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Gender Disparity in Third World Technological, Social, and Economic Development

Anthony I. Akubue

Despite their seemingly intractable problems, Third World countries have made remarkable progress in improving the well-being of their people in recent decades. In what seems a recurring observation in its annual Human Development Reports, the United Nations Development Program (UNDP) notes that the human progress that developing countries achieved in a period of three decades took the industrialized countries a century to attain. People are living longer, infant mortality rates and illiteracy rates have declined significantly, and appreciable improvements in basic-needs fulfillment of citizens have been realized. A troubling concern, however, is the notion that gains from progress have not been equally beneficial to the genders. Males tend to be better off in most cases, often capturing a disproportionate share of the proceeds than females. There is much evidence in support of the claim that women are in the majority of the poor in the Third World today. According to the UNDP (1995), 70% of an estimated 1.3 billion people living in poverty worldwide are women, most of them living in developing countries. However, the feminization of poverty is not so much about more women than men being poor, but about the "severity of poverty and the greater hardship women face in lifting themselves and their children out of the trap" (UNDP, 1997, p. 64). This differential gender impact underlies the UNDP (1997) statement that "for too long it was assumed that development was a process that lifts all boats, that its benefits trickled down to all income classes–and that it was gender neutral in its impact. Experience teaches otherwise" (p. 1).

This article is about Third World women in relation to technological and socioeconomic progress. It examines the differential gender outcome of this progress and probable causes. Nzewi (1996) attributed obstacles to women engaging in and pursuing careers in science, technology, and mathematics (STM) to factors of tradition and cultural norms, attitudes and prejudices, religion, poverty, and ignorance. Inherent in the socialization process of societies is a particularly damaging depiction of gender roles as biological rather than social constructs. The power of the socialization process in inhibiting women's education in science, engineering, mathematics, and technology education is often underestimated and has not received the attention it deserves among professionals in the field. The view espoused in this article is that this indoctrination inspires phobia, diffidence, and lack of interest among girls and women, who tend to believe that some academic disciplines and professional careers are beyond their abilities. This mindset is a powerful force that is contributing to the perpetuation of poverty among Third World women in particular and the Third World in general. Logic provides that peace cannot endure where poverty prevails, and that the poor will migrate toward relief if relief does not come to them.

Some Background

Investigations into women's issues in relation to technological, social, and economic

My use of the term "Third World" was as a result of my research of its origin and meaning. Alfred Sauvy coined it in the early 1950s as a forward looking and hopeful way of describing what was taking place in Africa and Asia in their quest for political independence. Like the Third Estate of pre-Revolutionary France and its role in the French Revolution, the Third World possessed a revolutionary potential to rise in rebellion against foreign rule and domination. This prediction materialized with the formation of the Non-Aligned Movement, a nationalist organization, in 1961. According to one writer, the Third World became a positive concept symbolizing the new and experimental arena of global politics of neither capitalist nor communist ideology. This is why I use the term, even though the 1989 fall of communism (the Second World) prompted calls for its discontinued use. Many leaders from the Third World continue to prefer that name to others.

progress have been relatively recent, but rural women have for years been affected one way or another by modern technology and development. Women and girls in Third World societies are more likely than men and boys to have less access to technology, education, technical training, land, credit, and basic needs. Historically, women have performed mostly laborious, gender-assigned duties with skills and tools passed down from generation to generation. The duties of Third World women can be placed into three categories: reproductive and nurturing, family and household management, and productive and/or income-generating roles (Momsen, 1998; UNDP, 1997). Studies have shown that in developing countries women, especially poor women, work an average of 12 to 18 hours a day compared to an average of 8 to 12 hours a day for men (Jacobson, 1993; Momsen, 1998). Among the tasks women perform are subsistence farming, food production and processing, traditional weaving and sewing, soap-making, petty trading, craft-making, baking, shop-keeping, procuring energy fuel and water, household work, payment of children's school fees, animal care, caring for the elderly, and raising children (Akubue, 1995).

Access to Productive Resources

The gap between male and female literacy rates in the Third World has been narrowing, although female illiteracy continues to be higher than male illiteracy. Out of an estimated 840 million illiterate adults in the developing world, 538 million of them are women. The female illiteracy rate stands at about 39% in contrast with a male illiteracy rate of 21% (Momsen, 1998; UNDP, 1997). Women and girls tend to receive less education and training than men and boys in most Third World societies (Herz, 1989). This is not surprising because in the absence or poor enforcement of legislation on compulsory education for all children, coupled with the tendency to value sons over daughters, girls are less likely than boys to go to school. Investments in education continue to be higher for sons than for daughters. This is in spite of studies showing that the education of girls tends to produce far-reaching socioeconomic benefits for the girls and women themselves, their families, and the society in general (Bellew, Raney, & Subbarao, 1992; Hadden & London, 1996; Herz, 1989; Summers, 1992). Indeed, most studies have revealed that when schools open their doors wider to girls and women, as well as boys and men, the benefits multiply. Dr. J. E. Aggrey, an eminent educator from Ghana, observed that "if you educate a man, you simply educate an individual, but if you educate a woman, you educate a family" (Topouzis, 1990, p. 62). Among the short-term benefits of educating girls and women are smaller families, better spacing of births, healthier children, less economic dependence, and less vulnerability to abusive spouses. "These initial gains seem also to be readily translated into a range of longer-term benefits that include longer life expectancy, declines in overall mortality rates, and improvements in both social and economic development rates" (Hadden & London, 1996, p. 43).

Increasingly, parents in Third World societies are realizing the importance of educating their daughters, but there are still some impediments. Not only are there more illiterate women than there are illiterate men, but also two thirds of the children not enrolled in school are girls (Momsen, 1998).

As much as women would like to participate in adult literacy programs, their incredible responsibilities and workloads keep them from taking advantage of opportunities. The persistence of poverty among many families also works against the education of girls and women. Due mostly to hardship in poor households, girls are more likely than boys to stay at home to help their mothers with income-earning efforts and other household chores. "In fact, the increasing tendency in many areas of keeping girls out of school to help with their mothers' work virtually ensures that another generation of females will grow up with poorer prospects than their brothers" (Jacobson, 1993, p. 75). The concern for the safety of daughters is another critical factor in the decision whether to send girls to school. Their vulnerability, the fear of becoming victims of rape, and a strong taboo on pregnancy out of wedlock are reasons to shield girls from the vagaries of life outside the home. In some societies, parents see educating girls as an exercise in futility since they are given away in marriage and the reward of years of education may elude the natal family. Lastly, the impact of colonial perspectives on gender roles continues to influence gender educational opportunities. A curriculum that emphasizes housework, for instance, does not help women improve their capabilities as farmers. This curriculum is, however, sustained on the premise that humanity would be best served if women could "improve the way in which they cared for their children and catered for the family needs. As a result family welfare programs were devised which gave women instruction in home economics, in improved nutrition, health, and hygiene" (Young, 1993, p. 19). Yet, women play an indispensable role in food production and processing in Third World countries. For example, women in Africa produce 80% of domestically consumed food, 70% to 80% of food crops grown on the Indian sub-continent, and about 50% in Latin America and the Caribbean (Jacobson, 1993; Momsen, 1998). Estimates from Kenya suggest that providing women with the same access to factors and inputs as men would increase the value of their output nearly 22% (World Bank, 2000).

The agricultural extension service is overwhelmingly a male-dominated profession in the Third World; only 13% of the agents in the late 1980s and early 1990s were women. In the continent of Africa and India, the statistics were as meager as 7% and 0.5%, respectively (UNDP, 1995). Trained and equipped usually in urban environments still laden with vestiges of colonialism, male extension agents are, not surprisingly, partial to men, even in areas where women are responsible for major cash or food crop production. A study of the pattern of visits by extension workers to farmers in Kenya showed that 49% of the female-operated farms were never visited by an agent in contrast with only 28% of male or jointly operated farms (Momsen, 1998). The gender bias against women is further compounded by cultural and religious practices that prohibit direct contact between women and male strangers/extension agents (Akubue, 1995; Young, 1993). Moreover, with a ratio of one extension agent to 2,000 or 3,000 farmers, extension systems in many Third World countries are severely constrained and understandably cannot meet the overwhelming demand for their services. The situation is quite the opposite in Europe and North America, where one extension agent serves 300 to 400 farmers (Quisumbing, 1998). Under this condition, it is often assumed that husbands would pass information on to their wives from extension service workers. Studies in Asia, Africa, and Latin America and the Caribbean, however, show that such information communicated indirectly is often distorted and less accurate (Akubue, 1995). According to studies in Kenya, "women farmers generally adopt the advice given by extension agents; where they do not, the principal reason they cite are lack of credit and income to buy inputs, and lack of enough land" (Herz, 1989, p. 44).

Generally, rural financial institutions still prefer and require land title as collateral for loan extension in many Third World countries. This requirement tends to be partial to male borrowers, since land ownership and title in most cases belong to men (Akubue, 1991). "In the patrilineal cultures found in Bangladesh, India, Pakistan, much of sub-Saharan Africa, and Latin America, women gain access to land only through their husbands or sons" (Jacobson, 1993, p. 70). This has not always been the traditional system of land tenure in the Third World. The current system is very much the result of European views of what constitutes gender-appropriate roles, which replaced a precolonial system of communal land ownership. To implement the new system, colonial administrations registered communal land and made land titles out in men's names (Momsen, 1991; Quisumbing, 1998; Young, 1993). Contemporary Third World development professionals have tacitly endorsed past actions by maintaining the status quo. For most rural women, access to land is usually in the form of user rights rather than absolute ownership rights (Quisumbing, Brown, Feldstein, Haddad, & Pena, 1995). In instances where women have ownership rights, their share is usually small relative to men's. Lacking outright land ownership and land title commonly required by banks for loan extension almost guarantees lack of funding for the women. The traditional moneylenders' practice of charging usury rates is an exorbitant and exploitative alternative source of credit. Without a propitious rural financial market to count on, women have difficulty mobilizing enough start-up capital for new businesses or expanding existing undertakings. Women, like men, need credit to acquire essential appropriate technology, tools, and material input to improve productivity, profits, and standard of living. Not surprisingly, the cumulative effects of protracted denial of women's access to productive resources, education, and training are worsening gender disparity and inequity.

Not having as much access as men inhibits rural women's technological literacy and, definitely, their motor, cognitive, and interpersonal communication skills. Consequently, some researchers have contended that the "most common result of 'development' is to relegate women to the subsistence sector in agriculture and low-paying jobs in manufacturing and industry" (Tadesse, 1982, p. 79).

Manufacturing and Industry

Technological development in the modern industrial sector unmistakably has opened up diverse job opportunities for Third World women. However, questions have been raised about the quality of the jobs thus created. These have been mostly low-wage, low-skill, dead-end jobs where they are easily dispensable. Lacking the necessary skills and specialization, women workers in modern sector factories "mostly are engaged in non-technological gathering, assembling, arranging and packaging activities and therefore technical skills are not being transferred equally to men and women" (Srinivasan, 1981, p. 91).

Regardless of what they are called, maquiladoras in Mexico or export processing zones (EPZs) elsewhere in Latin America, Africa, and Asia, they are industrial plants owned or subcontracted by multinational corporations with headquarters in the industrialized nations. They are export-oriented assembly and manufacturing firms producing goods primarily for re-export to Europe and North America. These industrial plants, predominantly electronics, textiles, apparel, and footwear industries, hire mostly female labor (Akubue, 1995; Momsen, 1998). It is claimed that women have a number of attributes that are not commonly exhibited by men. Women are said to be nimble-fingered, dexterous, docile, patient, and obedient, and to possess better attention spans than men do. Interestingly, these fine characteristics have contributed significantly to women's vulnerability in the maquiladoras or EPZs.

As manufacturing with laborsaving, capital-intensive technology has grown in the maquiladoras and EPZs, the traditional labor-intensive assembly for which they are known no longer enjoys the monopoly it once did, and the characteristic female labor dominance is on the wane. For example, the percentage of female workers in the Mexican maquiladoras fell from a 1982 figure of 77% to 61% in 1990 (Wilson, 1992). Also, cases of sexual harassment and molestation, as well as inhumane and unhealthy working conditions, are not uncommon at these enterprises (Kelly, 1983; Pena, 1997). Mitter (1995) conceded that jobs in the factories are not perfect, but argued that the "conditions of employment are superior to alternatives that women are likely to find as domestic workers, prostitutes, or as workers in the informal sector" (p. 23). This assertion is reasonable but only to the degree that one believes that half a loaf of bread is better than no bread at all.

Utilizing women to the extent of their potential in all spheres of life is not a matter of doing them a favor, but engaging the enormous human resource of one half of humanity for the betterment of communities and nations. A study of women workers in the Dominican Republic shows that they are usually fired when they fail to meet increasing output quotas, get married, or become pregnant (Momsen, 1998). Paradoxically, the so-called advantages of the female gender have merely served to congregate women at the lower rungs of the organizational ladder and increase their vulnerability. The situation is not much different for women in the mechanized agricultural sector.

The Agricultural Sector

It is not unusual for the introduction of a new farm technology to result in radical shifts in gender roles in agricultural labor. Anderson (1985) stated that "when a technology is introduced, those who either already enjoy higher status or who are in a position to corner it may move into tasks that were previously low status when done without the benefit of the new technology" (p. 61). Since men are more likely than women to have access to technology and associated technical training, any shifts in sex roles due to new agricultural technologies would tend to favor mostly men. Momsen (1991) argued similarly that the "introduction of a new tool may cause a particular job to be reassigned to the opposite sex and men tend to assume tasks that become mechanized" (p. 50). Thus the introduction of post-harvest food processing technologies may mean the loss of a traditional source of income for rural poor and landless women. For example, women who depend on the traditional hand pounding with mortar and pestle to de-husk rice or grain as hired labor may lose their job as a result to rice, corn, or oil mills operated by men. This is especially the case in Africa and Asia, where many women fit into this category of hired rural labor (Momsen, 1991; Quisumbing et al., 1995).

In rural West Africa, hired female labor process palm nuts and kernels for the extraction of widely consumed palm oil. Most of these women lost their jobs with the introduction of oil mills operated by men. Still, for Moslem women restricted by purdah from work outside the homestead and in the company of men, technology-induced relocation of the workplace to the mills may mean the loss of a vital source of income. Furthermore, while male landowners in Africa and elsewhere experienced lightened workload and expansion in cash crop cultivation with modern tractors and improved animal-powered farm equipment, work for their wives increased, with more area to weed, hoe, and plant (Jacobson, 1993). A study of a Tiv farm development project in Nigeria showed that women experienced "a disproportionately high share of the labor increase without a corresponding increase in income. Female labor requirements rose by 17%, while those of men rose by only 6%" (Young, 1993, p. 52). These conditions for women simply cannot be dismissed as fortuitous and without connection to existing power relations and decision-making processes in the Third World.

Decision Making

It appears from the above that technology and development have actually been contributing to widening the gender gap instead of reducing it. The general image of technological and socioeconomic development is and has been that of a male directed and controlled process. Seen as such, development has commonly been viewed as a process that is structured by men and for men, and women are expected to abide without questions. The literature is replete with evidence that women are often not involved or consulted in the planning and designing of technology-based development projects and programs with direct impact on them. For instance, projects involving solar cookers in India, hydraulic palm oil presses in Nigeria, and high yield variety maize in Mexico were implemented with little input from women who are and have traditionally been responsible for cooking and palm oil processing. The introduction of solar cookers in India, Kenya, and elsewhere seems expedient given the serious problems of deforestation and fuelwood scarcity. As logical as this innovation seemed, rural women resisted it mainly because of their labor patterns, food habits, and the intermittent nature of the sun. For instance, women cook the main meal of the day when they return from the farms in the evening. The solar cooker is not very useful at sunset, and it is highly unlikely that some women would readily abandon established labor patterns in the village to accommodate a new technology. Furthermore, since the solar cooker must face directly into the sun to be effective, it requires constant relocation to track the sun as it changes positions. This is inconvenient, to say the least. Finally, even though some governments subsidize the cost of solar cookers as in India for instance, the price remained prohibitive for a large number of people (Blankenberg, 1991).

The problems with the introduction of the solar cooker and similar schemes elsewhere were due mostly to flaws in the planning process. As appropriate as the innovations seemed, their planning and introduction lacked the valuable input of the women who are the majority of the target end-users. This mistake is often perpetuated by the erroneous assumption that men who dominate the decision-making process know what women need. The urgency of listening to women articulate their needs and including them in decision-making cannot be overemphasized. As the saying goes in India, "As a bird cannot fly on one wing, no society can make progress unless its women too join men in all activities" (Bhattacharya & Bose, 1995, p. 93). Science and technology have become the most potent sources of change and empowerment in modern society. To insist on the age-old practice of excluding women in decisions concerning their development is to be unwise and myopic.

Women are conspicuously under-represented in decision and policy making concerning technological and socioeconomic development. Explaining the reason for this condition, Young (1993) suggested plausibly that development practitioners are cautious not to violate what may be strongly regarded cultural practices and values. Mostly male-dominated government officials from the Third

World often claim that concerns about the absence of women at high levels of government and their lack of active involvement in policy making is a Western preoccupation of no interest even to their women. The few women in positions of power and authority are being lost through attrition as many of them experience first-hand what it entails to be "lonely at the top." However, efforts to improve the status of women and to enlist their self-confidence, intellectual, and decision-making capabilities for the benefit of society have culminated in landmark conferences and policy adjustments worldwide.

Confronting Gender Bias

As a result of concerted efforts in recent decades, the plight of women in general is a topic of serious research, discourse, and action worldwide. Various governments are cooperating with international agencies to initiate gender sensitive policies and programs. For instance, in 1973, the U.S. Congress adopted the Percy Amendment (Section 113 of the 1973 Foreign Assistance Act) sponsored by Republican Senator William Percy (retired) of Illinois. As the amendment requires, U.S. bilateral development assistance "shall be administered so as to give particular attention to those programs, projects and activities which tend to integrate women into the national economies of foreign countries, thus improving their status and assisting the total development effort" (Blumberg, 1990, p. 2). The amendment also directed the U.S. Agency for International Development (AID) to include the likely effects of development projects on women in its feasibility studies of projects. The Women in Development (WID) Office of the AID was established in direct response to this amendment. The office assists in the preparation and testing of case studies involving projects funded by the AID. This legislation was unprecedented in its strong endorsement of women

> as contributors and agents of economic development as well as its beneficiaries. Planners, therefore, must guard against the negative effects of their projects on women and focus on the need to enhance women's productivity, raise their income, and promote their access to economically productive resources as a means to achieving overall national economic growth. (Overholt, Anderson, Cloud, & Austin, 1985, p. 11)

Similar efforts followed the U.S. example. The British Commonwealth, for example, in 1980 established a Women and Development (WAD) program that received the endorsement of all of its member nations (Momsen, 1991). Third World governments have also initiated pragmatic educational reforms that are having positive impact on their literacy rates. More girls and young women are enrolling in schools today than ever before. The combined female primary and secondary enrollment in the developing world jumped dramatically from 38% in 1970 to 68% in 1992 (UNDP, 1995). Governments have also been working in alliance with multilateral agencies in the march toward gender equality.

The United Nations has been and remains an active agent of change in its global work on gender matters. The World conferences on women held in Mexico City, Mexico, in 1975; Copenhagen, Denmark, in 1980; Nairobi, Kenya, in 1985; and Beijing, China, in 1995 have kept attention focused on the condition of women and produced action plans for improving women's status worldwide (Kaye, 1995; Young, 1993). Not only was 1975 designated International Women's year, the UN Decade for Women, from 1976 to 1985, started with the creation by the UN General Assembly of a Voluntary Fund for the decade that became known as the UN Fund for Women (UNIFEM). UNIFEM's efforts are focused on three areas: strengthening women's economic capacity as entrepreneurs and producers, promoting governance and leadership that increase women's participation in decision-making processes that shape their lives, and promoting women's human rights ("UNIFEM," 1998).

The 1975 conference in Mexico adopted the World Plan of Action (WPA) from the UN. The WPA is a compendium of objectives encompassing priority issues such as enabling "educational opportunities for women, better employment prospects, equality in political and social participation, and increased welfare services" (Young, 1993, p. 25). The subsequent conferences in Copenhagen, Nairobi, and Beijing have been vital to review work in progress, evaluate accomplishments and challenges, pass important resolutions, and develop follow-up action plans. Professional associations also work cooperatively with the UN for gender equality and equity. For instance, the Gender and Science and Technology Association (GASAT) has through its conferences worked toward narrowing the gender gap in relation to increasing female presence in the fields of science and technology education. GASAT made vital contributions towards the inclusion of science and technology in the Platform of Action during the last UN conference on women held in Beijing, China (GASAT, 1998). All this has been impressive, but it goes without saying that this concerted effort to improve the status of women must continue without abatement, for there is much more yet to be done.

The Work to Be Done

Women's positions in most contemporary social institutions in Third World countries continue to be subordinate in many cases and border on tokenism in others. A thorough examination of the cultural and political milieu in educational systems and the workplace is imperative to identify and isolate factors that work against women's enrollment and success in technological fields and their upward mobility in public and private organizations. Any attempt to improve the enrollment of women in fields such as technology education, engineering, and science where they are poorly represented must start with attempts to identify and remove impediments keeping them out of these disciplines. Changes in institutional cultures, societal power relations, social values, and stereotypes are inevitable in this effort. Successfully identified, information about results must be widely disseminated and factored into all future program design and development.

The dissemination of information is crucial and cannot be overlooked in the effort to eradicate gender disparity and improve the status of women in general. Information dissemination will not only reduce the common practice of reinventing the wheel, but will also speed up the adaptation and replication of successful programs as needed in different locations. Due primarily to extensive publicity, highly successful Rotating Savings and Credit Associations (ROSCAs) such as the Grameen Bank of Bangladesh, which provide micro loans to rural women, are increasing in number and have been very effective in empowering women (Akubue, 1991). ROSCAs have enabled rural women, denied loans from conventional financial institutions for lack of collateral and track records, to purchase low-cost appropriate technologies for new businesses or to expand existing ones. Looms, hand-sewing machines, improved cooking stoves, hand grinders, manual typewriters, and hand tools are some examples of appropriate technologies purchased with loans from ROSCAs.

Programs in Mexico and Jamaica, for instance, teach young, unemployed, low-income women technical skills for jobs traditionally associated with the male gender. With assistance from UNIFEM, 10 women from Tempoal in Mexico started a thriving manufacturing enterprise after receiving training as welders and machinists in Colombia, South America. The women started a company to manufacture simple, easily affordable water pumps for export and domestic sale in Mexico. In the Caribbean island of Jamaica, a skill-developing training program that prepares women for careers in the construction industry is known for its high job placement rates (Antrobus & Rogers, 1980; Dorman, 1991; McLeod, 1986). The success of these programs is a strong testimony that gender roles are primarily social constructs as opposed to indelible biological impositions. Associations such as the GASAT remain unwavering in their belief that given a level playing field, women are quite capable of mastering the skills for careers in science, technology, and mathematics.

However, more extensive improvements in gender equality are possible if the replication of successful projects is executed in tandem with other strategies. Famous professional women can be enlisted as role models in a multifaceted strategy especially to inspire young women to pursue academic education and careers in traditionally male-dominated fields such as technology education, engineering, and computer science. Even in the United States where parity in literacy rates has been achieved between the genders, women still constitute a very small percentage of students graduating with bachelor's degrees in engineering and computer science. Only 9% and 29% of students who earn bachelor's degrees in engineering and computer science, respectively, are women (Rengel, 2000). Using famous women engineers, technologists, and scientists as role models, young women can be encouraged to enroll in related majors. For instance, Sarah Akbar of Kuwait Oil Company was a petroleum engineer and a member of the Kuwaiti team of firefighters who fought the inferno at Kuwait oil wells when operation Desert Storm ended in 1991. Sarah was the first woman ever in Kuwait and in the Middle East to participate in a potentially hazardous task of that kind. The publicity that followed Sarah's bravura turned her into a role model, symbol of equality, and mentor for young Kuwaiti women. A study at Kuwait University later showed that the number of women enrolled in petroleum engineering increased substantially since Sarah's unprecedented feat (Soliman, 1993). Sarah's efforts were a lesson in self-confidence, courage, and risk-taking for women, and another refutation of the theory that we are born with naturally assigned, not to speak of unchangeable, gender roles. However, to be effective, the task of collecting and making this and other successful schemes available for dissemination must be the responsibility of a central body established and supported by governments in the Third World.

Centers for the collection and dissemination of information on effective strategies for improving women's status and achieving gender equality have been set up in many Third World countries in recent years. Women's bureaus "collate, collect and coordinate existing information as well as encourage, fund and partially direct future research" (Nelson, 1981, p. 49). The charge of most women's bureaus is not only to ensure that women play a greater, and important, part in all development projects, but also to plan, coordinate, and monitor a wide variety of other projects having to do with women. To this end, women's bureaus act as catalysts integrating women into male-dominated areas such as the agricultural extension profession. Making sure that women are recruited and trained includes educating male colleagues on respect for and sensitivity to issues concerning women. Women's bureaus and similar agencies are definitely a welcome idea, but they can be subverted by inadequate funding, lack of trained personnel, and having little or no political clout. According to Young (1993), many of these agencies have not been very effective for these reasons.

Finally, socialization in traditional societies often includes risk aversion for women. The march toward gender equality will be better served with strategies that assist women to unlearn years of belief that risk-taking is improper for the female gender. Being able to give up what one "is" for what one "could become" is the essence of risk-taking. Women are by tradition and mores more likely than men to avoid taking risks for fear of failing. It is important to point out here that failure is itself an important aspect of the learning process. Properly managed, failure can be a positive guide to success. The notion of doing things for instead of with women, the result of the social and cultural orientation in most communities, presents a problem in that it denies them the chance to acquire vital knowledge and contacts. To sincerely work toward a society of gender equality and equity, women have to have access to political and economic networks. Speeches and reports that extol the benefits of gender equality are nothing more than empty rhetoric if they are not followed up with commensurate action. As Jacobson (1993) aptly remarked, "development strategies that limit the ability of women to achieve their real human potential are also strategies that limit the potential of communities and nations" (p. 76). Those of us in science and technology need to become involved through scholarly papers and presentations to lend credibility and a sense of urgency to the plight of Third World women and girls. In a "shrinking" world made possible through advances in transportation and communications technology, regional problems tend to quickly extend beyond regional boundaries.

Dr. Anthony Akubue is a professor in the Department of Environmental and Technological Studies at St. Cloud State University. He is a member-at-large of Epsilon Pi Tau.

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Alternative Routes to Certification of Technology Education Teachers

Marie Hoepfl

Virtually every state in the nation has provisions that allow school districts to hire nonlicensed individuals to teach if district authorities can demonstrate that no regularly licensed teachers are available. States are responding to this shortage through a variety of measures, including alternative routes to licensure. Begun as short-term measures to deal with immediate shortages, alternative paths are now becoming "institutionalized alternatives to college-based teacher education" programs (Stoddart & Floden, 1995, p. 1). Alternative routes are designed to reduce entrance requirements and preparation needed prior to paid employment as a teacher, and they emphasize on-the-job training (Zumwalt, 1996).

Defined simply, alternative certification (AC) is a process in which a state licenses a person who has not completed a university-based teacher preparation program (Wise, 1994). The term has been applied to a wide range of alternative models. The National Council for Education Information (NCEI) distinguishes "true" AC programs as those that "include formal instruction and mentoring while teaching, and are not driven by discipline shortages" (Ludwig, Stapleton, & Goodrich, 1995, p. 6). In spite of this, the AC programs in most states do not represent "true" models, since many have been implemented to address shortages, do not require formal mentoring, and may not require any formal instruction.

Alternative licensure routes typically focus on the more pragmatic issues of teaching—the survival skills—more than they emphasize the theoretical foundations of education. The pedagogical skills addressed are designed to help the teacher assume full-time responsibility for teaching with a measure of success (McKibbin & Ray, 1994).

Emergency teaching certificates have been used in K–12 education for a long time. These are typically temporary certificates awarded on an annual basis to fill a pressing need. In fact, the number of individuals teaching "out of field" or on an emergency basis is relatively high in some states and some districts. Certification through other than traditional routes has also been used in vocational education for the better part of this century (Walker, Gregson, & Frantz, 1996).

The nationwide shortage of teachers is being felt in technology education as it is in most other teaching fields (Weston, 1997). States appear to be responding to this shortage through a variety of measures, including alternative routes to licensure. Due to the continuing and apparently rapid decline in graduates from traditional technology teacher preparation programs (Volk, 1997, 2000), this study was conducted to examine the extent to which alternative routes to licensure in technology education are being used on a national level.

Alternative Certification: Background and Issues

According to Stoddart and Floden (1995), the first step toward widespread development of alternative routes to certification was the adoption of standardized tests for teachers as a means of ensuring their academic competence. This shifted the emphasis away from pedagogical skills toward content knowledge.

Growth in the use of alternative routes occurred at a time when the military services were downsizing, businesses were displacing workers, and universities were attempting to market their teacher education programs (Ludwig et al., 1995). At the same time, politicians and the public were criticizing the quality of education and the inability of universities to produce teachers to meet expected demands for teachers. The Department of Defense has acted as an important promoter of moving retired or nonactive military personnel into the classroom. Programs such as Troops to Teachers and Servicemembers Opportunity Colleges Education (SOCED) offer incentives and financial support to retired military personnel who enter teaching (Keltner, 1994).

The underlying assumption behind most alternative routes to certification is that traditional teacher preparation (i.e., pedagogical knowledge) is unnecessary for success in the classroom (Knight, Owens, & Waxman, 1990-1991). The following statement, issued as part of an "education manifesto" by a group of educators and policy makers, is representative of the rhetoric that often accompanies calls for alternatives:

> Today, Albert Einstein would not be able to teach physics in America's public school classrooms. That is ridiculous. Alternative certification in all its variety should be welcomed, and for schools that are truly held accountable for results, certification should be abolished altogether. Colleges of education must lose their monopoly and compete in the marketplace; if what they offer is valuable, they will thrive. (Thomas B. Fordham Foundation, 1998, p. 5)

Characteristics of the particular AC program and of the teaching context have been found to be critically important in evaluating program success (Zumwalt, 1996). In their examination of AC of trade and industry teachers, for example, Walker et al. (1996) found that requirements for certification across different states were so dissimilar that reciprocity agreements did not seem to apply.

According to the National Education Association (NEA), the primary reasons for using alternative routes are to boost the pool of minority teachers and to provide opportunities for midcareer professionals from other fields to more readily apply their talents to teaching (Ludwig et al., 1995). By streamlining certification requirements, talented people may be attracted from industry or government who would otherwise not be able or willing to serve (Litowitz, 1998).

Opponents of streamlined approaches claim that this results in teachers who are less prepared to fulfill their professional responsibilities. Instead, they believe, teaching should be modeled after other professional fields such as engineering or medicine, and licensure should be treated rigorously. Stoddart and Floden (1995) likened shortened alternative models to the trades, such as carpentry, plumbing, and the like, "where on-the-job training in the form of apprenticeships is the norm" (p. 3). Presumably, this is meant to suggest a less rigorous form of training.

A large-scale study conducted by Shen (1997) supports the claim that alternative routes lead to greater diversity in terms of gender and race (Zumwalt, 1996). The alternatively certified group did have a significantly higher percentage of minority teachers and a higher percentage of males than the traditionally certified group. The surprising finding was that over 50% of the alternatively certified teachers were recent college graduates, not older individuals seeking midcareer changes. An additional 24% of the teachers in Shen's study were seeking certification in a different field. An important implication of these findings is that AC routes allow new college graduates to circumvent the traditional teacher preparation process.

Proponents of AC claim that it is an effective way to meet the growing teacher shortages in many fields. While this may be true for some teaching fields and in some geographical areas, it is clearly not always the case (Ludwig et al., 1995). However, data from Shen's (1997) national study suggest that shortages in specific subject areas—namely, math, science, and technology—are being addressed (if not met) through alternative programs. In other words, a greater percentage of alternatively certified teachers held degrees in math, science, or engineering than the traditionally certified teachers (Shen, 1997).

Another claim made for AC programs is that they will help to meet the need for teachers in urban schools. According to Shen (1998), these programs have addressed the need in urban schools, where minority students are concentrated. AC programs do not, however, appear to have addressed the need for teachers in rural areas (Shen, 1998).

The great irony of many AC programs is that at the same time that policy makers have made it easier for noncredentialed individuals to enter the classroom, they are decrying the perceived lack of quality among graduates of traditional programs and implementing more stringent guidelines for the preparation of these teachers. The added hurdles make it even more difficult to attract people into the teaching profession via traditional routes. Stoddart and Floden (1995) called this the "two worlds of teacher education" (p. 2).

The argument for using alternative routes to find people with content-area expertise is challenged by two findings. Ludwig et al. (1995) found that participants in several AC programs studied felt they needed more content area training. And the widely held perception that knowing a subject does not guarantee you can teach it effectively has been supported by research (Ludwig et al., 1995). Young-Hawkins (1996) noted "subject-matter competence alone is inadequate for instruction because teaching requires the transformation of knowledge content into representations that enhance students' understanding and learning" (p. 27).

Finally, there is a notable absence of

discussion about the pedagogical skills of alternatively certified teachers; proponents instead focus on claims about their greater content expertise. One study compared the classroom learning environments of alternatively and traditionally prepared elementary and middle school teachers. Significant differences were found in five aspects of the classroom environment: friction, cohesiveness, use of higher-thought processes, cooperation, and pacing. That is, students in traditionally certified teachers' classrooms perceived greater use of higher-thought processes, a more appropriate pace for coverage of material, more group cooperation and cohesiveness, and less friction than did students in the alternatively certified teachers' classrooms. These dimensions of the learning environment have been identified as predictors of levels of student achievement (Knight et al., 1990-1991). This would certainly be an avenue for further research.

Alternative Certification in Technology Education

The decline in graduates from traditional technology teacher education programs is well documented (Volk, 1997, 2000). Less well documented is the number of technology teachers being certified through alternative routes (Volk, 2000). In an attempt to gain a better sense of the extent to which alternative licensure is being used on a national scale, a survey was sent to all state supervisors for technology education. Specifically, this study sought to address the following questions:

1. What is the extent of technology teacher shortages being experienced?
2. How are states responding to technology teacher shortages, if shortages exist?
3. What types of alternative licensure models for technology education are currently in place?
4. What effect(s) is the existence of alternative licensure models in technology education having on teacher shortages and on existing traditional technology teacher education programs?

How the Information Was Gathered and What It Yielded

A survey was sent to the designated technology education supervisors in each of the 50 states and the District of Columbia during the fall of 1999. A second-round mailing, follow-up telephone calls, and email reminders netted a total of 36 returns, for a response rate of 70%. At least four states, it was found, have either no person designated at the state level to work with technology education programs or the position was unfilled. These states were counted as nonrespondents.

The survey was designed to elicit information about the number of unfilled technology teaching positions in each state, the alternative models being used to certify technology teachers, and the perceived effectiveness of these alternative models in preparing teachers and in meeting the teacher deficits. Each of the specific findings are discussed and, in some cases, contrasted with the findings from other studies.

Number of Teachers

The state with the largest overall number of technology teachers was New York, which reported 3,000 technology teachers. The state with the smallest number of technology teachers, excepting the District of Columbia (50 teachers), was Hawaii, reporting 40 technology teachers. The average number for the 36 states responding was 917 teachers, with about one half reporting over 500 teachers and one half reporting fewer than 500.

For some states, reporting on the number of technology teachers was complicated by the fact that there is not always a clear distinction between technology education, trade and industry, industrial arts, computer technology, and related areas of study. An attempt was made, through follow-up telephone communications, to limit these findings to those teachers designated technology education or industrial technology education. For example, data on licensure models that appear to apply only to trade and industry teachers are not reported here.

Unfilled Positions

All but five states in this study reported having unfilled positions at the time the survey was conducted, with a maximum of 150 (Florida) and an average of 37 unfilled positions. A total of five states noted more than 100 vacancies. These figures may be misleading, however. As one state supervisor observed, "if you have four math teachers and lose one, the fraction becomes 3/4 and the administration moves quickly to fill the position. If you have four technology teachers and one leaves, the administration simply adjusts the fraction from 4/4 to 3/3 to fit."

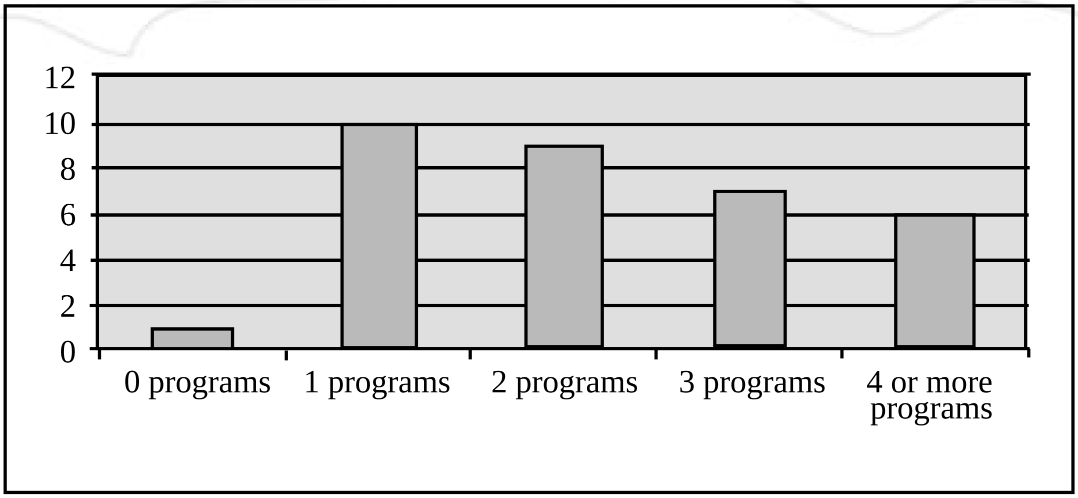

Figure 1. Number of traditional (university-based) programs (*n* = 33).

As a follow up, respondents were asked if they knew of any program closings as a result of districts not being able to fill a position. Seventy-four percent said yes, with an average number of nine closed programs per state. The maximum reported was 30 programs closed; however, one state indicated that 15 to 20 programs were being closed per year due to teacher shortages.

These findings can be compared to Litowitz's (1998) data showing that, nationwide, about 30% of states had an adequate supply of technology teachers. Litowitz found that 85% of state supervisors were aware of unfilled programs within their states, with a per state average of 19 unfilled positions.

Traditional Certification Programs

Figure 1 shows the number of university technology education programs in the responding states. One state had no university program, 10 had only 1 program, 9 states had 2 programs, 7 states had 3 programs, and 6 states had 4 or more certification programs. The maximum reported was 10 university programs (Texas).

When asked if the existing university programs were able to meet the demand for teachers in the state, all but two supervisors (94%) said no. The presence of multiple programs does not guarantee an adequate supply of teachers. Only one state with more than four programs reported an adequate supply of teachers and no unfilled positions. States reporting the greatest shortages had multiple traditional programs (see Table 1).

Alternative Certification Programs

Eighty percent of the states responding had AC programs in place for technology education. Of the eight states that did not, six were considering adopting alternative models. Thus, over 95% of the responding states either had, or were considering, alternative routes to

Table 1. Relationship Between Teacher Shortage and the Number of Traditional Technology Preparation Programs Within State

State	Unfilled Positions	Number of University Programs
Texas	100	10
New York	100	2
Pennsylvania	110	2
Missouri	125	3
Florida	150	3
Michigan	0	5

licensure in technology education. This finding can be contrasted with data from the Litowitz (1998) study, which indicated that 72% of states were considering or were using alternative licensing criteria to meet the demand for teachers.

The earliest date of adoption of alternative models for technology education appears to be 1980 (Texas). At least six states adopted alternative models during the 1980s, and 15 have adopted alternative models since 1990. Data from the remaining states are not available. Only 5 out of the 27 reporting states had changed their requirements for AC since the models were first implemented. One state, Nevada, recently adopted more stringent requirements for technology certification via its alternative route. Although this appears to be part of a larger shift toward measurement of teacher performance and a strengthening of AC requirements (Ludwig et al., 1995), there was no indication that other states were considering such a move.

Estimates about the number of technology teachers pursuing certification via alternative routes at the time of this survey ranged from lows of zero (District of Columbia) and 2 (Missouri) to a high of 400 (Florida). The average for the 27 responding states that recognized alternative models was 65 teachers, although about one half of the states reported fewer than 50 alternatively certified teachers.

Program Requirements

Respondents were given a list of models from which to select to describe their alternative licensure requirements. The greatest number of respondents (13) indicated that they allow teachers certified in other fields to teach technology, with the requirement that they complete specified training after beginning teaching. However, all models were used on a fairly equal basis (see Figure 2). In this chart, *work* refers to coursework or other teacher training requirements, either prior to or after beginning teaching.

The following additional details will help to clarify this information. Only three states (Florida, New York, and Texas) made use of all the models listed. Of the states that listed “other” as an option, it most often referred to an emergency certification or special critical-need model. One state identified local (county-level) certification as an option under “other.” At least three respondents were careful to note that the number of hours needed to satisfy certification requirements did not represent a shortened sequence of courses, but rather consisted of the same requirements that a traditionally certified teacher would have to meet.

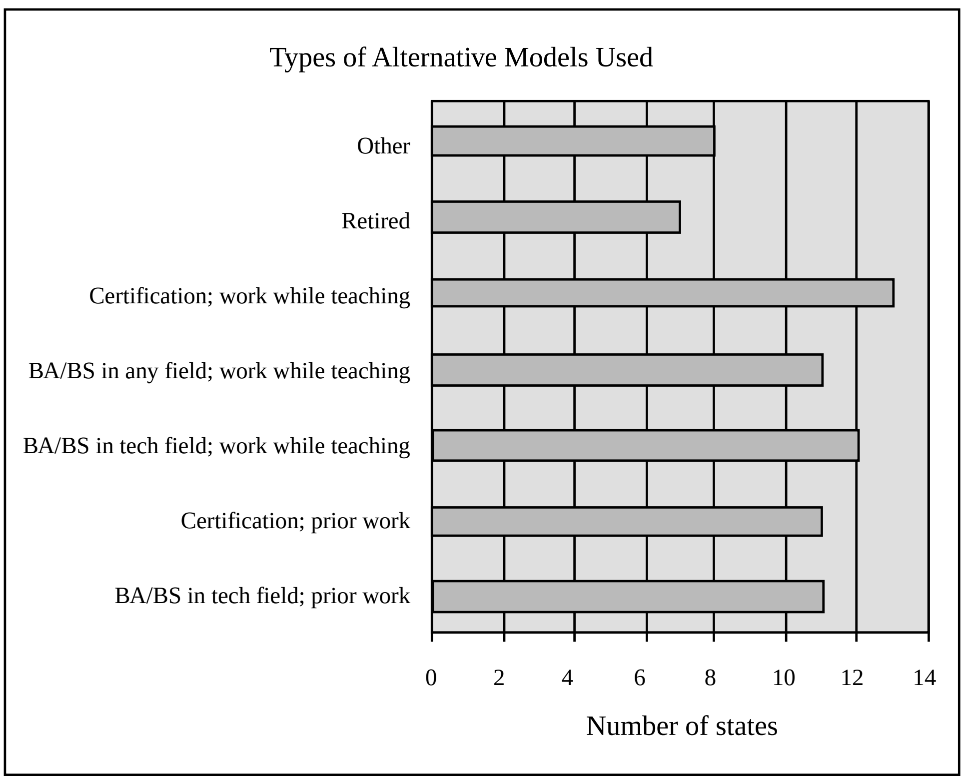

Figure 2. Frequency of use and types of alternative models adopted by states (n = 27)

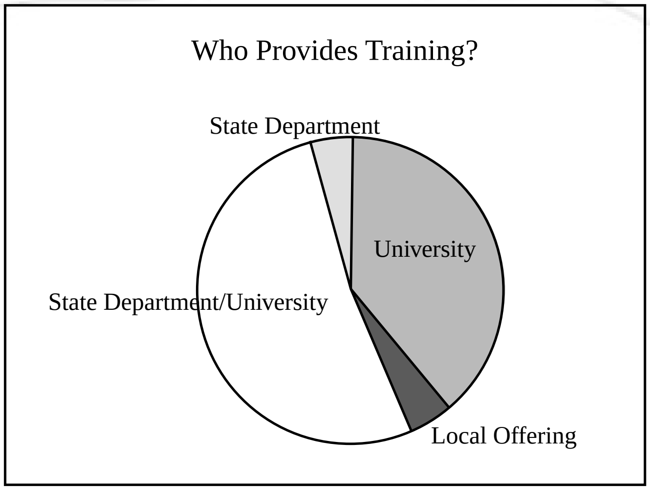

Figure 3. Source of training experiences.

Respondents were asked to describe in more detail the specific requirements for their various models. Without exception, candidates were required to hold a bachelor's degree to qualify for participation in alternative routes. Beyond that, models varied significantly from state to state. Even within states, requirements differed depending on the route taken. In some states, based on a transcript review by the state department or a university representative, an alternatively certified teacher may not have to pursue any additional training. For example, in Georgia, individuals certified in middle level education could teach any subject within the middle school setting. In other states, if students completed some type of technical degree and could pass a written test of technical content knowledge, they may not have required additional training.

Requirements, therefore, were typically decided on a case-by-case basis in relation to established standards. In one example, New Hampshire offered an alternative route that involved a portfolio review and interview process in which candidates documented their work, then met with an evaluation team consisting of a state department representative and other technology teachers. If successful, no additional training was required. The cost to candidates for applying was $100.

Some states had much more streamlined processes than others. For example, Mississippi required only a four-week training session prior to employment as a technology teacher. This option was available to teachers certified in another teaching field. The supervisor for that state believed that the four-week session was adequate preparation for teaching in the modular labs common there. By contrast, several state supervisors noted that teachers must satisfy the same requirements, both technical and pedagogical, that traditionally certified teachers do. The greatest number of requirements noted consisted of some 60 hours of coursework, plus a directed teaching experience. In some cases, candidates had a great deal of leeway in determining where and how they would satisfy requirements. For example, teachers might take technical coursework at a community college or select coursework based on the convenience of when, how, and where it was offered.

This information can be compared with that contained in the Litowitz (1998) study. He reported a minimum requirement of 6 credit hours and a maximum requirement of 64 credit hours, with a state average of 33 credit hours for nonteaching degree holders and 24 credit hours for individuals with an existing teaching degree. The findings from the current study support Young-Hawkins' (1996) observation that most alternative models do not require any formal internship or period of supervised teaching.

Who Provides Training?

Fourteen states reported offering some form of state level support for alternatively certified teachers. Eight provided financial support, with three states reporting substantial financial support for individuals pursuing certification. For example, Florida's loan forgiveness program provided up to $10,000 in loan forgiveness to some participants. Six states sponsored or offered workshops for alternatively certified technology teachers, although these were frequently available to any technology teacher who wanted to participate. Two states reported state-level support in the form of mentoring programs. For the most part, training programs were provided through collaborative efforts between the state department and university-approved programs (see Figure 3).

What Backgrounds Are Teachers Coming From?

The most frequently identified background for alternatively certified technology teachers was another teaching field. Some states appeared to specifically target this population. The next most frequently identified background was nonteaching technical bachelor's degree programs. Business and industry ranked third as a source for teachers, with the military ranking last.

How Well Prepared Are Alternatively Certified Teachers?

Fifteen (71%) of the 21 people responding to this question felt that teachers are being adequately prepared through AC programs. In this regard the wide variety of requirements across states should be kept in mind. Four respondents (19%) felt that the alternatively certified teachers are not adequately prepared, while two (9%) were "uncertain" with regard to this question.

In the study conducted by Ludwig et al. (1995) for the National Science Foundation, up to 40% of participants reported feeling underprepared for tasks such as classroom management, working with at-risk students, "survival skills," and administrative duties. Surprisingly, 11% felt inadequately prepared to cover course content, and subject area coursework was perceived to be as valuable as education coursework, even though participants were selected on the strength of their subject area knowledge. An interesting follow-up study could involve asking alternatively certified technology teachers whether they perceive the required training to be adequate.

When asked how they might improve the training required, seven (33%) supervisors indicated that they would like to include formal mentoring components. Four (19%) indicated that they would require more education courses, with an equal number stating that they would require additional technology courses. Two respondents specifically expressed a desire for more training regarding the philosophy of technology education.

Are Alternative Programs Meeting the Need for Teachers?

Eleven out of 23 respondents (48%) to this question said that alternative routes are meeting the need for technology teachers that would not otherwise be met by traditional routes. Twelve (52%) responded negatively to this question, saying that typically there is still a need for teachers. Others expressed the belief that although this approach is not the most desirable, it is better than having no teachers (i.e., unfilled programs).

When asked whether the presence of alternative routes is affecting existing traditional programs, 16 respondents (70%) indicated that they did not believe it is. Five (22%) believed that it is affecting university programs, but at least two noted that it is affecting them in positive ways. That is, traditional programs have been upgraded or, in one case, begun as a result of this influence. One respondent was uncertain whether there is any impact on traditional programs.

Turnover Rates

None of the respondents to this study could provide data on turnover rates for alternatively certified teachers, although two indicated that they had begun to track this information. According to Shen (1997), there is a higher attrition rate among alternatively certified teachers than among traditionally certified teachers. This data is not specific to technology education, however, and may not be representative of the field.

Promising Models

This study collected details regarding the requirements for alternative routes to certification in technology education, but no assessment was made regarding the advantages of one model over another, other than to consider suggestions from respondents regarding how they would like to see their models strengthened. The Council on Technology Teacher Education (CTTE) has issued a monograph that outlines the recommended components of an alternative licensure model for technology education (Litowitz & Sanders, 1999).

Ludwig et al. (1995) found agreement

among the various program partners in their study of university-based alternative models that the school-based portion of these models should attempt to improve instruction, prevent attrition, develop knowledge of school culture, and develop an understanding about student needs on the part of the alternatively certified teacher. An AC program examined by Miller, McKenna, and McKenna (1998) included condensed coursework to meet certification standards, a new-teacher mentoring program, and ongoing coursework to satisfy state requirements for middle level education. The study compared the characteristics and abilities of alternatively certified and traditionally certified teachers with results that support this type of model. Alternatively certified and traditionally certified teachers were found to be equally confident, to share the same problems, and to have no observable teaching behavior difference. The critical feature of the model program described in the study is its extensive mentoring component.

Numerous sources have supported the need for mentoring new teachers, whether certified through alternative or traditional routes (Associated Press, 1999; Kopp, 1994; Litowitz & Sanders, 1999; McKibbin & Ray, 1994; Talbert, Camp, & Heath-Camp, 1992). Whenever possible, the program should include some initial field experiences *before* a candidate assumes responsibility for the classroom. In addition to the continued support provided by the mentor teacher, ongoing feedback on performance that targets the specific needs of each teacher would, ideally, be provided. When all of these elements are in place, the candidate is more likely to experience success, and therefore satisfaction, with the teaching role (McKibbin & Ray, 1994).

Implications for Technology Teacher Educators

In 1999, the president of the University of North Carolina General Administration laid down this challenge to universities across the state:

> The growing teacher shortage [North Carolina had an estimated deficit of 8,000 teachers] has presented all of us with a dilemma. The need for teachers is *now*, adding impetus to solutions that simply place 'warm bodies' in classrooms. Universities are increasingly seen as part of the problem rather than part of the solution to teacher shortages as we seem unable or unwilling to develop more accessible, high-quality, flexible preparation programs for working adults. (M. C. Broad, personal communication, January 27, 1999)

An important implication for technology teacher education programs is that a university-based alternative program may represent a distinct opportunity to design a more effective program overall. At the very least, increased collaboration between school districts, university faculty, and state departments can be seen as beneficial. Ideally, there will be chances to combine the "best of practice and theory" (Ludwig et al., 1995, p. 107).

When designing an AC program, some questions that must be asked include:

- How much of the program should focus on career transition issues? Individuals entering the classroom are often surprised and overwhelmed by the discipline problems, workload, lack of parental support, and lack of student respect for teachers.
- What kind of incentives can be offered to cooperating teacher-mentors? It seems clear that for substantive mentoring to occur, there must be something in the relationship to benefit both parties.
- How much interaction between traditionally certified and alternatively certified students is desirable? For example, TC route students may resent the streamlined certification requirements of the alternative program. They may also become disenchanted by the "war stories" shared by practicing teachers.
- To what extent should program participants be encouraged to act as change agents in the schools where they work? Individuals who have made the transition from a business or industry setting are often not in tune with the pace and culture of the school setting (Ludwig et al., 1995).

There must be a realization on the part of those designing AC programs that nontraditional teacher candidates have different expectations and needs. For example, Ludwig et al. (1995) found that the location of the program (i.e., proximity to home) was a dominant factor in participation. Reputation of a program was another desirable factor for participants. Participants tended to be older, to have families, and to have taken significant pay cuts by making the transition to classroom teaching.

According to Young-Hawkins (1996), few programs are designed to accommodate the needs of nontraditional students, who may require more flexible scheduling, different modes of delivery, and more focused and pragmatic content than students in traditional programs. In her view, “the emergence of alternatives should provide us with new lenses for viewing the recruitment and preparation of technology education teachers” (p. 30).

One concern for university program coordinators is ensuring that involvement with AC programs does not detract from the reputation or quality of their traditional programs. At Appalachian State University, this author regularly works with classroom teachers pursuing certification through North Carolina’s provisional route. These individuals are nondegree seeking and take relatively few courses, yet consume a significant portion of my time due to their specialized advisement needs. The attempt to accommodate these individuals through flexible scheduling means that the traditional, full-time students must compromise by taking courses at less convenient times, or on a more compressed basis than would otherwise be desirable. These accommodations are made primarily as a service to the state and to the profession.

Suggestions for Further Research

The data collected in this study should by no means be considered definitive. Rather, they document the status of alternative licensure in technology education in the United States at a particular point in time. What these data do indicate is that the licensure landscape is a moving target, that AC programs for technology education are being increasingly relied upon to address teacher shortages, and that considerable research is needed to determine the effectiveness of AC program models.

Ludwig et al. (1995) posed three questions about AC that are important for all disciplines to address. First, what aspects of AC programs equal success in the classroom? What long-term impacts will alternatively certified teachers have on students in the classroom? Finally, how will AC programs affect the teaching population?

It is shocking and surprising how many initiatives are adopted in education without any formal evaluation to determine their effects. AC is no exception. To get a clear picture of the effectiveness of alternative approaches, multiyear follow-ups of candidates should be made (McKibbin & Ray, 1994). Compounding the lack of follow-up data on alternatively certified teachers is the lack of longitudinal data on the effectiveness of traditionally certified teachers, information that would be needed for a meaningful comparison of the two approaches (Sandlin, Young, & Karge, 1992). Zumwalt (1996) suggested that neither alternatively nor traditionally certified teachers are adequately prepared to meet the challenges in the nation’s most needy schools.

The ultimate challenge facing technology educators is to determine how best to satisfy the continuing demand for technology teachers. There are many good reasons for adopting alternative models, ones that take advantage of the strengths of this approach, rather than focusing on expediency. As Miller et al. (1998) stated, “alternative certification is here to stay; researchers should investigate not whether such programs work, but which ones work best” (p. 166).

Dr. Marie Hoepfl is an associate professor and coordinator of the Technology Education Program, Department of Technology, Appalachian State University. She is a member-at-large of Epsilon Pi Tau.

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A Kaizen Based Approach for Cellular Manufacturing System Design: A Case Study

Joseph C. Chen, John Dugger, and Bob Hammer

Organizations are currently encountering a necessity to respond to rapidly changing consumer needs, desires, and tastes. To compete in this continuously changing environment, these organizations must seek out new methods allowing them to remain competitive and flexible simultaneously, enabling their companies to respond rapidly to new demands. The contemporary industrial world is in a new era termed the “third industrial revolution” (Black, 1991). The effect of this new era is dramatic to most businesses because they have been forced into the global economy by emerging global competition. In order for companies to remain competitive, retain their market share in this global economy, and satisfy both external and internal customers, continuous improvement of manufacturing system processes has become necessary (Kokuo, 1992; Shingeo, 1988; Yaruhiro, 1993). The method used to design a flexible, unique, controllable, and efficient cellular manufacturing system has become a topic that modern industrial operations are eager to learn and implement. The Kaizen technique has been proven as an effective tool for process improvement (Yung, 1996), process reengineering (Lyu, 1996), and even for organizational designs (Berger, 1997). Kaizen now is further implemented in industries for designing cellular manufacturing system to reduce cost and working space.

As an example of the successful implementation of Kaizen, take the case of a U.S. wood window company in the state of Iowa. This company has been using Kaizen since 1991 to redesign their shop floor, replacing expensive, nonflexible automation with low cost, highly flexible cellular applications. This company uses Kaizen to respond rapidly to consumer needs and to resolve problems in their manufacturing processes. Kaizen is used extensively in Product, Process, and Production (PPP) development. The major strategy of this development is to design a new product while considering the functions of products, the production processes used, and efficient production practices on the shop floor. This approach is similar to concurrent engineering; however, the distinction between concurrent engineering and Kaizen is that the latter calls for the creation of a team that includes cross-functional employees, such as engineers, shop managers, and operators, working together on targeted areas. With a set of goals and a series of brainstorming processes, this team is expected to obtain a solution for resolving the problem within a week’s time. During this week, the team concentrates on nothing but the project at-hand. This wood window company has successfully undertaken hundreds of projects over the past eight years. Achieving success in this way, the company has become a model for many local industries.

The Kaizen process is successful because it employs the lean thinking approach of designing a flexible, controllable, efficient, and unique manufacturing process (Womack & Jones, 1996). This article describes an example of Kaizen’s success in a pull cellular manufacturing system and addresses this success in terms of cost, space, and improved worker satisfaction.

What Is Kaizen?

Kaizen is a Japanese word that has become common in many Western companies; the word indicates a process of continuous, incremental improvement of the “standard” way of work. This kind of creative improvement is something that every employee is capable of contributing to. The front-line employee is, in fact, most familiar with the actual work; there may be no one person to ask for improvement ideas.

Kaizen thrives by being adopted into the organizational culture. Successful implementation results in a cooperative atmosphere where everyone is aware of the key goals and measures of success. In this type of environment, implementation of new concepts is readily achieved with a high degree of success. Kaizen can be applied to any area in need of improvement. Kaizen is more than just a means of improvement because it represents the daily struggles occurring in the workplace and the manner in which those struggles are overcome (Kaizen Teian 1, 1992; Kaizen Teian 2, 1992). The flexibility inherent in this approach makes it applicable to myriad corporate situations with only a few basic requirements necessary before full implementation can be realized.

The Kaizen approach requires that all employees participate; therefore, everyone in the company is encouraged to play a role in Kaizen activities. Kaizen has three major components:

1. Perceptiveness: All Kaizen projects are based on identified problems. If no problem has been identified, there is no use for Kaizen.
2. Idea development: This stage requires more than one person to provide better innovative ideas; therefore, forming a Kaizen focus team for the identified problem is very important. In this team-assembly process, one key is putting employees who work in the problem area together in order to interact in this innovative team.
3. Decision, implementation, and effect: Kaizen is only valuable if and when it is implemented. In the decision-making process, the team identifies what appears

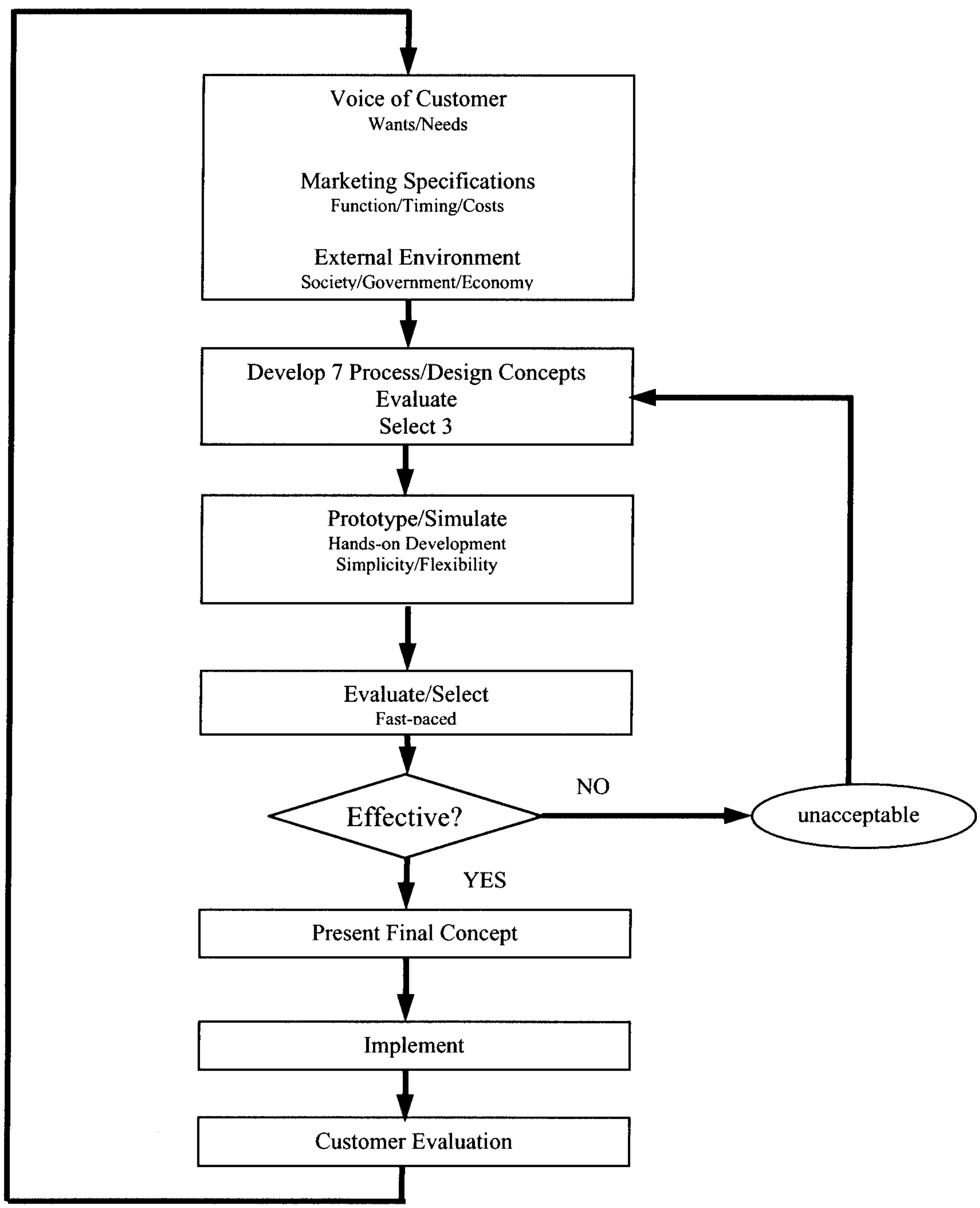


Figure 1. The Kaizen process overview.

to be the best solution to the problem being dealt with, and then begins the implementation process. Following implementation, the team is also responsible for evaluating the effect of the Kaizen process once it has been implemented in the shop flow of a factory.

Transferring these three stages into a systematic approach, Figure 1 shows the flow chart of the Kaizen process employed in this case study. The following section of this article introduces, step-by-step, how a Kaizen approach has been used to implement a pull cell design. The steps of this approach are summarized as follows:

1. Identify a problem.
2. Form a team.
3. Gather information from internal and external customers, and determine goals for the project.
4. Review the current situation or process.
5. Brainstorm and consider seven possible alternatives.
6. Decide the three best alternatives of the seven.
7. Simulate and evaluate these alternatives before implementation.
8. Present the idea and suggestions to managers.
9. Physically implement the Kaizen results and take account of the effects.

The following case study demonstrates the Kaizen practice.

Case Study

The focus of this project is the virtual manufacture of meat tenderizers. The full design of a meat tenderizer is shown in Figure 2. The problem identified in this virtual situation is that the product is currently too expensive to produce. After the cellular manufacturing system was introduced, a Kaizen team was formed to design a cellular manufacturing system to reduce production costs and improve the quality of every product. In order to address this system design problem, a design engineer, a manufacturing engineer, a quality engineer, and two machining operators were invited to be team members in this Kaizen project.

After identifying the problem, forming the team, and discussing the problem with all the employees in that production area, the team met to discuss the goal of this project. A brainstorming process was used to explore the team's goals. For this particular project, there were three goals: (a) reduce 25% of the unit cost, (b) design a cellular manufacturing system, and (c) reduce floor space by 15%. With setting these goals, the team could begin to review the current process of the product.

Review of Current Situation/Process

Meat tenderizer production consists of machining four basic components followed by a final assembly process (Figure 2). The facility is organized as a job shop with a separate assembly line. Flow of material follows a push

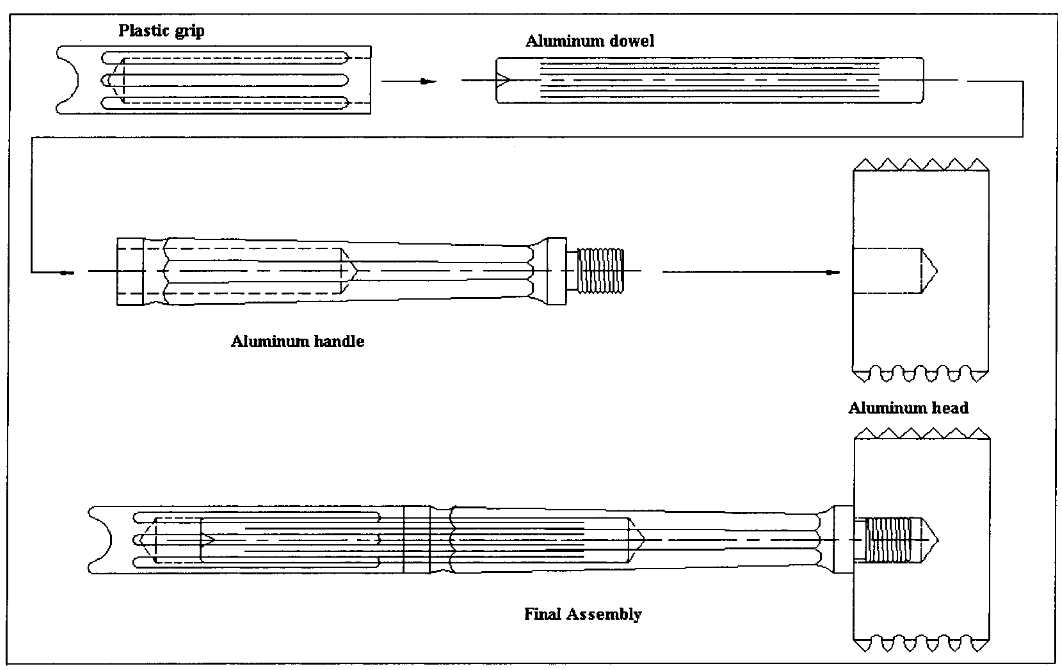


Figure 2. A final assembly drawing for the meat tenderizer.

model: the up-stream operation pushes the work-in-progress (WIP) to the down-stream operation and requests information from the down-stream operator. The current process needs to be determined and developed into a *Process at a Glance* (Figure 3), displaying the current method in a step-by-step flow.

The sequence of the manufacturing process begins with the cutting of raw stock. The operator is given a cut sheet and a cut quantity for each part. Some setup time is necessary between the production of each part and is considered as internal setup time. Referring to Figure 2, the first cutting operation produces the aluminum handle, the second produces the aluminum dowel, the third produces the plastic grip, and the fourth produces the aluminum head. After a specified quantity of aluminum is cut for the handle, it is delivered to the lathe operator, where the drilling and reaming operation is performed, allowing the handle to accept the dowel insert. Then, the relief cut, diameter reduction, and threading operations are performed. The proper length for the handle is established at this time. This process is repeated until the batch quantity delivered from the cutting operation is completed. The operator then performs the necessary setup required for the next operation.

The next part of the meat tenderizer to arrive at the lathe is the dowel. Both ends are faced, with one end center-drilled to facilitate a milling operation later in the manufacturing process. Straight knurling is also applied at this time. Once the batch quantity is completed, the setup for production of the plastic grip is done. At the lathe, the plastic grip is faced on one end, drilled, and reamed. The grip is also rotated to the opposite end to prepare it for a later machining operation. This operation is repeated until the required batch size is produced. At this time, the operator returns to the first operation for turning the aluminum handle.

Once the lathe operations on the aluminum handle and the dowel have been completed, the parts go to a press operation in the assembly area. At the press, the aluminum dowel is inserted into the handle to a specified depth of 2.375 inches. This operation is repeated until the predetermined batch size has been produced. From this point, the handle and dowel move to the milling operation, where the nine flutes are applied. When the complete batch is finished, the parts are moved to a polishing center where the handles receive a final finish. These finished parts are then inventoried until delivered to the assembly area.

The next component to move through the

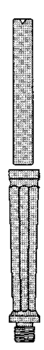
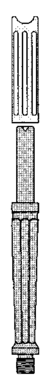
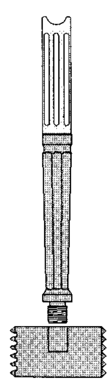
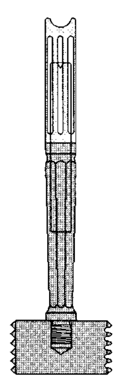
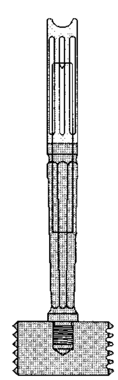
Process Number	10	20	30	40	50
Process Description	Press 0.5" dowel into aluminum handle	Press plastic grip onto 0.5" dowel	Thread handle assembly and tenderized head together	Clean, polish and prepare for packaging	Package completed product and ready for shipment to retailer
Process Sketch					
Tool	Arbor Press	Arbor Press	None	None	Shrink Wrap

Figure 3. The *Process at a Glance* of production of the meat tenderizer.

process is the plastic grip (Figure 2). After being prepared by the lathe operation, the grip is delivered to a milling process where 10 flutes are machined. Once this process has been done on the batch quantity, the plastic grips are taken back to the lathe to go through the final ball end-milling operation. From this point, the grips are cleaned and de-burred. Once this de-burring procedure is complete, the parts are passed to an inventory location, awaiting final assembly.

The meat tenderizer head (Figure 2) is produced concurrently with other parts of the product. Once the cutting operation is complete, the batch quantity is delivered to the milling operation where the block is faced on all sides and a pattern is cut on each end. Once the milling operation has been performed, the head is transferred to the drilling and tapping process, where the hole is drilled and tapped. After this operation is finished, the meat tenderizer head is delivered to a de-burring and polishing station, and then to inventory to await final assembly.

The assembly process operates around an assembly station consisting of four work-stations for each of the meat tenderizer's four components (aluminum handles, dowels, plastic grips, and the tenderizer head) with one worker at each station. First, the aluminum handle is threaded into a fixture to protect the threads and align the part. The dowel is then pressed into the handle and the assembly is removed from the fixture. This process is repeated until the lot size is complete. Next, the assembly is delivered to the milling operation where the nine flutes are milled onto the handle. After the handle is milled and polished, it is returned to the assembly area for final assembly. The aluminum handle is threaded into the fixture as before, in order to protect the threads. To ensure proper alignment, the plastic grip is pressed onto the handle. The assembly is then removed from the fixture and the tenderizer head is threaded onto the handle assembly. The completed product is cleaned, packaged, and prepared for shipment to a retail outlet.

Brainstorming and Consideration of Possible Alternatives

Once everyone on the team understands the current method, a brainstorming phase begins in order to accumulate ideas determining seven new processes to be evaluated. No ideas are too bizarre, ranging from doing nothing at all to viewing various ways to completely redesign the process. The number of new processes changes depending on the project, but seven is the number typically used because it creates a high degree of stimulation during the limited time allotted for the brainstorming phase.

The seven proposed methods should be displayed in a chart that allows everyone to view them quickly and easily. The information provided also needs to be clear and concise, including a process sketch, a brief explanation

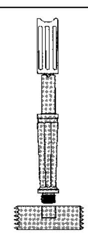
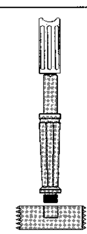
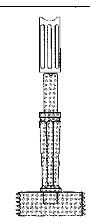
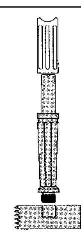
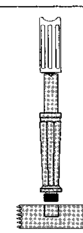
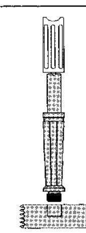
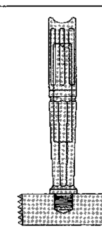
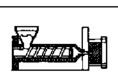
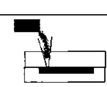
Process Number	1	2	3	4	5	6	7
Process Sketch							
Operation	Press dowel Press plastic grip Thread Head	Injection mold plastic grip Press dowel Thread Head	Press plastic grip Die cast head and handle all one piece	Press plastic grip Produce handle all one piece Press head (no threads)	Press plastic grip Produce handle all one piece (no flutes) Press head (no threads)	Use adhesive bond on plastic grip to handle assembly and on handle to head	Die cast entire part no assembly
Measuring Gauge	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Tool	Arbor Press	Injection mold	Die Cast	Arbor Press	Arbor Press	None	Die Cast
Fixture	Use Existing			Use Existing	Use Existing	None	

Figure 4. The seven alternative methods after Kaizen brainstroming process.

of the operation, a measuring gauge, a list of necessary tools, and required fixtures. The seven methods for this project are summarized in Figure 4. Once these methods are developed, an evaluation of these proposed processes must be undertaken.

Evaluation and Selection of Process

A group approach was implemented based on the three goals of this project to develop evaluation criteria. The decision was made to evaluate this project based on the following criteria: (a) *flexibility:* with two subcriteria: simplicity and ease of repetition; (b) *cost:* with five subcriteria: capital investment, labor costs, tooling costs, known technology, and required maintenance costs; and (c) *safety:* with seven subcriteria: safe, clean, ergonomic, of desired quality, required skills, defects per shift, and meets customer specifications. The first column in Table 1 shows the criteria for evaluating the seven alternatives. In addition, the weight of each criterion and the value of the subcriteria are also determined and shown in the second and third columns of Table 1.

The evaluation sheet determines how the seven proposed methods will be assessed. This sheet should consist of categories that are appropriate for the project. Once the evaluation sheet is prepared, each member of the team independently rates the seven proposed methods on a scale from 1 to 5, with 1 indicating strongly disagree and 5 indicating strongly agree. A value of X can be entered if the team member feels that one of the proposed methods is not an acceptable solution. After each member has voted, the results are tallied and entered into a chart as shown in the last seven columns of Table 1. From this chart, the three best methods can be selected for simulation. The top three methods selected in this study were Methods 5, 4, and 1. At this point, one method was chosen for simulation to determine how effective it might be when implemented.

Prototype and Simulation

Alternative number 5 shown in Figure 4 was chosen for prototyping and simulation because it had the highest score in the decision matrix (Table 2). The design of the cell was developed and carefully laid out using measurements from actual machines involved. Tables, chairs, cardboard boxes, or any other readily available material can be used to simulate the cell design. Members of the team used stop watches to simulate the cycle time of each station in the cell. The workers in the cell could not move to the next assignment in

Table 1. The Evaluation Criteria, Weights, Values, and Overall Scores for the Seven Alternatives.

Evaluation	Weight	Value	Category	Proposed Process						
				1	2	3	4	5	6	7
Flexible	25	5	1) Simplicity	4	1	1	3	5	4	4
		5	2) Easily Repeatable	2	2	1	2	5	3	4
		10	3) Inexpensive	2	2	1	3	5	4	1
			SUBTOTAL	50	35	20	55	100	75	50
Cost	25	10	1) Capital Investment	4	2	x	5	5	4	1
		5	2) Labor	4	4	2	4	5	4	4
		5	3) Tooling	3	2	1	4	4	3	1
		5	4) Known Technology	3	3	1	5	4	4	2
		5	5)Maintenance Required	3	2	2	4	5	2	3
			SUBTOTAL	105	75	#######	135	140	105	60
Safety	25	10	1) Safe	4	3	1	4	4	4	2
		5	2) Clean	4	3	1	4	5	3	1
		5	3) Ergonomic	3	3	1	4	4	1	3
			SUBTOTAL	75	60	20	80	85	60	40
Quality	25	5	1) Skill required	3	2	2	4	5	3	2
		10	2) Defects per Shift	2	3	1	4	5	4	5
		10	3) Meets Customer Specs.	1	4	3	4	5	4	5
			SUBTOTAL	45	80	50	100	125	95	110
			TOTAL	227	217	#######	317	355	263	214

the process until signaled by the timekeeper. By following this example, the cycle time of the cell was predicted very accurately relative to real-time values.

Another important key to success under the Kaizen methodology is to generate a written description of worker responsibilities. This key must be provided in order for everyone involved to be acutely aware of what is going on in the process. A pictorial representation of the cell design can be seen in Figure 5. Before worker responsibilities can be addressed, a few explanations of the cell are necessary.

Cell Design

The cell is a U-shaped pull design with a one-piece flow. A de-coupler is used between the workers to break the dependency of the process and relax the need for precise line balancing (Black, 1991). It holds one part with a specific input and output, and is not a storage area or buffer. Every part of the cell, in each machine and in each de-coupler, is ready to be advanced. Work begins at the last process, and no part can advance through the cell until the part is removed from the de-coupler. This signals the other worker to begin. In other words, the work is "pulled" through the cell. The assignment of the work is as follows.

Worker Responsibilities

WORKER 1

Starts at Station 4, and pulls the cleaned part from the de-coupler, signaling Worker 2 to begin the process at Station 3. Worker 1 places the clean part in Station 4 and packages it, then walks to Station 1 and waits until the de-coupler is empty to begin work. When Worker 2 pulls the part from the de-coupler, Worker 1 places the finished part that was in Station 1 into the de-coupler and begins this process. When the operation at Station 1 has been completed, the worker walks back to Station 4 and pulls the cleaned part from the de-coupler. The process is then repeated.

WORKER 2

Begins at Station 3 when Worker 1 pulls the part from the de-coupler. Worker 2 will move the already cleaned part to the de-coupler and will then move the part from Station 2 to Station 3 and clean it. After it is cleaned, Worker 2 will move to Station 2 and pull the part from the de-coupler, signaling Worker 1 to begin work at Station 1. Worker 2 will perform the process at Station 2 and then move back to Station 3. When the de-coupler is emptied, Worker 2 repeats this procedure.

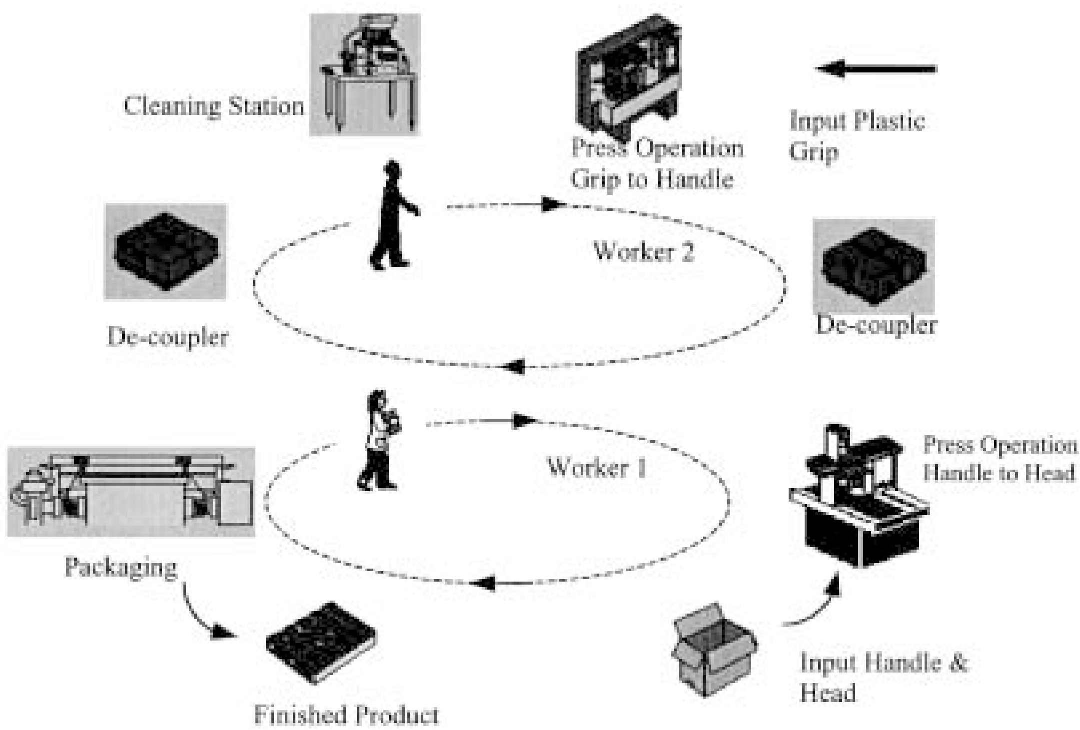


Figure 5. The proposed two-worker cell layout.

After physical simulation with this cell implementation, a cycle time of 27 to 29 seconds was obtained through measurement. These results exceeded the goal of the team, allowing them to plan for the presentation of this new alternative to upper management for approval before this approach could be fully adopted on the shop floor.

Presentation and Implementation

Presentation to upper management is crucial for Kaizen to succeed because it allows upper management to observe the impact Kaizen is having on the success of the organization while keeping them in the information loop. Additionally, it provides an excellent method to train the entire organization on Kaizen implementation. The presentation can also be used to provide feedback to improve the implementation of the Kaizen methodology, resulting in the continuous improvement the name *Kaizen* implies. This increase in visibility between upper management and the workforce establishes a high level of communication, creating trust and understanding, eventually resulting in improved employee relations and morale.

Results

The existing cycle time per assembly was 62 seconds. The new cycle time was about 28 seconds, which constitutes an approximate 44% reduction in cycle time. The existing assembly area consisting of workstations occupied 192 square feet. The proposed assembly area requires two cells, which use a space of 160 square feet. The new plan reduces the workspace by 37%. Quality to the consumer is 100% because the "make one check one pass one on" method provides 100% inspection, ensuring that no inferior-quality products are passed on to the consumer. Scrap and re-work are minimized because quality problems become visible immediately and can be addressed before additional defects may be produced. Employee morale is improved because the cellular design makes it possible for workers to fill multiple jobs. With Kaizen, workers rotate the tasks they undertake, raising satisfaction and morale. Higher worker satisfaction and morale decrease boredom, resulting in increased productivity and higher quality workmanship.

Conclusion

The Kaizen process acknowledges the information at all levels of an organization through the incorporation of a special type of intense teamwork. In addition, process steps that require seven alternatives force teams to think "outside the box," which often results in major innovations. Finally, the general guidelines are fundamentally sound manufacturing practices, such as "one piece flow" and the elimination of non-value added practices.

When implementing the Kaizen approach, much of the responsibility lies with upper management. Pitfalls include the tendency of upper management to micromanage the teams and a lack of initial training in teamwork effectiveness.

The ability of an organization to respond to the rapidly changing global marketplace will eventually determine the ultimate success of that organization. The implementation of Kaizen addresses many of the needs that modern organizations face. While Kaizen brings continuous improvement, it also develops a communications network throughout the organization that intrinsically supports a method of checks and balances within daily operations. The daily trials and tribulations that upper management once confronted on their own are now solved by the workforce, increasing morale and allowing upper management to concentrate efforts on strategic planning.

Dr. Joseph Chen is an associate professor in the Department of Industrial Education and Technology at Iowa State University. He is a member of Alpha Xi Chapter of Epsilon Pi Tau.

Dr. John C. Dugger is dean of the College of Technology at Eastern Michigan University. He is a member of Alpha Xi Chapter and received a Laureate Citation in 1997.

Mr. Rob Hammer is a technical and resource manager at Control Installation, Inc. in Des Moines, Iowa. He is a member of Alpha Xi Chapter.

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Software to Simulate and Optimize Asset Management in Construction and Manufacturing

by M.D. Salim and Marc A. Timmerman

In the 21st century asset management and resource allocation will be key technologies for the successful management of many public and private enterprises. In teaching asset management techniques in construction management and manufacturing courses in industrial technology programs, there is a challenge of finding enhancements to textbook-based instruction. Software tools to simulate real-world style problems in asset management are a valuable enhancement to this classical style of pedagogy. This article describes a number of such currently available tools. It also evaluates them according to such factors as cost, ability to solve complex problems, and suitability for use by nonspecialist students. The issue of using such tools to teach optimization techniques for asset management in the classroom setting using artificial intelligence methods of optimization is also explored. Finally, an overview of a real-world asset management case study as an instructional concept for classroom use is presented.

What Is Asset Management?

Asset management combines and integrates the acquisition, evaluation, storage, and distribution of assets and resources required by an organization. A tremendous amount of management control can be exerted through a properly designed asset management and resource allocation system that is operated by trained management personnel. But, there are costs involved with developing and implementing an asset management system. Organizations using such systems must dedicate resources for funding their implementation. The costs and benefits of asset management systems vary greatly, depending on the type of systems implemented, the scope of the systems put into service, and a number of other factors. Rapid changes in existing technologies require frequent updating of asset management systems. In many cases, the changes are so significant that completely new systems must be developed.

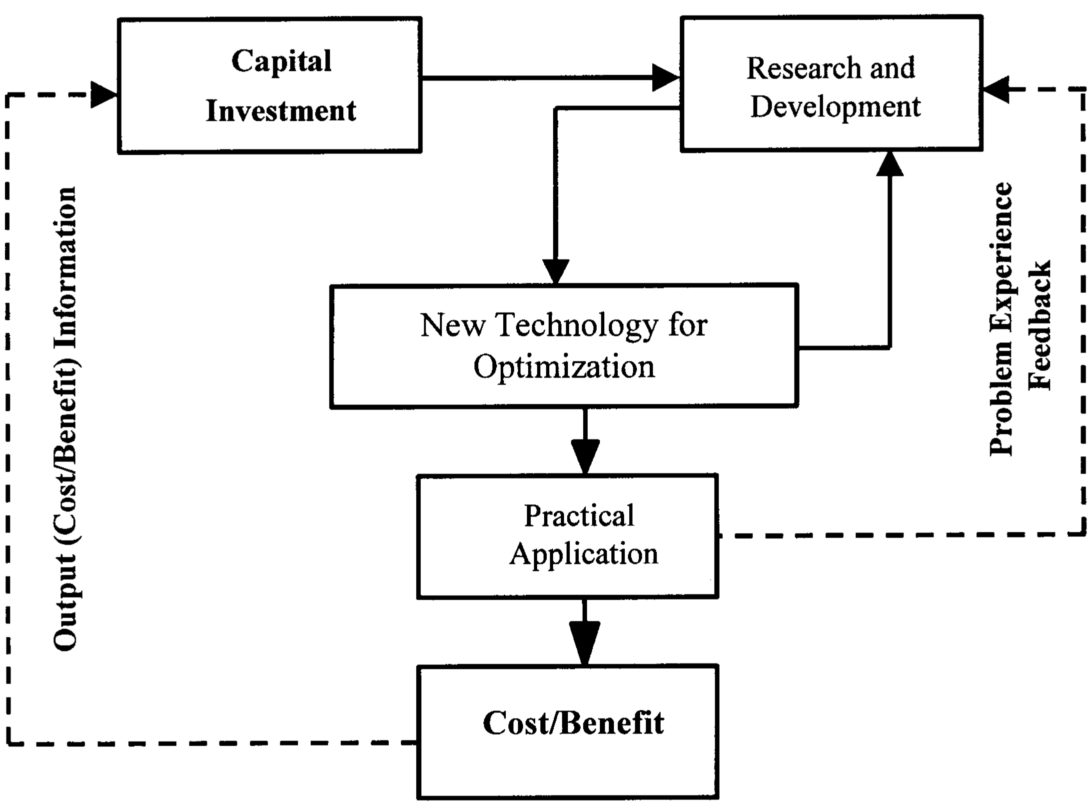

Figure 1. Asset and resource management paradigm.

Capital investment is the key stimulus for updating existing and developing a new asset management system as indicated in Figure 1. Capital investment enables research and development, which leads to improved technology for asset management and resource allocation. The figure also suggests that cost/benefit analysis on the practical applications of this improved technology is usually relevant. A computer-based asset management system will track what equipment and other resources are to be issued for a specific project including personnel composition and personnel assignments. Studies have shown that personnel are much more productive when an asset management system tracks assets and other allocated resources in real-time.

The recent literature on the importance of asset management to construction, manufacturing, and other industrial technology education areas is enormous. Some highlights would include the work of Satter, Wood, and Ortiz (1998) on the use of asset management in petroleum industry related construction. Curtis and Molnar (1997) have described the use of asset management in public works construction. Carpenter (1997) has written about the use of asset management in manufacturing, specifically in the area of machining. Gibson (1998) and Van Rijn (2000) have described the use of asset management tools for the maintenance aspects of manufacturing. Finally Stys (1997) has written about the use of asset management for maintenance in the utility industry.

Artificial Intelligence

Authors define artificial intelligence (AI) in different ways. For example, Kurzweil (1990) defined AI as the art of creating machines that perform functions that require intelligence when performed by people. According to Lugar and Stubblefield (1993), AI is the branch of computer science that is concerned with the automation of intelligent behavior. In the past decade there have been numerous articles about the application of AI as “expert systems,” which are also called “knowledge-based systems” by some investigators.

The architecture of an expert system is presented in Figure 2. It shows that knowledge engineering is the first step in creating an expert system. The knowledge engineer usually acquires and places the knowledge into the expert system’s knowledge base. In other words, the knowledge engineer is the interface between

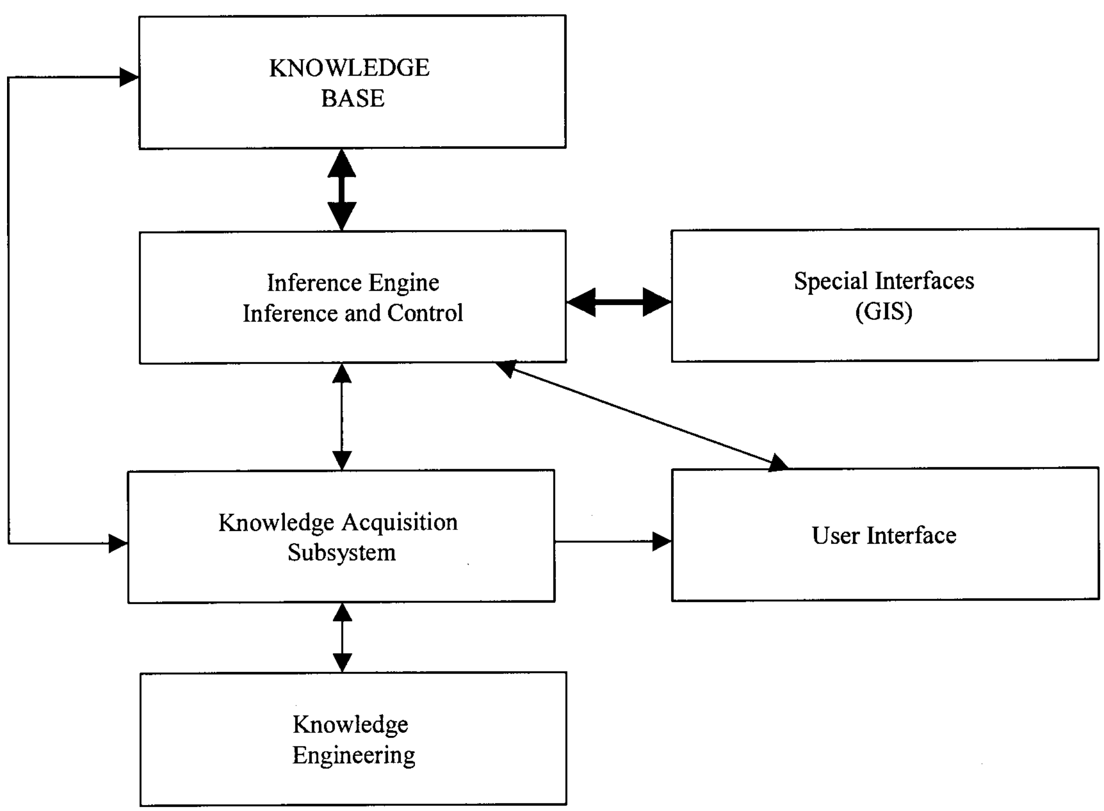

Figure 2. Artificial intelligence concepts.

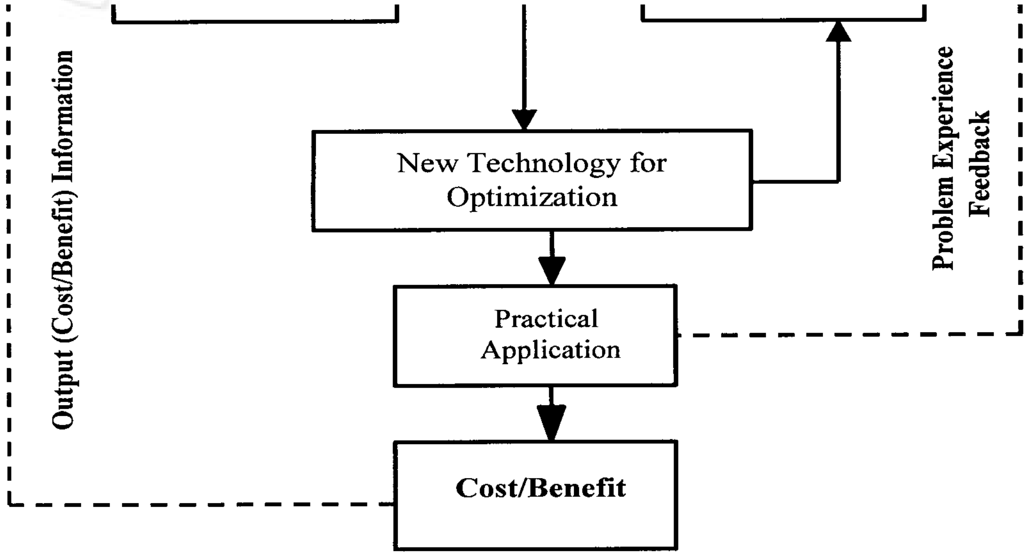

Figure 1. Asset and resource management paradigm.

the human expert and the expert system. In an expert system the knowledge base is kept separate from the control mechanism known as the inference engine, which directs or controls the system when it searches its knowledge base in a dynamic environment. The expert system can be integrated with other programs and/or databases to solve specific problems. In the following paragraphs, we describe a model of an expert system to optimize asset management. It is an AI-based system that uses a Geographic Information System (GIS) database for attributes and values to optimize asset/resource management.

Selecting an Artificial Intelligence Shell

A computer software that is very often utilized for the development of an expert system is known as an "AI shell." These AI shells are generic software environments to implement expert systems, much in the same way as a word processor is a software environment to edit text. However, selection of the correct shell to meet specific needs is becoming increasingly critical, considering the ever-growing use of computers and the availability of diverse shells to build expert systems. The fundamental issues of choosing "shells" for asset/resource management applications are offered beginning with a six-step plan of action for selecting a shell: (1) define the selection criteria; (2) find all available shells that might fit the needs or criteria chosen; (3) narrow the list obtained from the second step down to a revised or a short list; (4) try to shorten the list even more by researching those shells in much greater detail; (5) test the remaining shells; and (6) select and purchase the most suitable shell.

We began our study on available shells with the creation of a list of criteria as in Step 1. These requirements can vary greatly depending on the task and the size of job. It is important to note that selection of shells is always need-driven. We listed the criteria as follows:

- Platform it runs on (Windows, Unix). *Windows is preferred for instructional use.*
- Limitation on the number of rules. *Must have more than 100 rules for planned scope of class projects.*
- Limitations on database size. *Must be able to use large GIS databases 100 MEG+ for planned class projects.*
- Speed of execution. *Must be fast enough to be able to run several complex cases in the space of a two-hour lab session.*
- Internet interface capabilities. *Very desirable in a distributed network environment such as a teaching lab.*
- Compatibility with GIS package. *Must be able to read data from desired databases for class projects.*
- Cost and licensing issues. *Must be available in a multi-used academic version at reasonable cost.*

For Step 2 we considered shells advertised on the Internet and in computer trade magazines and professional journals and periodicals. Because there are literally hundreds of shells that deal with different types of applications and users, this is a daunting task. A short list of the shells is created based upon the selection criteria under Steps 3 and 4. In the final steps the shells are tested, resulting in the final list presented in Table 1. The ideal result will be the selection of one shell. This may not always be the case because more than one shell may perform the needed tasks. In this case cost becomes the key factor in deciding what shell to select. In this particular case, the final step was to examine demonstration versions of the selected shells.

Optimization

Optimization is the search for better solutions. Many problems in industry have non-unique solutions, and optimization is a systematic way of generating these non-unique solutions and finding the best solution of the set. The term *best* can refer to cost, time, energy usage, product quality, or some other beneficial quality of interest. A monograph by Traub and Wozniakowski (1980) summarized optimization techniques. Lau's (1986) standard reference of optimization techniques expressed them in the form of computer programs. Khan and Hayhurst (2000) and Suh and Shin (1996) described the application of optimization techniques to problems in manufacturing in great detail.

Optimization methods can be thought of as falling in two categories: heuristic and non-heuristic. Non-heuristic techniques involve the application of complex mathematical methods from an area of mathematical analysis known as the calculus of variations. These methods include the dynamic programming method of Bellman, the optimal principle of Pontryagin, the time-dependent Lagrange multiplier method, and derivatives of these methods such as the Hamilton-Jacobi-Bellman method; all are described in detail by Bryson and Ho (1975). These methods require extremely complex calculations and are generally best suited for highly specialized applications such as the design of NASA's space missions and nuclear weapons research. They are pedagogically unsuited for industrial technology education, and they are, in general, too computationally demanding for use in day-to-day industrial problems.

Heuristic optimization methods are based on concepts from AI. They are based on general observations or "rules" about the qualities of an optimal solution. These rules are programmed into the "shell" and are used repeatedly to generate, improve, and test the solution. Heuristic optimization techniques are pedagogically suitable for industrial technology education and are easily studied using computing resources usually found in industrial technology departments. The relative ease of use and simplicity of these rules also make them useful in the solution of day-to-day industrial problems.

A Case Study: Snow Removal Asset Management

Both manufacturing and construction industries have embraced AI techniques to optimize resource allocation, manage assets, and improve productivity. For example, in manufacturing, as fully automated machinery increases in capability, the assignment of individual jobs to such automated machinery becomes very complex. AI-based optimization techniques have been widely deployed to solve such challenging "shop management" manufacturing problems. To study the manufacturing optimization techniques used for these shop management problems, industrial technology students need some familiarity with the type of automated machines involved, the process times of machining tasks, and similar parameters. The same observations hold true for construction management studies.

The deployment of snow plows in a municipality for the purpose of snow removal is our example of a case study of a problem in optimized asset management. The object is to plan routes for the plows so as to remove the most snow using the least amount of resources such as driver time, plows, sand, and salt. The main reason for selecting snow plowing as our case study is that it is very familiar to students in colder climates from daily life and is also familiar to others from television and cinema depictions. Snow plowing contains all of the needed elements of a good case study in a format that is well suited for instruction.

This problem is an enhanced version of a classical textbook problem in optimization called the traveling salesman problem or the TSP. The idea of the TSP is that a salesman

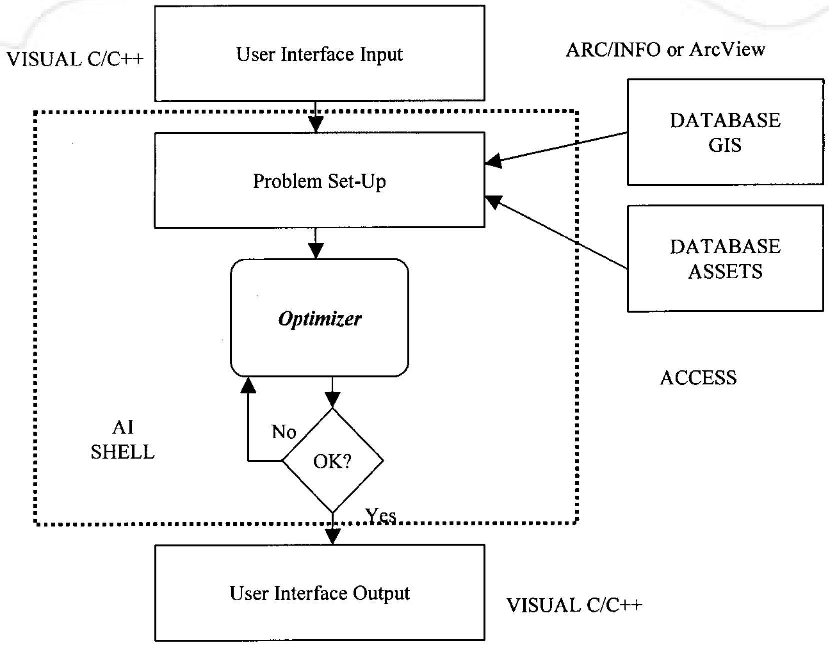

Figure 3. Asset management case study.

has to make a number of sales calls in different cities. He needs to plan a trip that will allow him to visit the largest number of these cities possible in the least amount of time and traveling distance. Burkard, Deineko, and van Dal (1998) have contributed an excellent summary of solved TSP problems for instructional purposes. The TSP has many applications in real-world industrial problems such as material delivery in manufacturing settings. Chalasani and Motwani (1999) and Bertsimas, Chervi, and Peterson (1995) have also described applications of the TSP to real-world industrial problems.

For our purposes let's assume then that an idealized community has one snow plow, a personnel budget of 100 man-hours, and 1,000 tons of road salt. The optimization problem would be to maximize the miles of road plowed, minimize the cost to the city of the work, stay within the available resources, and respect the physical reality of the problem.

Stated mathematically this would mean that we want to make this expression LARGE:

Miles plowed Road 1
+ Miles plowed Road 2
+ Miles plowed Road 3
... and so on for all roads ...

Total miles of road plowed

To make this expression SMALL:

Man-hours Road 1 x salary rate
+Man-hours Road 2 x salary rate
+Man-hours Road 3 x salary rate
+... and so on for all roads ...
+Man Hours Deadheading x salary rate
+ Salt used on Road 1 x salt cost
+ Salt used on Road 2 x salt cost
+ Salt used on Road 3 x salt cost
+ ... and so on for all roads ...

Total cost of plowing

While obeying the physical realities of the problem:

- Salt on Road 1 = length of Road 1 x needed salt rate
- Time on Road 1 = length of Road 1/ maximum plowing rate
- Salt rate Road 1 = function of road surface, snow depth, temp, etc.
- Plow rate Road 1 = function of road surface, snow depth, temp, etc.
- Road 1 connects to Road 3 only.
- Etc....

And also while staying within the limits of the available resources:

Man-hours Road 1
+Man-hours Road 2
+Man-hours Road 3
... and so on for all roads ...
+Man-hours Deadheading

Less than 100 hours

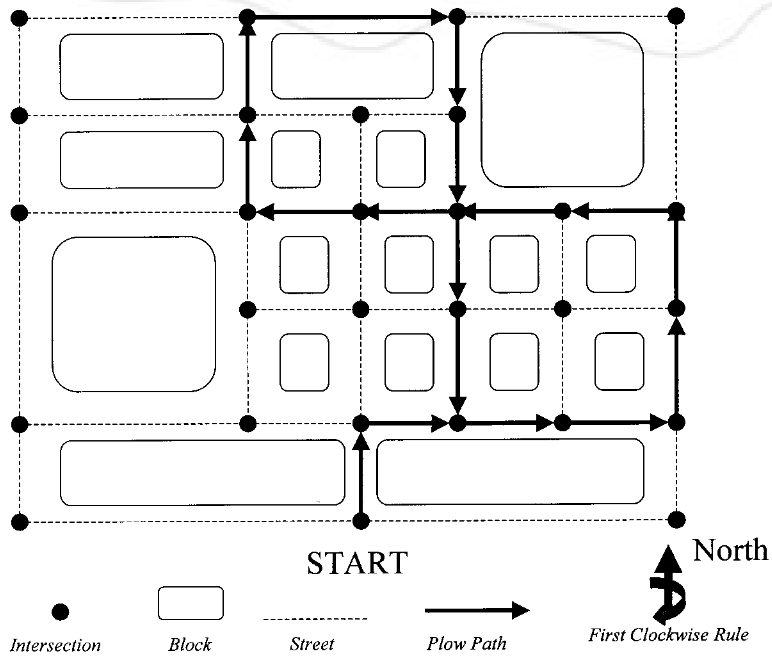

Figure 4. Nearest neighbor heuristic rule.

Salt used on Road 1
+Salt used on Road 2
+Salt used on Road 3
... and so on for all roads ...

Less than 1,000 tons

Figure 3 presents an overview of the software tasks that the students would perform in solving this case. The "shell" would be used to implement the heuristic rules to first generate solutions to the problem and then to improve on these solutions. Typically this is done in iterations with the program only stopping when an acceptable solution has been reached. Other tasks would be to write C/C++ programs to format the input and output data in user-friendly forms and to use database software to implement database of the assets involved and of the geography of the city in GIS format.

The heuristic rules involved in creating a snow plowing path are quite interesting. In order to generate an optimal solution, a number of heuristic techniques are available. For illustration purposes, a single snowplow is considered as plowing the streets of a small community. Figures 4, 5, and 6 depict the street map. The boxes represent city blocks, the dotted lines represent city streets, and the black circles represent the intersections. The snowplow begins plowing from a fixed starting point. The heuristic rules are presented in terms of this imaginary model.

Figure 4 presents an example of the nearest neighbor heuristic rule. In this rule, the snowplow driver stops at each intersection and picks the shortest street to the next intersection. If there are two or more equally short streets, the plow driver uses the "first clockwise rule." The driver imagines that the minute hand of an imaginary clock is sweeping clockwise from due North at 12 o'clock. The first of the two or more equally short streets to be swept over by the minute hand of this imaginary clock is selected by the driver. As can be seen in the diagram, this heuristic rule results in a relatively short and efficient path, but creates the situation of the same streets being plowed more than once. In contrast, Figure 5 presents the furthest neighbor heuristic rule. In this case the plow driver stops at each intersection and picks the longest street to the next intersection. Again, the driver uses the first clockwise rule to select from two or more equally long streets. This heuristic rule creates a much longer and more winding path than the nearest neighbor heuristic rule. This path also requires some streets to be plowed more than once. Figure 6 presents the circular route heuristic rule. In this rule the driver creates a mental picture of an imaginary clock whose minute hand is centered at the geographic center of the city. The driver imagines the minute hand of this clock sweeping over the plow's starting point at 6 o'clock and towards the next clockwise intersection. The plow driver follows this imaginary minute hand and plows the streets in the same order that the intersections are

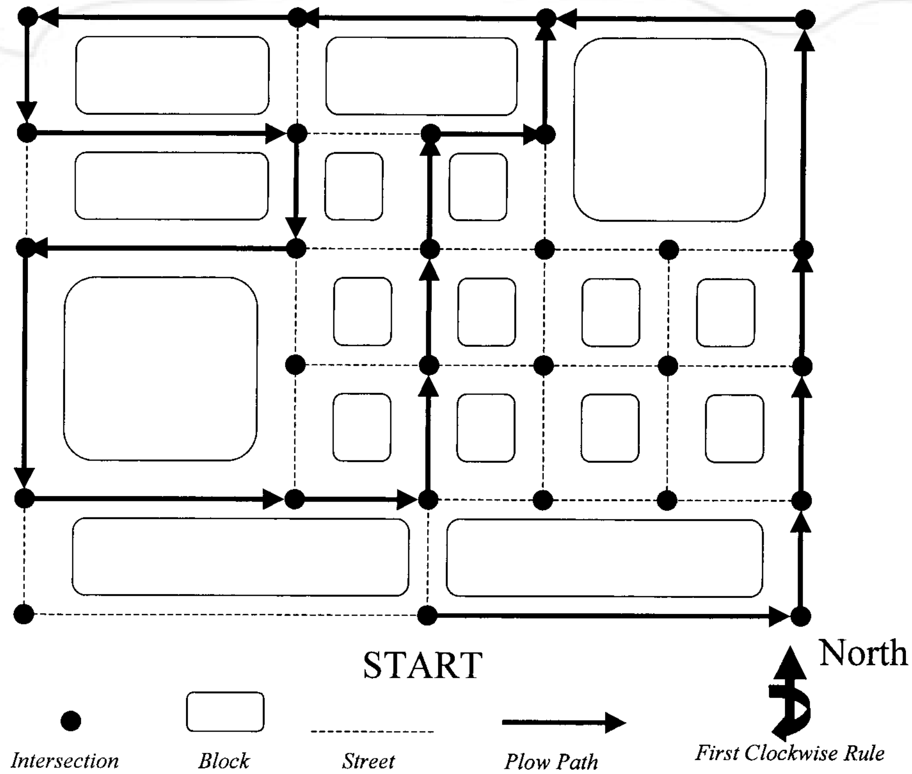

Figure 5. Furthest neighbor heuristic rule.

swept over by the imaginary clock's minute hand. In contrast to the furthest neighbor and the nearest neighbor heuristic rules, the circular route rule never requires that the same street be plowed more than once. However, the circular route rule does not result in the interior streets of the city being plowed.

Of course, the plowing route of a real city would be far too complicated for a driver to use the nearest neighbor, furthest neighbor, and circular route heuristic rules while actually driving the plow through the community. Instead, an expert system shell would implement these heuristic rules on a database of the streets and intersections to generate the plowing path.

More complex heuristic rules exist that an expert system shell can use to make even better path selections. The one-opt heuristic rule examines each street in a plowing path and sees if substituting another street available at the same intersection would reduce the overall path length. By systematically considering the "option" (the origin of "opt") of replacing each street by a shorter street, the one-opt heuristic rule helps an expert system shell create a shorter overall plowing path. The two-opt heuristic rule does exactly the same thing as the one-opt heuristic rule except that two streets are considered at a time rather than one at a time. The nearest insertion heuristic rule works like the one-opt heuristic rule with the difference that the intersections rather than the streets in the plowing path are considered. Using the nearest insertion heuristic rule, the expert system shell looks at each intersection visited in the plowing path and sees if swapping this intersection for another neighboring intersection would result in a shorter overall path. Finally, a very sophisticated method called the Lin-Kernighan heuristic rule looks at removing both intersections and streets from the plowing path and examines if substituting other intersections and streets into the plowing path results in an improvement. The ultimate object of the expert system shell is to plow all the streets of the city on the plowing schedule with the minimum number of duplicate plowings of the same streets. All of these heuristic rules-nearest neighbor, furthest neighbor, circular route, one opt, two opt, nearest insertion, and Lin-Kernighan-can easily be implemented on an expert system shell. The choice of which rule or rules to use and in what order is up to the imagination and ingenuity of the students.

Pedagogically, such a problem could be assigned either as a single group project for a

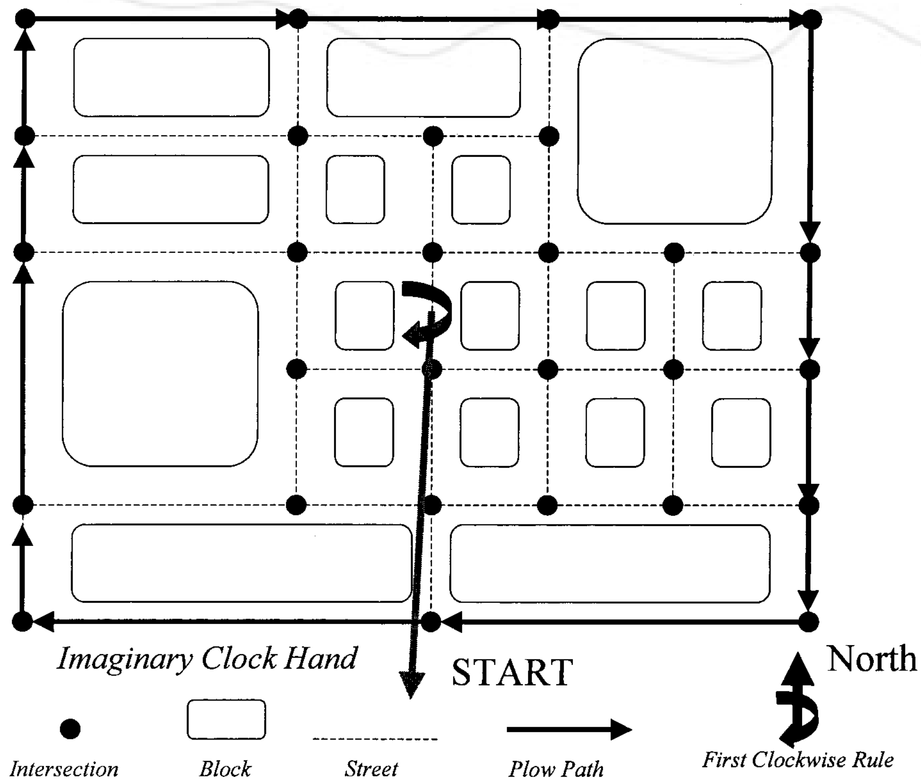

Figure 6. Circular route heuristic rule.

term project experience or could be divided up into smaller tasks to be used as weekly assignments. There are many examples of this type in the literature and on the Web, and library or Internet components could be added to help hone the student's research skills as well. This type of case study is a good candidate for AI-based solutions as indicated in Figure 3.

Conclusions

In order to keep industrial technology education timely and interesting, it is desirable to supplement the traditional lecture-homework pattern of student experiences with real-world case studies. We have presented two concepts of contemporary interest to industry, the use of asset management concepts and the use of AI tools, to solve real-world problems. The steps needed in selecting an AI "shell" or programming tool were also presented. A case study of the real-world task of snow plowing was also presented as an example of a student project that vividly illustrates the use of these industrial problem-solving tools in a pedagogical context.

Dr. M.D. Salim is currently serving as an associate professor of Construction Management in the Industrial Technology Department of the University of Northern Iowa, Cedar Falls, Iowa.

Dr. Marc A. Timmerman is currently an assistant professor of Electrical Engineering Technology at the University of Arkansas at Little Rock, Little Rock, Arkansas.

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Developing Critical Thinking Skills of Tech Prep Students Using Applied Communications

Don R. Gelven and Bob R. Stewart

Introduction and Theoretical Base

Employers and educators are generally in agreement that students need to increase their problem solving and critical thinking skills. One goal for improved educational outcomes have pointed out that American students should perform at a higher level in these areas (National Education Goals Panel, 1994). Improved problem solving and critical thinking skill experiences have been included in tech prep initiatives which have tended to focus on activities designed to better prepare students for the world of work (Custer, Ruhland, & Stewart, 1997). However, little evidence was found that tech prep initiatives, and especially applied communications activities, addressed the improvement of problem solving and critical thinking abilities of students.

The theoretical base for this study was formed from cognitive and behavioral learning theories and theories of self-efficacy as applied to problem solving and critical thinking. These learning theories fall into two broad areas. The first area deals with the nature of problem solving and critical thinking. The second considers whether problem solving and critical thinking can be taught.

The ability to think critically and to solve problems has been a concern of philosophers, educators, and psychologists for many centuries. Sternberg (1986) attributed the modern-day critical thinking movement to John Dewey. Dewey (1933) was concerned with the nature and value of thinking. He considered thinking to be the process by which individuals find meaning in the world in which they live. The ability to think critically is a prerequisite for problem solving and as such is of significant value. Dewey believed that the ability to think critically and reflectively was a function of one's experience as well as one's intellect.

The basis for the second area of learning theory, that which deals with methods for developing cognitive abilities, can be traced to Bloom, Englehart, Furst, Hill, and Krathwohl (1956), who developed a taxonomy of cognitive levels of learning. Each level requires a different mental activity or way of thinking. Lower levels of learning are prerequisites for higher levels, where higher levels are often referred to as requiring higher order thinking skills. Bloom stated that higher order thinking skills are built on the ability of students to identify concepts and analyze and integrate multiple concepts to solve problems. Therefore, problem solving requires higher order thinking, which Bloom stated can be taught. A number of authors have proposed methods for teaching thinking and problem solving. For example, Bruner, Goodnow, and Austin (1956), Gallagher (1993), Halpern (1984), and Ruggiero (1988) have described various aspects of thinking, learning, and problem solving and methods for developing problem solving skills. The methods they proposed are based upon both cognitive and behavioral learning theories.

Bandura (1986) defined self-efficacy as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (p. 408). Greenburg and Baron (1993) stated that self-efficacy develops "partly through direct experiences, in which individuals perform various tasks and receive feedback on their success, and partly through vicarious experiences, in which they observe others performing various tasks and attaining varying levels of success at them" (p. 208). They further stated that, regardless of how it develops, "the stronger individuals' beliefs that they can perform successfully, the higher their performance actually tends to be" (p. 208).

Problem solving is one of the foundation skills needed for high-skill, high-wage employment (Daggett, 1992; U.S. Department of Labor, 1992). Life in technologically oriented countries, such as the United States, is characterized by rapid change. This rapid change complicates life and makes it necessary for students to learn how to be effective problem solvers. It is particularly desirable that students learn to be effective problem solvers in the context of actual work situations. In order to keep up with international competition and the faster pace of technological change, employers in the United States are demanding that the public schools be responsible for developing students' critical thinking and problem solving skills. In response to this demand, goals have been defined at the national level for developing students' problem solving skills. The fifth objective of National Education Goal 6 states: "The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively, and solve problems will increase substantially" (National Education Goals Panel, 1994, p. 10).

About the Study

The primary purpose of this study was to examine the effect of participation in a tech prep program and specifically an applied communications course on the problem solving self-appraisal and selected aspects of critical thinking skills of secondary students. A secondary purpose was to examine the effects of a traditional English course and an honors English course on these factors. Three null hypotheses were formulated to test for differences among performance of students in three types of English courses.

What We Did

A pretest-posttest nonequivalent control group design was used for the study. Demographic information and two instruments were used to collect data.

The Problem Solving Inventory (PSI) Form B (Heppner, 1988) was used to measure an individual's self-appraisal of problem solving self-efficacy. The PSI contains 35 items and uses a 1 to 6 Likert-type scale with 1 representing strong agreement and 6 strong disagreement with the statement. Reliability for the PSI was reported to be $r = .89$ for test-retest reliability and $r = .90$ for internal consistency. The Watson-Glaser Critical Thinking Appraisal (WGCTA) Form B (Watson & Glaser, 1980) was used to measure selected aspects of the students' critical thinking abilities. It consists of 80 items divided into five subscales of 16 items each and includes exercises that are purported to be examples of problems, statements, and interpretations of data that are regularly encountered at work or school. The split-half reliability estimates for 11th grade students was reported to be $r = .79$. The maximum raw score for the WGCTA is 80.

The purposive sample consisted of the students enrolled in four sections of each of three different English courses: an applied communications course, a traditional English course, and an honors English course. When there were more than four sections of a course, sections were randomly selected for this study. At the time of the pretest, 254 students were enrolled in the 12 sections studied. The number of students increased to 279 by the time of the posttest. Complete data on pretest and posttest measurements for the PSI and WGCTA were obtained for 136 students, including 53 Honors English III students, 43 English III students, and 40 English IIIC applied communications students. All students were in the 11th grade, except one 10th-grade student who was in English III and three 12th-grade students who were in English IIIC applied communications.

The Statistical Analysis System (SAS, 1990) was used to calculate a multivariate analysis of variance (MANOVA) value using the general linear model adaptation for a two-factor repeated measures experiment or a Pearson product-moment correlation, as appropriate. The null hypotheses were rejected if the F value was significant at equal to or less than the .05 alpha level.

The Data

The mean pretest and posttest scores (see Table 1) on the PSI for the honors English students were 83.7 and 79.0; for the English III students, 92.4 and 90.8; and for the English IIIC applied communications students, 93.2 and 95.7. The mean pretest and posttest scores on the WGCTA for the honors English students were 57.5 and 59.1; for the English III students, 48.5 and 45.6; and for the English IIIC applied communication students, 43.1 and 42.6.

The multivariate analysis of variance procedure showed a significant difference for course ($F = 43.3$; $p = .0001$) and interaction ($F = 3.5$; $p = .0088$) as reported in Table 2. There was not a significant difference found for time of administration of the instruments.

The first hypothesis proposed that there is no statistically significant difference in the mean total scores from the PSI and WGCTA by type of English course assignment. The hypothesis was not supported at the .05 level of significance. Table 3 data show a significant difference on the PSI ($F = 7.82$; $p = .0006$) and the WGCTA ($F = 75.67$; $p =. 0001$) in mean total scores of students by English course assignment. Students assigned to the honors English III course had mean total scores

Table 1. Mean Pretest and Posttest Scores for the PSI and WGCTA

Variable	*M*	*n*	*SD*	Variance	*SE*
Course 1-Honors English III					
Pretest PSI	83.736	53	17.811	317.237	2.447
Posttest PSI	79.000	53	19.104	364.962	2.624
Pretest WGCTA	57.453	53	6.256	39.137	.859
Posttest WGCTA	59.151	53	7.140	50.977	.981
Course 2-English III					
Pretest PSI	92.419	43	14.945	223.344	2.279
Posttest PSI	90.791	43	18.809	353.788	2.868
Pretest WGCTA	48.488	43	7.830	61.303	1.194
Posttest WGCTA	45.628	43	8.449	71.382	1.288
Course 3-English III C					
Pretest PSI	93.225	40	19.453	378.435	3.076
Posttest PSI	95.725	40	21.664	469.333	3.425
Pretest WGCTA	43.100	40	7.063	49.887	1.117
Posttest WGCTA	42.575	40	6.898	47.584	1.091

Table 2. Pillai's Trace Test for Multivariate Analysis

Value	Source	*F*	*NDF*	*DDF*	*PR>F*
Course	.78878902	43.3075	4	266	.0001*
Time	.01707687	1.1467	2	132	.3208
Interaction	.09904930	3.4650	4	266	.0088*

* Significant

(PSI = 81.4; WG = 58.3) that were significantly more positive than the mean total scores of students assigned to English III (PSI = 91.6; WG = 47.1). The mean total scores of English III students were, in turn, significantly more positive than the mean total score of English IIIC applied communication students (PSI = 94.5; WG = 42.8).

The second hypothesis suggested no statistically significant difference in the mean total scores from the PSI and WGCTA by time of administration of the test instruments. The hypothesis was supported at the .05 level of significance. Table 2 shows no significant difference (F = 1.1; p = .321) between the pretest and posttest mean total scores from the

Table 3. ANOVA for PSI and WGCTA

PSI	*DF*	*SS*	*MS*	*F*	*PR>F*
Course	2	9076.396	4538.198	7.82	.0006*
Error	133	77163.659	580.177		
Time	1	111.202	111.202	0.95	.3322
Interaction	2	596.763	298.381	2.54	.0825
Error	133	15613.174	117.392		
R^2 = .847					

WGCTA	*DF*	*SS*	*MS*	*F*	*PR>F*
Course	2	12143.342	6071.671	75.67	.0001*
Error	133	10671.936	80.240		
Time	1	21.208	21.208	0.83	.3632
Interaction	2	247.125	123.562	4.85	.0093*
Error	133	3388.153	25.474		
R^2 = .871					

* Significant

PSI and WGCTA, for any class of students.

Results were also examined for interactions. An analysis of variance procedure (see Table 3) revealed that there was a significant interaction (F = 4.85; p = .0093) between the mean WGCTA scores by the type of English course assignment and time. A post hoc test (see Table 4) was used to isolate source of the differences between the interaction of course and time. The mean pretest and posttest WGCTA test scores of honors English III students were significantly higher than the mean pretest and posttest WGCTA scores of English III and English IIIC applied communications students. English III students' pretest and posttest scores were significantly higher than the pretest and posttest scores of English IIIC applied communications students.

The third hypothesis asserted that the correlation between the students' scores from the PSI and from the WGCTA would not be statistically different from zero. The results from the Pearson product-moment calculation showed that the correlation of .41 for the students' posttest scores from the PSI and WGCTA was significantly different than zero and the hypothesis was not supported.

Implications from the Data

The results of this study do not support a conclusion that the critical thinking skills of any of the three groups of subjects of this study were significantly changed during the course of the school year. Therefore, it cannot be concluded that the applied communications course significantly changed students' critical thinking skills. Also it cannot be concluded that the honors English III or the traditional English III courses significantly changed students' critical thinking skills.

These results may support a belief that critical thinking skills and problem solving skills cannot be developed in a short period of time. This explanation is consistent with a conclusion reached by Langholz and Smaldino

Table 4. Least Square Mean, Least Square Standard Error, and Least Significant Difference Test for Dependent Variables PSI and WGCTA by Course

					LSD Test	
Course	*n*	*M*	*SE*		2	3
Dependent Variable = PSI						
Honors English III	106	81.367	1.052	1	.0001*	.0001*
English III	86	91.604	1.168	2	.0904	
English IIIC	80	94.475	1.211	3		
Dependent Variable = WGCTA						
Honors English III	106	58.301	0.490	1	.0001*	.0001*
English III	86	47.058	0.544	2		.0001*
English IIIC	80	42.837	0.564	3		

* Significant

(1989). They pointed out that there is not much evidence to support the conclusion that critical thinking and problem solving can be developed in a short period of time.

There is some literature that supports the idea that training can develop a more positive self-appraisal of an individual's problem solving abilities. Gallagher (1993) pointed out that the PSI has been used as an outcome measure for problem solving seminars. In a study of an eclectic approach to training paraprofessionals in counseling, Gallagher administered the PSI both pre and posttest and found that the PSI scores of trainees decreased significantly, indicating that the trainees' self-appraisal of their problem solving was more positive after training. Interestingly, the self-appraisal of their problem solving abilities by the subjects in the study reported in this article did not significantly change over the time of the study. In addition, the pretest-posttest comparisons found no statistically significant evidence indicating that the spread between the self-appraisal of Honors English III students as compared to the self-appraisal of English IIIC applied communications students increased over time.

Although the change was not statistically significant, the posttest mean PSI scores of Honors English III and English III students were lower than their pretest mean scores. This could indicate that a slightly more positive self-appraisal of their problem solving abilities was developed. By way of contrast, the posttest mean PSI score (95.73) of the English IIIC applied communications students was higher than their pretest mean score (93.23). A possible explanation for this slightly less positive self-appraisal might be that their understanding of problem solving increased and the posttest score provided a more realistic awareness of their problem solving abilities.

Students' grade point averages and PLAN test scores were also examined to provide additional background information for the study. An examination of the data revealed that both the grade point average (3.5 vs. 2.2) and PLAN test scores (23.1 vs. 14.2) of the honors English students were higher than for English IIIC applied communication students. Students' scores from the PLAN test, which requires higher order thinking skills, were significantly related to their PSI and WGCTA scores. This indicates that the students assigned to the different courses had different characteristics that likely influenced their performance on the test instruments.

The tech prep curriculum for the applied communications course should incorporate specific objectives to improve the critical thinking skills of students and to develop a more positive perception of their ability to solve unstructured problems of the type encountered at home and at work. To achieve these objectives, instruction specifically designed to develop inductive and deductive reasoning skills and to develop the ability to draw inferences should be incorporated into the tech prep applied communications curriculum.

Dr. Don R. Gelven has recently retired from the postition of vice president of Academic Affairs at Linn State Technical College. He is a member-at-large of Epsilon Pi Tau.

Dr. Bob R. Stewart is a professor in the Department of Curriculum and Instruction at the University of Missouri-Columbia. He is currently serving as chair for the Council for Career and Technical Education.

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Delivering "Legal Aspects of Industry" on the Internet (Experiential Account and Observation)

Ronald C. Woolsey and John Sutton

Introduction

The spring semester 1998 was Central Missouri State University's (CMSU) initial course offering of Mf&C 5015 "Legal Aspects of Industry" using the Internet. The course has now completed our fourth offering since its creation. The course was designed to provide a basic overview of the law and methods of legal research for graduate students in fields of applied science and technology. The course also gained approval as a required course in the "General Technology Core" of courses for the recently approved Doctorate of Philosophy (Ph.D.) in Technology Management. The Ph.D. in Technology Management is offered through Indiana State University and delivered by a partnership of seven universities making up the Consortium for Doctoral Studies in Technology.[1] The primary delivery mechanism for consortium courses is web-based technology. To find out more about this program please refer to the web site: http://web.indstate.edu/distance/techm.html or http://web.indstate.edu/ConsortPhD/.

Background

We were responsible for the design, content, and implementation of the curricula for web-based delivery, communications, and assessment of our course. To gain experience in the new communications technologies and pedagogy of asynchronous education "anytime-anyplace," we pursued this as a pilot or "beta" course, with the following goals:

1. To identify opportunities in which the delivery system and technology tools added value for students or enhanced their learning experience in ways different from the traditional "same time-same place" classroom model. Specifically, we wanted to discover if these new technologies and tools were effective in assisting or promoting research, learning, and collaboration in project work done by students taking this course from diverse geographic locations.
2. To identify sufficient substantive legal information that was available on the Internet. After the initial offering of this course, it was determined that this legal material needed to be incorporated into Blackboard/CourseInfo delivery tools. We found that the location of Internet information was unreliable from semester to semester. We had to find ways to overcome this problem. Blackboard supplies the following general areas for posting course documentation: Announcements, Staff Information, Course Documents, Assignments, Communications, External Links, and Student Tools. Multiple folders and documents can be posted in each of these areas.
3. To provide a learning experience that translated into lifetime learning skills in the law, as well as in communications and educational technologies.

We faced a number of course challenges and constraints. First, the instructors and the students had limited experience and training in the new delivery technologies and the pedagogy of asynchronous education, and second, CMSU was beginning to develop technology support systems for the students and faculty through the newly created Center for Academic Technology (CAT). These resources were new and limited when we began this undertaking. Many gains have been realized in this area including Extended Campus assistance in enrollment and communication, an 800 number for the campus "help desk," and standardization of Blackboard/CourseInfo as the base university tool for organizing course delivery. Third, we were unaware of the extent and availability of legal content on the Internet; it was difficult to ascertain content accuracy, currency, and appropriateness. A self-imposed constraint was to design the course so that the only technology requirements for our students were Internet access and a working email address. We worked hard to ensure that the students, as a result of the course design, would not incur additional costs beyond these software/hardware requirements. Since the initial offering in 1998, it has been necessary to add a required textbook and law dictionary because of the unreliable and transient nature of materials available on the web. Even the textbook website has changed its URL twice.

An interesting caveat was that we knew the enrolled students had the skills and intelligence to be successful in a nontraditional classroom setting before enrolling in the course. This is a tremendous advantage; graduate students are usually highly motivated, self-directed learners, and anxious to be part of emerging technologies. Perhaps the biggest challenge to the faculty was ensuring that the technology and delivery method would never become an obstacle to student success. This has been a continuous and ongoing challenge over the last three years. Time has been our best ally due to the rapid improvements in everything from basic access to communications and file management.

Methodology

Instructor's Explorations

Preparation for this course began in July 1997, approximately six months before the course was first delivered in the spring of 1998. Early preparation involved extensive time searching, surfing, and browsing the web on two major topics: (a) the law and applications in industry and (b) distance education and Internet delivery systems/ software. Both Internet Explorer and Netscape Navigator were utilized. The idea was for the instructors to experience the learning curve the students would undergo while utilizing the Internet technology. Even in today's offering this has proven to be an informative exercise but no longer is a focus of the course.

Extensive time was also spent experimenting with several email packages. CMSU utilizes Groupwise for faculty email. While Groupwise has many powerful features for organization and email handling, it was found to be a clumsy and time-consuming package for course communications. Later offerings of the course utilized Blackboard's email communications tools because of the ease of integration with student information. It was anticipated that most students would utilize a variety of email providers and software including Outlook, Outlook Express, Eudora, Hotmail, or a browser email utility. All these technologies have the ability to attach a file prepared by a word processor, which was the original way students would submit all class assignments. Current course offerings utilize Blackboard/CourseInfo to manage student email information, and all students submit their assignments utilizing the student drop box included in the communications tools. Email attachments are used as a backup to this system. It is very important that each student verify the information supplied to Blackboard/CourseInfo to make sure the information is correct. The email account information is especially critical because the instructor tools included in Blackboard/CourseInfo will utilize this as the primary point of contact. The instructors use Microsoft Office as the default format for all student submissions. This allows the instructor to read all submitted files.

Prior to the initial course offering, interviews were conducted with CMSU faculty experienced in utilizing computers, email, and the web to assist in course delivery. Some faculty had course web sites containing course syllabi, staff resumes, assignments, lecture notes, and handouts for downloading or printing. Some sites also contained reading lists and "external links" to web sites for further reading. One instructor was utilizing email in a "correspondence course mode" to make assignments and receive student work. All had regularly scheduled course times to meet face-to-face with the students. For these other courses, the technology was only utilized to supplement the traditional in-class activities. Some instructors developed or used computer-aided self-instructional programs available in the computing labs. Many of these courses contained self-testing components with multiple assessment feedback methods. No utilization of interactive online technology or testing through the Internet was encountered during this research phase during 1997-98.

The instructor's research and readings into the subjects of asynchronous teaching, online delivery, and computer-assisted/web-based training (WBT) was informative. Books on these subjects are outdated by the time they get to the shelf. The web is the best source, but several professional and trade journals are also helpful. The *Chronicle of Higher Education* at http://www.chronicle.com/infotech/, *T.H.E. Journal* (Technology in Higher Education) at http://www.thejournal.com/, *Syllabus Magazine* at http://www.syllabus.com/, and *Training Magazine* at http://trainings.website.com/ provide both printed and electronic versions with useful articles and links. Research, reading, and interviews were supplemented by attending "Delivering Online Courses" in the fall of 1997 in Phoenix, Arizona, presented by the College Board, Office of Adult Learning Services. The opportunity to listen and speak to practitioners pushing the envelope of technology and online education proved extremely valuable.

Challenges and Accomplishments in Course Development

Numerous publications address guidelines and issues in course development for distance and web-based learning. Below is a partial list of materials that should be supplied to all course developers. These documents form a critical foundation for future policy development, assessment criterion, and material development.

- *Draft Principles of Good Practice for Distance Learning* (adopted by the Coordinating Board for Higher Education, April 13, 2000 - Missouri Department of Higher Education): http://www.mocbhe.gov/acadafrs/prindis.htm
- *Quality on the Line: Benchmarks for Success in Internet-Based Distance Education* (PDF Download - U.S. Department of Education): http://www.ihep.com/quality.pdf
- *NCES Report: Distance Education at Postsecondary Education Institutions 1997-98* (PDF Download - U.S. Department of Education): http://nces.ed.gov/pubs2000/2000013.pdf
- *Core Academic Values, Quality, and Regional Accreditation: The Challenge of Distance Learning* (Judith S. Eaton, Council for Higher Education Accreditation [CHEA]): http://www.chea.org/Commentary/core-values.cfm
- *Principles of Good Practice for Alternative and External Degree Programs for Adults* (prepared by task force of the American Council on Education): http://www.ahea.org/pogp.htm

Extensive new course development is required to duplicate the rigors of a traditionally presented curriculum. Institutions have the responsibility to establish standards and encourage academic integrity through distance learning equivalent to courses offered in a traditional campus-based environment. It should be the faculty's intent to work with this belief as a basic guideline. Early in the development process it was decided that the role of the instructor was that of facilitator and guide, with the foundation of the course design centering on the course syllabus. Course learning objectives were specifically matched to student work assignments. Identification of student "deliverables" stressed the important items required for submission and assessment. Two categories of deliverables were utilized: The individual student work consisted of (a) exercises/ readings, case briefs, and journal reviews, and (b) a term research paper.

Over the past three years, three additional deliverables have been incorporated. First, the instructor-directed "virtual chat" requires students to submit a minimum of two questions that address the chapter reading assignment prior to each weekly scheduled chat sessions. Second, group work consists of preparing legal subject outlines in four distinct legal areas of interest to industry and related case briefs. The exercises centered primarily on finding legal sites on the web, summarizing the contents, and sharing these sites with the rest of the class. Readings directed students to web sites identified by the instructor that contained relative, substantive content. Preparing case briefs required the students to search the Internet, locate relevant legal cases, and prepare summary briefs in a standardized format that would link back to the source document's Internet address (URL), which would contain the full text. Third, journal article reviews were submitted from reputable online journal sources, with summaries (also linked) prepared in a standard format.

To qualify as acceptable, a legal case or journal article must contain an industry player (company, corporation, or industry group) as a party to some legal action or issue. Journal readings keep the content applied and current. The links provided anyone electronically viewing the brief or journal (with Internet access and a browser) the opportunity to immediately read the source document. All prepared work is submitted to the instructors through email as attached files. Because of the mercuric tendencies of new URL links it was suggested that students obtain hard copies of those articles applicable to their company or business interests.

The first two online course sessions consisted of achieving the following objectives: (a) defining administrative course guidelines and responsibilities (i.e., how to get passwords to protected areas, how to contact the instructor, how to access and submit assignments); (b) updating personal information for each student, their course expectations, hardware and software they would be using, self-assessment of their experience and proficiency with the technology; (c) introducing exercises, such as searches for specific legal topics and sites; and (d) submitting results. These sessions were used to evaluate student competency with the web and email, evaluate their responsiveness to instructions, and assist in gaining the skills and confidence to progress successfully in the course.

The next six course sessions incorporated the use of large-group virtual chats on specific topics in the textbook and also introduced the format for submitting assignments such as legal outlines, case briefs, and news journals. To explore the possibilities of group collaboration, students were placed into teams, using Blackboard's group options, to research and explore four areas of the law: contracts, property, torts, and constitutional law. The next four sessions required the teams to collaborate using Internet tools to develop and submit a team meeting schedule and minutes of each meeting and to deliver a presentation with supporting materials on the one of the above topics. The last course meetings involved the review of presentations using virtual chats and the thread discussion forum, the submission of an individual term paper on a legal topic selected by the student, and a final online written assessment.

What We Learned and Our Conclusions

Individual and peer assessment was utilized to determine student compliance with course objectives and their ability to use the technology to find relevant information. The instructional coordinator handled the collection and general format issues while the subject matter specialist evaluated written work for content. Group work was shared with the other groups, with the best group product setting the standard for evaluation. A three-person team, the lead instructor, subject matter specialist instructor, and the course facilitator, assessed 47 research papers.

Communications Technology Tools

Blackboard/CourseInfo's components supported the necessary communications. The software includes areas for posting announcements, information, documents, assignments, assessment, and external links. Four different communications techniques are included: individual email, group email, threaded discussion forums, and virtual classroom chats. One other area of communication incorporates a number of student tools for checking grades, a digital drop box to the instructor, tutorials, daily schedule, and personal administrator. CourseInfo was set up as a class meeting place where information, questions, and answers could be shared between and among students. A textbook and accompanying transparencies were used to direct the weekly virtual chat sessions. Some specific areas were established for each of the major legal topics and for each "cyberteam" project. Group pages and group virtual classrooms were created and incorporated for use by these teams. Email was utilized among the students to exchange collaborated outlines or to just communicate with each other more privately than through CourseInfo. The instructor required students to submit all assignments via the digital drop box. Questions could be submitted via email, and the instructor would reply to the requesting student or to the entire class if the issue applied to all students or teams.

Delivering and Administering the Course Today (2001)

CMSU and its technical staff support Blackboard/CourseInfo. The staff maintains the server hardware and software. Recently, 47 students enrolled in two sections of the course with the entire group being off-site. The classes contained an equal mix of master's degree and doctoral degree students. Three instructors facilitated the classes: the lead instructor handled the setup and administration of the coursework with CourseInfo, the subject matter specialist directed all content discussion, and the course facilitator kept up with the daily communications and problem solving.

The instructors used software such as Microsoft Office 2000, Front Page 2000, and Allaires Cold Fusion for creating and saving the content in a format that facilitated web site content and activities. Blackboard/CourseInfo is designed with a public side and a restricted side for the instructor. The public side displays the different components to students while the restricted side is only for instructor access, which requires a password and user name.

Daily tasks for the instructors involved logging assignments deposited in the digital drop box, answering individual students' email questions, monitoring the course-threaded discussion forums, and taking phone calls from those students who required additional real-time contact.

Weekly tasks included meeting at a scheduled time in the virtual classroom to discuss new reading topics, responding to new threads in the discussion forum, and meeting in "cyberteams" to coordinate the group activities. The course facilitator instructor provided an outline of valuable feedback from the students as the course proceeded.

Some Problems and Solutions

Just as in the traditional classroom, not all things go as planned, and we offer three examples:

Problem 1: The course had just begun and it was apparent through early assessment modules that some of the students possessed insufficient skills to use the Internet and email. One of the course objectives was to ensure that the technology did not become an obstacle to the student's success.

Solution: Students were directed to third party, public Internet sites that contained information and instruction on the Internet skills needed. These students were also assigned to "cyberteams" whose other members were more technologically sophisticated and who were able to assist the other team members. The team leader was also made aware of the situation and monitored the students' participation closely.

Problem 2: Regularly scheduled virtual classroom chats require an alternative compliance plan as well as a standard backup plan.

Solution: Students who were not able to attend a chat were required to submit several questions via email prior to the scheduled chat event. These questions were included in the chat session and the student was responsible for reviewing the chat archives. The standard backup plan was established in case of technical failure. Students were instructed to continue with posted assignments and deposit a topic outline for that week's discussion material.

Problem 3: The course only provided for an overview of legal topics. Contract law, employee protections, securities, and even the student's specific field of interest (i.e., construction law) were covered only lightly.

Solution: The briefs contributed to the legal outlines and journal reviews allowed the student to focus on industries, companies, or issues. The term paper allowed special interests to be investigated, and each student reviewed the other students' presentations and papers, hopefully finding some topics of common interest or other usable information. The course was also designed to develop lifetime learning skills and an ability to access online legal topics. It was anticipated that skills learned and resources found would allow the student to further investigate any area of the law which was of interest. It was also hoped that these skills would contribute to becoming a more effective and better informed citizen, corporate participant, educator, or family member.

Conclusions

Not all individual teaching or learning styles are well suited to a particular delivery method, course materials, classroom, or lab setting. The same is true for asynchronous Internet delivery. In asynchronous delivery, the instructors must realize they are the university. Students in distant locations will utilize the instructor as the first point of contact, not only for course problems, but for technology questions, enrollment, administrative questions, and even academic advisement. The institution must ensure that technical and administrative support remains easily accessible to instructors.

The students and instructor must clearly understand their respective responsibilities, course time requirements, and obligations to other students. This requires developing and learning new rules of classroom engagement. Time management is one of the most important aspects of this course delivery methodology.

In the instructors' estimate, it took approximately three times the effort to develop and deliver this course as compared to traditional course delivery. Not all courses would lend themselves as easily to Internet delivery as "Legal Aspects of Industry." Law courses are notably heavy in written content, not requiring many visuals or demonstrations. Visuals would require more elaborate web site preparation by the instructor or programmer than was utilized in this course. In addition, an abundance of legal information exists and is readily accessible via the Internet. Very little original material or content was presented, except those developments that occurred in the law as it was redefined by each new court case.

Future advances in technology and pedagogy will provide more effective means and tools to deal with the course development, delivery, and communication problems. The future will provide an assortment of tools for graphics, automation, streaming video, and interactive communication for instruction and testing. Much advancement has been seen in the creation of CourseInfo, WebCT, and E-College for course delivery. One area needing further study is in the use of software such as RealPlayer, Windows Media Player, and Quicktime for streaming media as well as Ivisit and Netmeeting for interactive video. As with the topics we teach, an educator must experience and use these technologies first hand to be current in the future. With the immense amount of information available and ease of access via the Internet, educators can no longer be merely disseminators of information, rather, they must become guides and facilitators to the development of knowledge, critical thinking, and lifetime learning skills.

Dr. Ronald C. Woolsey is an assistant professor in the Department of Manufacturing and Construction in the College of Applied Science and Technology at Central Missouri State University. He is a member-at-large of Epsilon Pi Tau.

Dr. John Sutton is professor and chair in the Department of Manunfacturing and Construction in the College of Applied Science and Technology at Central Missouri State University.

Endnotes

1. The Consortium of Doctoral Studies in Technology includes of the following university charter members: Indiana State University, Texas Southern State University, East Carolina University, Bowling Green State University, University of Wisconsin-Stout, North Carolina A&T State University, and Central Missouri State University.

The New “Living Technology” Curriculum in Taiwan’s Elementary Schools

(Chia-Sen) Jimmy Huang and Yen-Shun Wei

Elementary technology teacher education programs in Taiwan have been challenged by the following three recent developments: (a) Elementary teachers are expected to hold bachelor degrees, (b) the traditional craft-work (fine arts and industrial arts) curriculum has shifted to technology education, and (c) preservice teacher education tracks have needed to diversify (Lee, 1992).

Few research studies have proposed a formula for technology teacher education in Taiwan to cope with the above three developments. This leads to two interrelated problems: Although technology teacher education reform in Taiwan is underway, there is no coherent and rational guide to reform, and the lack of objective information leads to criticism of future reform as arbitrary judgments (Wei, 1993).

Despite the lack of a coherent plan, several changes have occurred in the field of technology teacher education programs as well as in the certification requirements for technology teachers.

The first development is that elementary teachers are being encouraged to obtain bachelor degrees. Since July 1987, the nine teachers colleges were changed to the National Teachers Colleges by the Taiwan government. Recently, all the nine national teachers colleges have established a department of fine arts and technology education. The main purpose of the department is to cultivate preservice elementary teachers into elementary fine arts and living technology educators.

The second development results from a revision of the elementary curriculum standards administrated by the Ministry of Education. In 1996 new national curriculum standards regarding craft-work were initiated: (a) The name was changed to ‘’living technology” or ‘’technology education”; (b) the goals are to provide an understanding of the presentation, appreciation, and practical application of the arts; (c) the curriculum contents cover the knowledge and skills of craft-work and relate these ideas to the students’ daily lives; (d) each course lasts two hours per week for first and second grades, and three hours for third through sixth grades; (e) the principle methods of instruction include hands-on experience, audio-visual media, and field trips; (f) instructional strategies are to provide comprehensive and systematic activities ranging from basic introductions to in-depth analysis; and (g) evaluation should emphasize process, results, and students' attitudes and performances as team workers (The Ministry of Education, 1993).

Most living technology teachers in elementary schools graduate from the departments of fine arts and living technology education at Taiwan's national teachers colleges. That curriculum must prepare technology teachers who are capable of meeting these revised curriculum standards. Naturally, this new "living technology" or "technology education" affects technology teacher education programs throughout Taiwan (Liang, 1993).

Taiwan's Ministry of Education has also called for diversifying preservice teacher education tracks. The Teacher Education Statute Amendment mandates educational reform. Currently, elementary school teachers are prepared in nine national teachers colleges and some universities that have teacher education programs. Every teachers college or university provides a one-year program for those who have bachelor degrees and an interest in teaching at elementary schools. Candidates for these programs must take an entrance examination. Accordingly, the Teacher Education Statute Amendment emphasizes diversifying elementary preservice teacher education tracks, enforcing student teaching practice in elementary schools, constructing teacher certification systems, and providing students with financial aid (Lee, 1994).

The Why and How of Our Study

We wanted to identify and analyze the basic technical competencies that the living technology teachers need in Taiwan as a basis for supporting the living technology teachers' preservice and in-service training programs, certification examination, and self-evaluation for teachers' professional development at Taiwan elementary schools. We sought to answer three questions:

1. What is the current content of new living technology programs at Taiwan elementary schools?
2. Why is it important to establish living technology teachers' technical competencies at Taiwan elementary schools?
3. What existing living technology teachers' technical competencies enable them to cope with the new national curriculum standards?

Then, we offer our interpretation regarding the implications of what we learned. To answer the first question, we analyzed the literature concerning the new national curriculum standards of elementary living technology programs in Taiwan. For the second and the third questions, we conducted a survey to determine the technical competencies of living technology teachers.

We contacted two categories of individuals: (a) 332 in-service teachers of elementary living technology programs and (b) 70 local consultants of elementary living technology programs. Of those contacted, 74.7% of the in-service teachers and 95.7% of the local consultants responded, providing returned questionnaires from 248 in-service teachers and 67 local consultants.

We also assembled a draft of survey items, mainly from publications, interviews, and individual experiences, that addressed living technology teachers' technical competencies at Taiwan elementary schools. This provided a fundamental scheme for further classification. To provide a systematic, logical framework for this instrument, the development of the items fell into three categories: (a) presentations, (b) appreciation, and (c) practical applications. The final instrument included nine demographic items and 27 technical competency items. A 5-point Likert-type scale was used to determine the level of agreement of respondents about the statements.

The survey items were revised by a panel including elementary teachers and consultants, and scholars of National Taiwan Normal University whose comments were incorporated to improve the instrument's content validity. These items were also pilot tested on 50 living technology elementary teachers who also suggested minor modifications. For this study, the result of each item reliability was very high. These coefficient alpha values (over 0.97) were considered to be reliable for this survey instrument.

The data analysis involved an examination of the demographic data and the testing of hypotheses. Descriptive statistics were calculated on all variables for the total sample to obtain demographic data to study the distribution of variables. Frequencies and percentages were used to report demographic data and the scale of results in general while the means were drawn to generally report how teachers and consultants perceived the technical competencies in terms of the 27 items. Furthermore, a Spearman rank correlation and a *t* test were employed to further analyze and test the hypotheses, which determine differences between teachers' and consultants' mean scores regarding the living technology technical competencies at Taiwan elementary schools.

What the Survey Revealed

First, teachers and consultants strongly believed that it is necessary to have seven technical competencies in the aesthetic area, which are: (a) understanding how students learn about visual development, (b) appreciating students' creative works, (c) understanding the basic principles of shape, (d) understanding the basic principles of color, (e) familiarizing the students with concepts of aesthetics, (f) familiarizing students with art history of Oriental and Western cultures, and (g) understanding famous art work and their characteristics. The mean values of consultants (from 3.84 to 4.66) were higher than the mean values of teachers (from 3.51 to 4.32). Thus it appears consultants emphasized a greater need for the seven technical competencies in the aesthetic area than the classroom teachers. Possibly, teachers may not have enough materials when they teach.

Second, teachers and consultants strongly believed that technical competencies must have practical implications in the following competencies: (a) directing students to appreciate the works of their living environment and (b) applying art literacy into daily life. The mean values of consultants (from 4.48 to 4.51) were higher than the mean values of teachers (from 3.99 to 4.10). Again, consultants felt sure that these literacies were more crucial than the teachers.

Third, both teachers and consultants believed that 18 technical competencies are important in making presentations, which are: (a) familiarizing the varied skills of sketch, (b) familiarizing the basic skills of color drawing, (c) familiarizing the basic skills of paste drawing, (d) familiarizing the basic skills of Chinese painting, (e) familiarizing the varied skills of print, (f) familiarizing the basic skills of sculpture, (g) familiarizing the basic principles of design, (h) familiarizing the basic concepts of paper material, (i) familiarizing the two-dimension skills of paper material, (j) familiarizing the three-dimension skills of paper material, (k) making the simple work drawing, (l) familiarizing the basic skills of wooden arts, (m) familiarizing the basic skills of metal arts, (n) familiarizing the basic skills of ceramics arts, (o) familiarizing at least three types of skills of folk arts, (p) directing students to create their works by groups, (q) understanding the basic management of home economics, and (r) understanding the basic skills of horticulture. The mean values of consultants (from 3.43 to 4.28) were higher than the mean values of teachers (from 3.03 to 3.93). Thus the consultants demonstrated a greater necessity for the 18 technical competencies embedded in presentations.

Finally, teachers and consultants alike listed seven other skills as crucial: (a) understanding the skills of waste reproduction, (b) familiarizing students with at least three skills of local traditional folk arts, (c) integrating all of the 27 technical competencies, (d) understanding the art history of Taiwanese culture, (e) understanding that living technology education can play an important role of protecting the environment, (f)familiarizing the students with technological products (such as computer graphics and photography), and (g) understanding the skills of maintaining and managing tools.

In consideration of the preceding data we drew the following conclusions:

1. The technical competencies we have cited can be used by the Taiwan Ministry of Education to design a new national elementary living technology curriculum, a preservice teacher education program, in-service teacher education, a qualification examination for living technology teachers, and self-evaluations for living technology teachers.
2. It is important for Taiwan elementary living technology teachers to teach students according to each student's psychological learning developmental stage.
3. It is crucial for living technology teachers to have the 27 technical competencies they wish to train their students.
4. Likewise, Taiwan living technology teachers must cultivate their own fine arts skills in watercolor, paste drawing, Chinese painting, print, sculpture, and design.
5. Taiwan living technology teachers also need to cultivate their industrial arts skills in paper working, work drawing, wood working, metal working, ceramics, horticulture, home economics, and traditional folk arts.
6. Students should experience using used material to make creative works at Taiwan elementary schools.
7. It is suitable for elementary living technology teachers to introduce technological products (such as computer graphics and photography) to students at Taiwan elementary schools.

Finally, four recommendations are offered as follows:

1. Educational authorities should hold seminars to introduce the 27 technical competencies of living technology programs to Taiwan elementary teachers.
2. This list of technical competencies can be used as a reference for modifying the new Teacher Education Statute in the near future.
3. Qualitative and quantitative studies need to be conducted by scholars of living technology education to develop apt criteria for Taiwan's educational reform.
4. This study could serve as a basis for modifying the 2001 new national elementary curriculum standards regarding the "science and living technology" program in Taiwan.

Dr. (Chia-Sen) Jimmy Huang is a full professor in the Department of Fine Arts and Technology Education at National Taichung Teachers College, Taiwan. He is a member of Alpha Xi Chapter of Epsilon Pi Tau.

Mr. Yen-Shun Wei is a lecturer in the Department of Fine Arts and Technology Education at National Taichung Teachers College, Taiwan.

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Computer Use Profiles of 1,300 Award-Winning Educators

Betty J. Young

As educators and their schools dedicate monies to obtaining computers and wiring schools for Internet connections, a central question remains: To what extent do teachers use computers and the Internet for instruction? In 1993, less than one half (49%) of elementary and secondary teachers reported using computers at work with much of the use being in the areas of word processing and desktop publishing functions (Bureau of Census, 1993). By the fall of 1996, only 20% of all public school teachers (22% of elementary and 18% of secondary) reported using advanced telecommunications for teaching (National Center for Education Statistics [NCES], 1997). In spite of this under-utilization of computers in instruction, only 13% of schools, districts, or certification agencies mandated any form of teacher training and in over one half of the schools, teachers were left on their own to seek computer training opportunities (NCES, 1997).

There is a need to look more closely at the patterns of computer use among educators. By examining changes in the computer skill levels, types of computer uses, and perceived barriers or obstacles to greater computer use, there can be a clearer focus of efforts to expand the computer skill and usage of American educators. This study examined the background characteristics and computer use profiles of 1,300 teachers, administrators, and educational support professionals from 32 states. Those in the sample had received "Outstanding Educator" awards between 1987 and 1996 from a private foundation. The foundation collected facts and opinions from the award winners since the early 1990s. Given a particular interest in fostering the use of technology and computers in schools, this foundation requested a wealth of information regarding the educators' levels of involvement and expertise in this important area.

The following questions guided this investigation:

- What is the incidence of high levels of computer skills among high-achieving educators?
- How are the computer skill levels distributed by gender, job type, years of experience, and community income levels?
- What is the degree of access to computers and the Internet among these educators?
- How are the educators using computers? How has this changed in recent years?
- What obstacles or barriers to computers and Internet use are seen by this population? How has this changed in recent years?

Who We Studied and How Data Were Collected

The group of 1,300 outstanding educators of this study were selected by the private foundation in conjunction with the Departments of Education in 32 states in order to identify educators distinguished by achievement and promise. This population is particularly interesting for several reasons. First, this group of practitioners has been recognized for outstanding contributions and leadership in the field of education. Second, as of the spring of 1997, the outstanding educator group numbered 1,020 (1,300 of whom have remained active) from states throughout the country, so there is a substantial number of educators in this group. Third, these practitioners have been honored by a foundation that holds a high regard for educational technology, principally meaning computer use, as a means for school improvement. The foundation's mission statement illustrates this purpose:

> In education, the Foundation is committed to:
> - strengthening the profession by recognizing and rewarding outstanding educators; by expanding their professional leadership and policy influence; and by encouraging talented young people to become educators.
> - Stimulating creativity and productivity among educators and students of all ages—especially by using technology to improve learning and teaching.

Fourth, the foundation maintains contact with the educators through conferences and other professional development activities that have a strong focus on educational technology. The vice president of the foundation's education division wrote:

> Education technology is only as effective as the educator who uses it, and we recognize that its potential imposes new demands on educators. This is why we have made it a priority to help educators become fluent in and think systematically about technology's use; to acquire and share expertise in technology's applications to education; and to integrate it with good practice.

Therefore, this group of educators has had rich opportunities to develop skills and broad views of computer and Internet use in schools. Finally, the foundation has been collecting, by means of extensive surveys, opinions and information from the growing population since 1990. Thus, there are data collected over time related to computer use.

Data Collection

Award-winning educators were given an extensive survey in the first year of their award and yearly update surveys in the ensuing years. In some years, somewhat different versions of the surveys were given to teachers and to other educators so that the questions could be more tailored to the work experiences of each group. Some 14 different survey instruments were used since the first effort in 1990. The response rates for these surveys ranged from 90% to 100% probably in part because the foundation maintains contact with the outstanding educators through various activities. In all, over 4,000 surveys were completed from the awardees. Because approximately 138 awards were given each year, the number of outstanding educators answering a particular survey varied. Among the 14 survey forms, identical or similar questions in several areas allowed the comparison of key issues over time.

In order to make the comparisons presented here, the survey responses were converted into a central database in the SPSS format using common identification numbers to merge data for each educator from all the surveys completed by that individual. Some variables, particularly the background characteristics, were available for the total sample of "active" awardees. In the case of some other questions, there were different segments of the total population who have provided information. The database allows the maximum number of subjects to be included in each comparison; however, it also means that the number of educators represented in different analyses varies. Nevertheless, there are substantial numbers of participants who have contributed to each area.

Surveys consisted of many fixed response items related to background characteristics, computer access and use, and perceptions of obstacles to greater computer/technology use in schools. On several of the most recent surveys, educators were asked to describe, in their own words, various aspects of their computer attitudes and uses as well as programs and areas of expertise that they viewed as their greatest accomplishments. The responses on relevant open-ended questions were content analyzed using an emerging category system of post priori coding.

Characteristics and Computer Use of Outstanding Educators

Almost 60% of the sample were female, which is particularly interesting given the fact that only about one fourth of the educators were from the traditionally female group of elementary teachers. The average length of experience in education was 25 years, and the bulk of the awardees had 16 to 35 years of experience. Especially in the earlier years of these awards, states selected very experienced educators. More recently, the foundation encouraged state departments of education to identify some earlier career educators in order to increase the "years of influence" that this growing cadre of outstanding teachers and administrators would have after the receipt of the awards. Over one half (55%) of the educators were associated with secondary schooling though there were a number in the group who were superintendents or directors with responsibility for all levels from K to12. As of 1996, the group was fairly evenly divided between classroom teachers (49%) and administrators (30%) or those in other education roles (21%).

Work Settings of Outstanding Educators

The greatest proportion (36%) of these recognized educators worked in the western United States. This fact resulted from the greater number of participating states in that region and the fact that several western states have been selecting outstanding educators in each of the 10 years included in the study. However, there were a substantial number of teachers from each of the major regions of the United States: Midwest, 25%; South, 24%; and Northeast, 15%.

Most of the educators (58%) worked in towns with populations between 2,500 and 49,999 residents. Another 27% of the awardees worked in small cities with between 50 and 500 thousand people. Very few of the educators (about 8%) worked in districts with high proportions of students living in poverty as measured by the percentage of students receiving free lunch. Nearly one fourth of the home districts had less than 25% of the student body participating in the free lunch program. These findings had a special relevance because schools in more affluent areas have been shown to have greater access to computers and other forms of technology (Martinez, 1994).

In two of the most recent studies (1995 and 1996), educators rated their level of computer skill on a scale of 1 to 10. A score of 1 indicated no experience; scores between 5 and 7 showed use of word processing, database, and spreadsheet; 8 and above represented those who also used on-line communications and multimedia tools for professional activities. Based on the 1996 report of 973 of the educators, the average skill level was 6.4, though the mode was 8. For the 524 subjects who reported their skill levels in 1995 as well, there was an interesting change pattern. Forty-seven percent of the educators showed an increase in skill level in this one-year interval, indicating a high degree of professional development in this area. About 30% did not change their rating. However, nearly one fourth of the awardees rated themselves lower on the second survey, possibly because the current explosion in educational computer and Internet opportunities gives one the feeling of losing ground just by staying at the same level of expertise. While some of these changes could be due to simple inconsistencies in self-reporting, 35% of the sample changed their report (up or down) by more than one level, which probably does indicate real changes in perception.

The computer skill levels were also examined by gender, by position, and by grade level (for those currently teaching). For this analysis, the 10 possible computer skill levels were divided into three groups: low (1 to 3), medium (4 to 7), and high (8 to 10). In examining the distribution of computer skill by gender, there was a significant difference between males and females on self-reported computer skill levels ($\chi^2 = 15.36$, $df = 2$, $p = .000$). While similar numbers of men and women were in the group with undeveloped computer skills, there were more males and fewer females in this group than would be expected if there were no systematic differences between them. In the group of high skill folks, there were more women, but more male educators than expected as well as fewer females were present. Generally, the men had higher computer skills than women.

Regarding the skill levels for job groups, there was a significant difference in the way computer skill was distributed within these groups. For example, there are fewer high skill educators than expected among administrators. Teachers, on the other hand, made a stronger showing in the top level and the strength in computer skill is among teachers in upper elementary grades and high school.

Those newest to the profession had experiences with word processing and other computer tools and many had advanced training in computers and Internet use. Generally, skills of the least experienced awardees were significantly stronger than for those with the most years in education. This finding may be related to the foundation's call for younger practitioners and increased use of computer technology as one suggested criterion for selection.

Finally, there appeared to be an advantage related to computer technology for schools with fewer students from families living in poverty. There was a significant difference between affluent and nonaffluent schools (as judged by percentage of students receiving free or reduced lunch) in terms of the computer skill level of educators who worked in these districts.

Access to Computers, Modems, and the Internet

About two thirds of the 1,300 awardees answered questions related to their level of access to computers, modems, and the Internet. Of the group responding, only 69 did not have access to a computer at school and only 105 did not have a computer available at home. Thus, home and school access was fairly comparable. One fourth of all responding awardees did not have Internet connections at school; 34% did not have a connection from home.

Computer Experience and Use

In 1996, 725 awardees reported the number of years of computer experience they had. Of this group, 165 (17%) reported having no experience. The average years of experience was just over eight years, which coincides with the large scale donation of Apple II computers to schools across America in 1983. The most frequent span of years was between 11 and 15, showing that 21% of this population had substantial computer experience. When the reported level of tech expertise is broken down by years of computer experience, it is interesting to note that it is not until computer experience reaches 11 years and beyond that the highly skilled computer users outnumber those reporting medium or low skills. Thus, it seems that many awardees were continuing to use computers in some ways but were not building onto their skills by using some of the more advanced applications that have been recently introduced.

In the 1996 update survey for those who had received awards between 1987 and 1995, educators were asked to indicate how frequently they used computers for four main purposes: instructing students or colleagues in computers, teaching their discipline, completing administrative tasks, and accessing the Internet for professional tasks. By far, the most frequent use related to handling administrative tasks. The second most frequent use related to accessing the Internet for instructional purposes. The two areas of computer-related teaching and accessing the Internet showed the greatest growth between 1995 and 1996.

Another view of the computer use of these educators was obtained by conducting a content analysis of three open-ended questions on the 1996 surveys. Educators indicated seven categories of responses given when the 1987 to 1995 groups were asked to describe five areas of expertise. Of the 542 educators who returned surveys, only 107 of them mentioned computer-related expertise. However, these 107 awardees listed 246 separate types of tech-related expertise. The three main areas cited were instructional functions (e.g., desktop publishing, LEGO/LOGO robotics, basic computer literacy courses), multimedia capabilities (e.g., PowerPoint, Hyperstudio, CD-ROM), and technology policy or planning (e.g., grant writing, wiring and installation, development of district technology plans). When these same 542 awardees were asked to describe five programs they were instrumental in developing, 128 of the respondents listed computer-related or Internet programs, such as on-line courses, tech fairs, computer camps, a virtual school program, and numerous websites and homepages for schools and districts.

The 138 educators who received their awards in 1996 were asked to describe the role of computers and other technology in their classrooms or districts. The most frequent role related to some aspect of instruction (e.g., publishing stories, use of CD-ROM books, Internet data sharing). The next most frequent computer use was communications and multimedia (e.g., video production and digital cameras as well as more conventional technologies such as tape recorders, overhead projectors, and VCRs). Thus, *technology* did not exclusively mean computers and Internet or e-mail use to many teachers. Additionally, many teachers chose to feature the noncomputer technology as evidence of their technological skill with little reference to computers.

Obstacles to Computer Use in Schools

Educators were asked to rank and describe obstacles to computer technology use. The 1993 survey asked 582 educators to indicate how frequently they encountered five possible obstacles: lack of training, lack of funds for equipment, lack of good software, lack of technical support, and insufficient electrical wiring. The greatest obstacle was funding for computer hardware with almost three fourths of the educators reporting this as *somewhat* or *very much* an obstacle. Lack of technical support, lack of training, and lack of good software were clustered very closely in second place. Wiring was the least emphasized constraint.

The 1996 awardees were asked to describe obstacles to computer technology in their own words. These 138 educators named some 336 distinct barriers that were then grouped for analysis. Interestingly, the five obstacles from the first survey were the top-ranking items. Most frequently, educators reported a shortage of funds for equipment. Second was the need for more training opportunities; however, in the race to connect classrooms to the Internet, insufficient wiring was the third most frequent problem cited. In addition to the five main problems were more general complaints of the lack of money, time, and space as well as the issue of reluctant teachers and parents.

What It All Means

This study provides an interesting view of the world of education from educators we would most like to support in their great contributions to American children. It was expected that the outstanding educators would provide a new perspective on the infusion of computer technology into the nation's schools; however, in some ways, they looked much like the other groups of teachers who have been studied in the past. What makes this remarkable is that these educators were recognized leaders who were encouraged to develop skills in using computers as tools as well as to infuse the use of related technologies and the Internet in their instructional programs. Thus, they had an enhanced opportunity to learn. Additionally, the numbers of educators from relatively affluent school districts should be an advantage, yet there were not astounding differences. A substantial number of educators reported the availability of computers at school and at home, but there were still almost 20% of the group who reported having no computer experience.

The results of this study shed light on an area that has not been well studied in the literature—the computer/technology use of administrators. In this study, the administrators lagged behind teachers in the acquisition of computer skills. Even in their discussions of the role of computers and the Internet, their ideas were more general and full of buzzwords. Given the fact that the lack of administrative support was found to be an area of need, it would seem that training administrators would help them to support computer-enhanced instruction as well as increasing their effectiveness as an administrator.

The chief difficulty for all these educators was the funding of a computer infrastructure that includes the hardware, software, wiring/Internet access, and on-going technical support to allow educators to facilitate the incorporation of computer technology into their working schemes. Smart use of computers and the Internet in the service of enhancing student outcomes and school effectiveness can only take place when all the parts of the system are in place. Thus, there is a need for great coordination of efforts in this area.

Nonetheless, there are indications that this group was participating in the groundswell of training efforts underway across the country as indicated by the increase in reported skill levels in a one-year period. Within this group were many teachers and some administrators who were visionaries in the area of school computer use. There are many areas of this data that have not yet been sufficiently explored. For example, subgroup analyses of the extreme computer skills (the 1s and the 10s) could yield important insights. Additionally, a look at only the administrators would add greatly to the current picture of computer use within schools and districts. The greatest limitation of any computer technology study is the rapid change in computer and Internet situations across the country. By the time a large set of data is analyzed, the complexion of the problem and the physical and human capital investments of districts may well have changed dramatically. Nevertheless, the data provided by large-scale studies such as the present effort should assist districts in making more rational, data-driven decisions that will enhance the effectiveness of monies devoted to hardware, software, and training.

Dr. Betty J. Young is a professor in the School of Education at the University of Rhode Island.

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