect to communicating technical information.

The current NAIT certification test is a cognitive, norm-based, multiple-choice test. It contains four 40-question subsections: production planning and control, quality control, safety, and management/supervision. Summary statistics, including classical difficulty and discrimination coefficients (point biserial correlation) based on a sample size of approximately 1,200 students, are available from the authors. Efforts are also underway to analyze these exam items using item response theory (IRT) methods. There appears to be a significant level of interest by NAIT-accredited programs for use of the certification exam in both program and student evaluations.

Description and sequencing of the test construction process (preparing test specifications, item construction and review, detecting item bias, estimating reliability, etc.) are readily available in, for example, Crocker and Algina (1986). All tests used for assessment are expected to pass a review against generally accepted test construction guidelines.

Other instruments currently under consideration include Dyrenfurth's (1991) technology literacy test, a survey of attitudes toward technology (DeVries, Dugger, & Bame, 1993; Raat & DeVries, 1986), multiple technological problem-solving appraisals developed in the manner suggested by Kimbell and Stables (1999), and the assessment of technology projects and activities using group process and student individualized performance rubrics suggested by Custer, Valesey, and Burke (2001).

We envisioned the deployment of the aforementioned assessment instruments across the department and longitudinally over the students' four-year period of study. The plan would have



the department's faculty establish a database of specific course goals and objectives and then crosswalk each to the department outcomes. Existing tests and other assessments would be cross-indexed to these goals and objectives. Tables of specification would be used to identify weighting and/or coverage gaps, inappropriate proportions, etc.

Subsequently, innovative assessment mechanisms, such as authentic assessments, portfolios, rubrics, and adaptive testing, would be expanded to complement and/or modify the current assessment strategies. Some authentic assessment activities are currently in place in the industrial technology program at Iowa State University. Freeman and Field (1999) discussed assignments given to groups of safety students that involve job safety analyses, along with equipment and process reviews in labs run for manufacturing students. These assignments are identical to the tasks safety students might find when working in an industrial setting following graduation. Students have also been asked, for example, to develop and construct tooling for specific tasks in metallic materials and processes labs. Many of these laboratory-based activities offer opportunities for authentic assessment.

Multiple-choice assessments will be subject to item analysis and will be recorded in the item database. These assessments have their place as tests of technological knowledge; however, Kimbell and Stables (1999) do not consider them to be valid tests of technological problem solving. Kimbell and Stables offer a great deal of insight into the development of performance assessment instruments for technological problem solving and the development of assessment rubrics to translate performance qualities into numeric data for statistical analysis.

A summary listing of the anticipated system development activities are shown below:

- Conceptualize outcomes based on inputs from faculty, NAIT, and the Advisory Council.
- Analyze objectives for each course in program.
- Analyze NAIT certification examination table of specifications.
- Crosswalk course outcomes to objectives.
- Crosswalk objectives to NAIT certification examination table of specifications and exams for each course.
- Select instruments:

- Conduct additional literature review.
- Review American Educational Research Association presentations.
- Explore available tests or identify and develop appropriate new instruments.
- Define benchmarking process.
- Finalize assessment timing.
- Develop assessment-sampling matrix that secures data, which may then be aggregated without imposing all tests on all students.
- Bring test administration and analysis online through the use of off-the-shelf software.
- Develop analysis plan.

Student performance will also be recorded in a database and, within legal guidelines and pending student approval, certain elements of the information will be available to assist peer and industrial mentors in conducting discussions with students. Peer and industrial mentors will be expected to offer each student constructive perspectives as to how his or her performance is progressing against personal and professional standards. Assessment validation will involve the program's industrial advisory council members so that real-world standards are not only employed but are also made clear to students. A key goal is to demonstrate student awareness of growth over time. Potentially confidential topics from a student perspective will be handled through discussions with faculty and faculty mentors.

### Summary

There are clear and persistent indicators that changes are needed and expected in our system of education. In 1999, the National Research Council reported, "The goals and expectations for schooling have changed quite dramatically during the past century, and new goals suggest the need to rethink such questions as what is taught, how it is taught, and how students are assessed" (pp. 152-153). In 2001, the Council reviewed and expanded on trends, which "are changing expectations for student learning and the assessment of that learning" (National Research Council, 2001, p. 22). Efforts to design and implement a more holistic assessment of students in industrial technology programs are certainly timely and in keeping with the spirit of the recommendations by the National Research Council and others. Our work represents an initial step towards

capitalizing on some of the innovation that, while important, nevertheless reflects singular enhancements. Our goal was also to integrate several of these innovations into a more systematic approach. To this end, we have conceptualized a framework for moving forward, we have established the feasibility of using the Work Keys® employability skills instrumentation, and we have described some necessary implementation steps. We invite members of the profession to join in the challenge of implementation of such enhanced systems of assessment.

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# Technologies Applied in the Toshka Project of Egypt

Wafeek S. Wahby

## Background

The Toshka Project, located in Egypt (see Figure 1), involves excavating a canal to carry about 380 billion ft<sup>3</sup> of water every year from Lake Nasser to the Toshka Depression, southwest of Aswan. This will eventually create a new valley to the River Nile in the western desert of Egypt in addition to the currently existing prehistoric river course. Before discussing the Toshka Project, it is important to first identify the following (see Figure 2):

- Toshka Region
- Toshka City
- Toshka Depression (in Arabic: *Mon-kha-fadd Toshka*)
- Toshka Bay (*Khore Toshka*)
- Toshka Spillway (*Ma-feed Toshka*)
- Toshka Canal (*Sheikh Za-yed Canal*)

The *Toshka Region* is located southwest of Aswan, about 600 miles south of Cairo. *Toshka City* is a new metropolitan city that is planned to serve a future population of 5 million. *Toshka Depression* is a natural depression in that area with an average diameter of 14 miles and a storage capacity of 1,665 billion ft<sup>3</sup>. *Toshka Bay* is a shoot off Lake Nasser towards Toshka. *Toshka Spillway* is a free spillway discharging the water of Lake Nasser when it exceeds its highest stor-

age level of 620 ft. It is a 14-mile long, man-made canal connecting Toshka Bay with the Toshka Depression and works as a safety valve for Lake Nasser, upstream of the High Dam.

*Toshka Canal* is the heart and soul of the Toshka Project. It is a new canal conveying the excess water of Lake Nasser that is pumped into it through a giant pumping station that elevates the water about 175 ft. The water then flows through the canal to reclaim and irrigate 534,000 new acres in the western desert of Egypt (El-Hag-Gar, 2001). The Toshka Project is an integral part of a much larger, mega project, the Southern Valley Development Project (SVDP), that aims at doubling the amount of cultivated land in Upper Egypt through developing the Toshka, East El-O-Wee-Nat, and the New Valley Oases (Ministry of Water Resources and Irrigation, 2000).

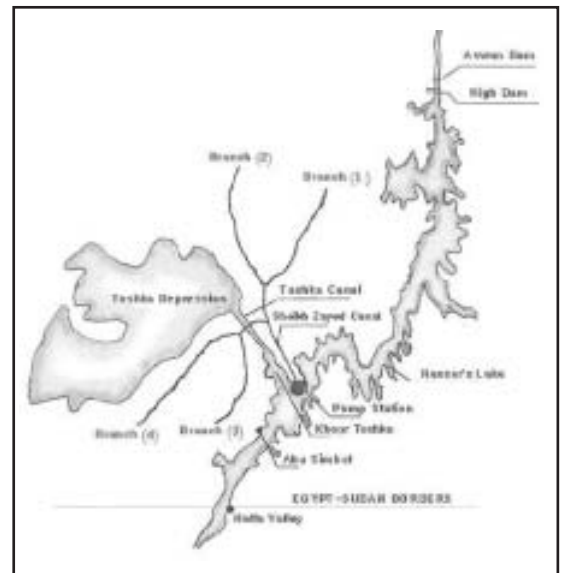
## The Southern Valley Development Project

The SVDP is *not* a mere irrigation or agricultural project. The SVDP is a multifaceted, multiphase, development project that mainly involves horizontal expansion and land reclamation projects in the southern part of the Nile Valley in Egypt. It is a national, integrated,

Figure 1. Egypt.



Figure 2. The Toshka Project (Younan, 2001).



massive development project, aiming mainly at creating a balanced, re-organized Egyptian map from the demographic, habitation, economic, and security points of view. Total investments for implementing this project by 2017 are estimated at some US\$ 100 billion, of which 20% to 25% is pledged by the Egyptian government to construct the main canal and its four off-shoots, the pumping station, major roads, and main electricity network. The remaining 75% to 80% is to be supplied by the private sector.

Agriculture in the SVDP is only a base for the integrated development planned. Industry, mining, alternative energy production—and possibly oil and gas production and storage—and tourism are other parts of the vision, with plans for desert safaris, car rallies, conferences, and medical tourism.

Objectives of the SVDP include:

1. Adding new areas of agricultural land lying in the Southern Valley region.
2. Establishing new agricultural and industrial communities based on the exploitation of the agricultural raw material available in the new land.
3. Attracting and retaining a workforce, thus gradually dealing with the problem of overpopulation in the old Nile Valley.
4. Constructing an efficient network of main and side roads in accordance with the development objectives and plans.
5. Promoting tourist activities in such regions rich in ancient monuments.

### **The Toshka Project Infrastructure**

The Toshka Project infrastructure includes the main pumping station (*Mubarak pumping station*), the Toshka Canal, water production wells and artificial charging, and wind and sand storm breakers (Wahby, 2001).

#### ***Mubarak Pumping Station (MPS)***

The Toshka Project begins with the main pumping station—also known as *Mubarak pumping station (MPS)*—located on the left bank (west) of Lake Nasser, and north of Toshka Bay. More specifically, the pumping station is located 5 miles north of Toshka Bay spillway canal, 28 miles south of intersection with the Abu-Simbel/Aswan main highway. From this intersection it is 133 miles to Aswan northward and 37 miles to Abu Simbel southward. When completed, it will deliver 12,000 ft<sup>3</sup>/sec into the main feeding canal.

The construction of the pumping station has been undertaken by the European Egyptian Japanese Consortium and led by London-based Skanska Cementation International. Engineering group ABB was awarded the contract to supply all the electrical equipment by Japanese Hitachi (part of the European Egyptian Japanese Consortium) in 1998. The contract included the high-capacity frequency converters for the pump motors (Water Technology, 2003).

The multistage MPS is one of the world's largest, designed to have a maximum static head of about 175 ft, which guarantees its operation when the water level in Lake Nasser reaches its lowest level of storage (445 ft; Abdel-Rahman, 2001). SonTek/YSI has provided the Toshka Project with four Argonaut-SLs to continuously record and display flow and level data for day-to-day operation of the canals. Data will also be logged and used as a historical record for a mathematical model that will give optimal set points for the canal water level (Sontek, 2002). Twenty-four pumps (12 each side), each with a discharge capacity of 600 ft<sup>3</sup>/sec, are being housed inside the pumping station. The maximum energy necessary to operate MPS during maximum lifting is 375 M.W.

The station will be fed with 11 kV electrical power through a transmission line from a substation constructed close to the 11 kV switchgear building that is linked to the electric power double 220 kV line from Aswan High Dam with a length of 160 miles. The MPS is also an integral part of a concurrent project called the New Valley Development Project (NVDP), aimed at establishing an agro-industrial development in an adjacent area of about 988,000 acres.

Loughborough-based Morris Material Handling supplied five cranes having the combined qualities of size and flexibility required by the MPS project: three cranes with a capacity of 130t for lifting pumps and two smaller 30t gate cranes, each with a lift height of approximately 180 ft. One 130t goliath and the two 30t “odd-leg” goliaths were mounted on top of the completed pumping station. The 130t goliath lifts the pumps from the pump room to the loading bay, and the two 30t odd leg goliaths lift gates within the station. The two 130t overhead traveling pump room cranes started operation on site in mid-2001 with the other three cranes being installed on top of the pumping station at



the end of 2002. These 5-500 series cranes were chosen because of their versatility to meet varying customers' requirements. Built on-site, the cranes for this project were designed and manufactured in the UK, with Morris staff commissioning the machines on-site in Egypt (Water Technology, 2003).

Under a turnkey lump sum contract, with operation supervision during a guarantee period of 48 months, the MPS includes the design, construction, and maintenance of the following:

- An intake channel, 3 miles long, conveying water from Lake Nasser to the suction basin of the pumping station. Part of the channel (1 mile) is dry excavation (volume of excavation is 187 million ft<sup>3</sup>), and the rest (2 miles) is wet excavation (volume of excavation is 196 million ft<sup>3</sup>). The wet excavation is done using three gigantic dredgers (the world's largest at 200 ft arm length) for excavation under water.
- A reinforced concrete pumping station having length x width x height dimensions of 462 x 132 x 231 ft located as an island in the center of the suction basin. The lower 165 ft of its height will be permanently submerged underwater. Project designers for the concrete structure are Germany's Lahmeyer International and Cairo-based Hamza Associates.
- Twenty-four discharge concrete ducts having width x height dimensions of 9 x 8 ft, delivering the water from the pumps to the Toshka Canal via the discharge basin.
- Two annex buildings housing the 11 kV switchgear and the diesel generators.
- Three workshops: electrical workshop with laboratory, mechanical workshop, and automotive workshop.

Groundbreaking of the Toshka Project took place on January 1998, and excavation work at the MPS site started on June 1, 1998. The station was scheduled to be completed in 2002 at a cost of US\$ 400 million. However, on January 12, 2003 during the celebrations of the 5<sup>th</sup> anniversary of the project's groundbreaking, only two pumps were put to work in a test operation with symbolic power enough to let water fill limited parts of the new Toshka Canal, only to a modest depth.

### *The Toshka Canal*

The Toshka Canal is the main canal of the project, having a length of 44 miles that branches into four subcanals, with a total length of 160 miles. The canal and its four subcanals are designed to carry a discharge of 900 million ft<sup>3</sup>/day to reclaim and irrigate four areas: 118,600 acres, 118,600 acres, 198,000 acres, and 98,800 acres, respectively—totaling 534,000 acres, an area equivalent to the combined areas of three neighboring governorates: Aswan, Kena, and So-Haag (Ministry of Water Resources and Irrigation, 1999).

The maximum designed water depth in the canal is 20 ft and the bed width is 100 ft, with a longitudinal slope of 6.67 inches/mile. The side slopes of the canal are 2:1, making the width at its top 200 ft. While the evaporation from the canal is estimated to be 0.7%, its cross-section is being lined with dense concrete to prevent any water leakage. After excavation to the required section, an 8-inch thick layer of stabilized soil (a compacted sand/cement mixture) is placed. Before pouring the top 8 inches of padding concrete layer onto that sub-base, 0.04 inches thick polyethylene sheets are placed on top of the sub-base stabilized soil layer to completely cover and "seal" it. A total of over 200 million ft<sup>2</sup> of polyethylene sheets are expected to be used in that process (Ramsis, 2001).

Two huge aggregate excavating and processing systems have been constructed and are able to supply coarse and fine size aggregates for concrete mixing. With the addition of two other concrete batching plant systems, the concrete production rate could reach 86,000 ft<sup>3</sup> per hour, which can satisfy the capability of 20 million ft<sup>3</sup> per month concrete placing. Each batching plant has its own cooling system that guarantees a 45°F temperature for cooling concrete, even in extremely hot weather (Taha, 2001).

To date, 70 miles have been completely excavated, of which 25 miles have already been also padded. The strict commitment to the workplan helped in complying with the schedule set for concrete-padding works, even under extremely unfavorable weather conditions. The usual operating rates amount to more than 370 longitudinal feet per day. However, in some instances it exceeded 430 longitudinal feet per day. When finished, the Toshka Canal is

expected to have utilized over 40 million ft<sup>3</sup> of concrete. Quality assurance and quality control procedures guarantee that code requirements, technical specifications, proper work practices, and safety measures are rigorously followed in all engineering works.

### ***Water Production Wells and Artificial Charging***

Currently, water required for various applications is supplied through the available groundwater stored in the local aquifer. Along the main canal, five productive wells were constructed to irrigate about 740 acres. However, to fully utilize the available ground water, another 200 wells are being dug to serve an area of about 29,600 acres.

Meanwhile, the Egyptian Ground Water Research Institute (GWRI) carried out studies to use the excess in floodwater, discharged to the Toshka Depression since 1996-97, to charge the Nubian ground aquifer. Artificial charging is now being carried out with an expected initial cost of about US\$ 3 million.

### ***Wind and Sand Storm Breakers***

Wind and sand storm breakers comprising two rows of kaya and ponsiana trees are being planted on each side of the main canal as well as its four branches to protect them from the wind and the sand storms that ravage this region throughout the year. Almost 65 miles of trees have been planted to date (Abol-Hag-Gag, 2001).

### ***Data and Statistics***

Total excavation work in the Toshka Project is estimated at 3,100 million ft<sup>3</sup>—seven times that which was needed in the construction of Aswan High Dam (only 445 million ft<sup>3</sup>). To date, about 2,700 million ft<sup>3</sup> of excavation work is complete. As for sand filling work, 290 million ft<sup>3</sup> out of 540 million ft<sup>3</sup> has been accomplished.

Basalt and gravel for concrete work are provided locally from the Toshka area, whereas sand is transported from the nearby Kom-Ombo (65 miles) and the cement from Ass-Yoot (220 miles). Patching plants are located at 3-mile intervals, and eight mixing units produce over 37,000 ft<sup>3</sup> per day. Special chemical additives are incorporated into the water used for mixing and curing concrete to keep its temperature at 45°F.

Currently, five companies are working on the site using seven padding machines to pad the sloping sides and the short horizontal parts at the berm and the bed levels (Kadry, 2001). The bottom segment of the canal padding is manually lined using mechanical concrete mixers, pumps, and vibrators for concrete placement.

To serve ongoing reclamation projects, the area is equipped with an electric power grid and an excellent network of roads. Over 90 miles of new passageways and asphalt roads, besides another 375 miles of rehabilitated roads, were completed, which form an efficient and vital communication and transportation network (Hass-san, 2001).

### ***The Toshka Project Controversy***

The Toshka Project has attracted the attention of many individuals and groups in Egypt as well as worldwide and created much controversy on whether it is a mirage or marvel (El-Khodari, 2000). Some are very enthusiastic and optimistic about it, to the extent of calling it “The New Delta Project” or “The Inverted Pyramid Project.” On the other hand, the Toshka Project also has fierce critics, ranging from environmentalists worried about its demands on Nile water to economists who question its profitability.

Advantages of the Toshka Project include:

1. Dealing with the complex problems arising from skyrocketing population growth in Egypt that include jobs, food, housing, health, education, and transportation.
2. Doubling the amount of cultivated land in Upper Egypt.
3. Utilizing the massive amounts of water stored in Lake Nasser.
4. Facilitating power generation projects.
5. Offering venues for navigation and waterway transportation.
6. Promoting and developing fishery, tourism, and recreational activities.
7. Reaching new areas with fresh water and creating favorable conditions for the south-to-northwest water transfer.
8. May yield new archeological discoveries.
9. Relieving Lake Nasser from silt accumulating on its bed since the building of Aswan High Dam in the 1960s and

alleviating its negative effects on the lake's capacity as well as the High Dam's stability.

10. Construction of the new Toshka City that would serve a population of 5 million to relieve the overcrowded old valley.
11. Yielding botanical and animal resources that can be utilized in several pharmaceutical and fish-processing industries.
12. Developing an environment in the area of the new project to attract wild birds and animals.
13. Including solar and wind energy development used in generating clean electrical power to meet expected demand.

Disadvantages of the Toshka Project include:

1. Egypt is pouring money into desert reclamation—wasted finances that could have been used more productively in other urgent needs such as health care, housing, and education.
2. This project, in addition to other concurrent mega-projects in Egypt, is causing liquidity and cash flow crises by sucking the lifeblood out of the economy.
3. Poor cost-benefit analysis of the project.
4. Historically, Egyptians resist moving from their homes to new settlements in the desert, and the Toshka Project is no exception.
5. Unrealistic water resources management by diverting water badly needed in the traditionally most fertile land of the Nile Valley.
6. Egypt could even run short of water if other Nile basin countries to the south should build dams and divert some of the flow.
7. The negative effects this project may have on the River Nile ecology, particularly on wildlife, groundwater table level, irrigation, urbanization, and pollution.

### The Future

A minimum of 720 billion ft<sup>3</sup>/year of otherwise wasted water at Aswan can be saved by implementing water conservation projects in the upper Nile sub-basin, through the cooperation of Egypt and the Nile basin countries. This excess amount of saved water would be used to fill the Toshka Depression completely—through

the Toshka Canal and the Toshka Spillway—turning it into a permanent storage reservoir that could be used as a stable water supply for irrigation.

A new canal would then be constructed to convey water from the depression northward towards the Cut-taara Depression through the western desert of Egypt, forming a new green valley parallel to the existing valley (Younan, 2001). This would create new communities aiming at expanding the Egyptian habitation land from the current 5% to about 25% of Egypt's area. Water would eventually be directed northward, as a second branch of the Nile and parallel to it, towards the Mediterranean Sea.

Started in 1998, the construction of the Toshka Project was hoped to be completed by 2004 with an estimated cost over US\$ 2.5 billion. The Egyptian government wants to reclaim and cultivate some 534,000 acres (890 sq miles) around Toshka to deal with Egypt's population explosion, crowded cities, and falling per-capita farm output.

The construction of the Toshka Project in Egypt presents a challenge to engineering technology because work is sometimes done under extremely unfavorable weather conditions. Production rates never before attained are becoming the norm in order to keep the sizable project on schedule.

The first fruits of the promising success of the Toshka Project can be witnessed in many locations such as that around Productive Well No. 21, at the 45 mile landmark, where the volume and density of the green color of vegetables, fruits, and flowers extend for almost 60 acres—wholly cultivated in an area previously thought of only as barren, uncultivable desert.

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## Books Briefly Noted

Alexander, Brian (2003). *Rapture: A raucous tour of cloning, transhumanism, and the new era of immortality*. New York: Basic Books. ISBN 0-7382-0761-6, pb, \$15.00.

Brian Alexander takes readers into the surprising stories behind cloning, stem cells, miracle drugs, and genetic engineering to show how the battle for the human soul is playing out in the broader culture—and how the outcome will affect each and every one of us. *Rapture's* Dickensian cast of characters includes the father of regenerative medicine, an anti-aging guru, and a former fundamentalist Christian and founder of the company that reportedly cloned the first human cell. This motley crew is in part being united by the force of the opposition: a burgeoning coalition of conservative Republicans, the Christian right, and the Greens—predicting impending doom should we become adherents of the new bio-utopian faith. The book is irreverent, shocking, and highly entertaining as it seeks to separate hype from reality.

Anderson, John D., Jr. (2004). *Inventing flight: The Wright brothers and their predecessors*. Baltimore, MD: The Johns Hopkins University Press. ISBN 0-8018-6875-0, pb, \$18.95.

The invention of heavier-than-air flight craft counts among humankind's defining achievements. In this book, the renowned aeronautical engineer John D. Anderson, Jr., offers a concise and engaging account of the technical developments that help to explain the Wright brothers' successful first flight on December 17, 1903. While the accomplishments of the Wrights have become legendary, we do well to remember that they inherited knowledge of aerodynamics and considerable flying-machine technology. Beginning with the earliest attempts at flight, Anderson notes the many failed efforts. He tells the fascinating story of aviation pioneers such as Sir George Cayley who proposed the modern design of a fixed-wing craft with a fuselage and horizontal and vertical tail surfaces in 1799 and of William Samuel Henson who won a patent in 1842 but never flew. He also examines the crucial contributions of German engineer Otto Lilienthal to the science of aerodynamics. With vintage photographs and informative diagrams, *Inventing Flight* will interest anyone who has ever wondered what lies behind the miracle of flight.

Beattie, Andrew, Paul R. Ehrlich (2004). *Wild solutions: How biodiversity is money in the bank*. New Haven, CT: Yale University Press, 2<sup>nd</sup> edition. ISBN 0-300-10506-1, pb, \$16.00.

In this fascinating and abundantly illustrated book, two eminent ecologists explain how the millions of species on Earth not only help keep us alive but also hold possibilities for previously unimagined products, medicines, and even industries. In an afterword written especially for this edition, the authors consider the impact of two revolutions now taking place: the increasing rate at which we are discovering new species because of new technology available to us and the accelerating rate at which we are losing biological diversity. Also reviewed and summarized are many "new" wild solutions, such as innovative approaches to the discovery of pharmaceuticals, the "lotus effect," the ever-growing importance of bacteria, molecular biomimetics, ecological restoration, and robotics.

Bergeron, Kenneth D. (2004). *Tritium on ice: The dangerous new alliance of nuclear weapons and nuclear power*. Cambridge, MA: The MIT Press. ISBN 0-262-52433-3, pb, \$15.95.

This winner of the Gold Award in Political Science in 2002 is now in paperback. For more than 50 years after the start of the nuclear age, the U.S. followed a policy barring commercial nuclear reactors from producing the ingredients of nuclear weapons. But in the fall of 2003 all that changed when a power plant operated by TVA started making tritium for the Department of Energy at the same time producing electricity for the commercial grid. Tritium, a radioactive form of hydrogen, is needed to turn A-bombs into H-bombs, and the commercial nuclear power plant that was modified to produce tritium is of a type called "ice condenser." This book provides an insider's perspective on how this nuclear policy reversal came about, and why it is dangerous.

Bødker, Keld, Finn Kensing, Jesper Simonsen (2004). *Participatory IT design: Designing for business and workplace realities*. Cambridge, MA: MIT Press. ISBN 0262-02568-X, hc, \$50.00.

The goal of participatory IT design is to set sensible, general, and workable guidelines for the introduction of new information technology systems into an organization. Reflecting the latest systems-development research, this book encourages a business-oriented and socially sensitive approach that takes into consideration the specific organizational context as well as first-hand knowledge of users' work practices and allows all stakeholders—users, management, and staff—to participate in the process. Drawing on the work of a 10-



year research program in which the authors worked with Danish and American companies, the book offers a framework for carrying out IT design projects as well as case studies that stand as examples of the process.

Broadbent, Marianne, Ellen Kitzis (2004). *The new CIO leader: Setting the agenda and delivering results*. Boston: Harvard Business School Press. ISBN 1-59139-57-1, hc, \$35.00.

Two converging factors—the ubiquitous presence of technology in organizations and the recent technology downturn—have brought Chief Information Officers to a critical breaking point. Then can seize the moment to leverage their expertise into a larger and more strategic role than ever before or they can allow themselves to be relegated to the sideline function of “chief technology mechanic.” Drawing on extensive Gartner, Inc. interviews and research with thousands of CIOs and hundreds of companies, the authors outline the agenda CIOs need to integrate business and IT assets in a way that moves corporate strategy forward. Dozens of case examples appear throughout the book including AXA, Banknorth, British Airways, Citigroup, Commerce Bank, Disney, SKF, Starwood, Unicef, and U.S. city and federal agencies.

Bunch, B. & Hellermans, A. (2004). *The history of science and technology: A browser's guide to the great discoveries, inventions, and the people who made them from the dawn of time to today*. Boston: Houghton Mifflin. ISBN: 0-618-22123-9, \$40.00.

Have you ever wondered how bridges are built? Do you know what medical discoveries led to the introduction of vaccines and antibiotics? Do you know why PCR (polymerase chain reaction) is one of the pillars of the biotechnology revolution? *The History of Science and Technology* is the ultimate resource for answers to questions about the when, what, why, and how of science and technology.

This accessible reference work, organized within 10 major periods of history, is a comprehensive, chronological guide to the scientific discoveries and technological innovations from the earliest periods of recorded history into the 21st century.

With more than 7,000 concise entries in such fields as archaeology, biology, computers, food and agriculture, medicine and health, and transportation, the book covers trends, important breakthroughs, births, deaths, and other useful information. Features include:

- in-depth section introductions that place each epoch in context
- short essays on intriguing topics, such as the history of DNA, the transit of Venus, the nature of light, and the relationship between electricity and magnetism
- 300 brief biographies of such personalities in science and technology as Galileo, the first scientist of the scientific revolution, and Charles Babbage, designer of the first mechanical computer
- 300 black-and-white drawings and photographs

Most entries are cross-referenced so that the reader can easily trace connections over time. This arrangement allows the reader to choose between following the development of a specific field through history and focusing on the breadth of innovation during a certain period.

Browsable yet richly detailed, *The History of Science and Technology* is an invaluable desktop reference for general reader and educator alike.

Campbell-Kelly, Martin (2004). *From airline reservations to Sonic the hedgehog: A history of the software industry*. Cambridge, MA: The MIT Press. ISBN 0-262-53262-X, pb, \$16.95.

From its first glimmerings in the 1950s, the software industry has evolved to become the fourth largest industrial sector in the U.S. economy. Starting with a handful of software contractors who produced specialized programs for a few existing machines, the industry grew to include producers of corporate software packages and then makers of mass-market products and recreational software. This book tells the story of each of these types of firms, focusing on the products they developed, the business models they followed, and the markets they served.

Cassidy, David C. (2004). *J. Robert Oppenheimer and the American century*. New York: Pi Press. ISBN 0-13-147996-2, hc, \$27.95.

The story of J. Robert Oppenheimer, physicist extraordinaire and the man who led the scientific team for the Manhattan Project that built the atomic bomb, has fascinated many people. Award-winning author David Cassidy, using previously unexamined documents, presents for the first time an integrated and coherent account of the man within the context of the nation he loved and so profoundly affected. Cassidy has crafted a richly detailed, gripping, and nuanced look at the theorist who theorized about black holes, the humanist who read Sanskrit, the man who loved his family, and the statesman who confronted the hardest

moral dilemmas and scientific problems of his age. The hidden story of the political and social forces that shaped the world in the 20th century is the rise of American science, and Oppenheimer was at its epicenter. His story is at the crux of America's astonishing rise to power and an insight into the technological progress of our nation.

Chadarevian, Soraya de, Nick Hopwood, Eds. (2004). *Models: The third dimension of science*. Stanford, CA: Stanford University Press. ISBN 0-8047-3971-4, pb, \$24.95.

Now that "3-D models" are so often digital displays on flat screens, it is timely to look back at solid models that were once the third dimension of science. This book is about wooden ships and plastic molecules, wax bodies and a perspex economy, monuments in cork and mathematics in plaster, casts of diseases, habitat dioramas, and extinct monsters rebuilt in bricks and mortar. These remarkable artifacts were fixtures of laboratories and lecture halls, studios and workshops, dockyards and museums. Considering such objects together for the first time, this interdisciplinary volume demonstrates how, in research, as well as teaching, 3-D models played major roles in making knowledge. Accessible and original chapters by leading scholars highlight the special properties of models, explore the interplay between representation in two dimensions and three, and investigate the shift to modeling with computers. The book is fascinating reading for anyone interested in the sciences, medicine, and technology, and in collections and museums.

Clarke, David, Ed. (2005). *Theory of technology*. New Brunswick, NJ: Transaction Publishers. ISBN 0-7658-0844-7, pb, \$29.95.

The history of technology is often troubled by good ideas that do not, for one reason or another, take off right away—sometimes for millennia. Sometimes, technology comes to a standstill, and sometimes, it even reverses itself. Thus, unlike science, which seems to proceed at a reasonable and calm rate, the progress of technology is difficult to theorize about. David Clarke brings together 10 authors from a range of disciplines who try to understand technology from a variety of viewpoints. These essays originally appeared in two issues of *Knowledge, Technology & Policy* in 2002 and 2003.

Eglash, Ron, Jennifer L. Croissant, Giovanna Di Chiro, Rayvon Fouché, Eds. (2004). *Appropriate technology: Vernacular science and social power*. Minneapolis, MN: University of Minnesota Press. ISBN 0-8166-3427-0, pb, \$25.95.

From the vernacular engineering of Latino car design to environmental analysis among rural women, to the production of indigenous herbal cures—groups outside the centers of scientific power persistently defy the notion that they are merely passive recipients of technological products and scientific knowledge. This work is the first study of how such "outsiders" reinvent consumer products—often in ways that embody critique, resistance, or outright revolt.

Emsley, John (2004). *Vanity, vitality, and virility: The science behind the products you love to buy*. New York: Oxford University Press. ISBN 0-19-280509-6, hc, \$28.00.

Acclaimed popular science writer John Emsley explains the nature and behavior of about 40 ingredients that play important roles in every aspect of modern living. There are chapters on cosmetics, foods, sex, hygiene, depression, and on four unexpected ways in which modern products improve our lives. So if you have ever asked yourself whether cosmetics can deliver what they promise, whether certain spreads really can reduce cholesterol, whether nitrates in water are a cause of cancer, or whether Prozac is as safe as they say, dive into *Vanity, Vitality, and Virility* and discover things you always wanted to know.

