THE ADOPTION AND USE OF ELECTRONIC INFORMATION RESOURCES BY A NON-TRADITIONAL USER GROUP: AUTOMOTIVE SERVICE TECHNICIANS


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The growing complexity of machines has led to a concomitant increase in the amount and complexity of the information needed by those charged with servicing them. This, in turn, has led to a need for more robust methods for storing and distributing information and for a workforce more sophisticated in its use of information resources. As a result, the service trades have “professionalized,” adopting more rigorous academic standards and developing ongoing certification programs.

The current paper deals with the acceptance of advanced electronic information technology by skilled service personnel, specifically, automotive service technicians.

The theoretical basis of the study is Davis’ technology acceptance model. The purpose of the study is to determine the effects of three external factors on the operation of the model: age, work experience, and education/certification level.

The research design is in two parts, beginning with an onsite observation and interviews to establish the environment. During the second part of the research process a survey was administered to a sample of automotive service technicians.

Results indicated significant inverse relationships between age and acceptance and between experience and acceptance. A significant positive relationship was shown between education, particularly certification, and acceptance.
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Arne J. Almquist
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## CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>Problem Statement</td>
<td></td>
</tr>
<tr>
<td>Research Question and Hypotheses</td>
<td></td>
</tr>
<tr>
<td>Methodology</td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td></td>
</tr>
<tr>
<td>Definition of Terms</td>
<td></td>
</tr>
<tr>
<td>2. REVIEW OF THE LITERATURE</td>
<td>8</td>
</tr>
<tr>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>User Acceptance of Technological Innovation</td>
<td></td>
</tr>
<tr>
<td>Diffusion of Innovations</td>
<td></td>
</tr>
<tr>
<td>The Technology Acceptance Model</td>
<td></td>
</tr>
<tr>
<td>The Hypotheses and External Variables</td>
<td></td>
</tr>
<tr>
<td>The Research Population: Automotive Service Technicians</td>
<td></td>
</tr>
<tr>
<td>The Development of the Automobile</td>
<td></td>
</tr>
<tr>
<td>Major Changes in the Industry</td>
<td></td>
</tr>
<tr>
<td>Environmental Concerns</td>
<td></td>
</tr>
<tr>
<td>Safety Concerns</td>
<td></td>
</tr>
<tr>
<td>Adoption of Electronic/Microcomputer Technology and Pollution Control</td>
<td></td>
</tr>
<tr>
<td>The Rise of the Automobile Service Technician</td>
<td></td>
</tr>
<tr>
<td>Electronic Technology in the Service Center</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>Summary</td>
<td></td>
</tr>
<tr>
<td>3. METHODOLOGY</td>
<td>33</td>
</tr>
<tr>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td>Research Design</td>
<td></td>
</tr>
<tr>
<td>Data Collection</td>
<td></td>
</tr>
<tr>
<td>Human Subjects Approval</td>
<td></td>
</tr>
<tr>
<td>Part 1: Context Interviews</td>
<td></td>
</tr>
<tr>
<td>Part 2: Survey Questionnaire</td>
<td></td>
</tr>
<tr>
<td>Instrument design</td>
<td></td>
</tr>
<tr>
<td>Pilot test</td>
<td></td>
</tr>
<tr>
<td>Survey administration</td>
<td></td>
</tr>
<tr>
<td>Part 3: Survey Follow-Up Interviews</td>
<td></td>
</tr>
</tbody>
</table>
4. DATA ANALYSIS AND RESULTS ................................................................. 53

Introduction
The Sample
Demographics
Gender and Ethnicity
Age and Experience
Education
Certification
Use of Computer-Based Resources
Use of Print and Other Information Resources
First Exposure to Computers and Home Computer Ownership
Group Acceptance of Computers
Acceptance and Usage

The Hypotheses
H1: Age Related to Acceptance and Usage
H1 Summary
H2: Work Experience Related to Acceptance and Usage
H2 Summary
H3: Education Related to Acceptance and Usage
H3 Summary

Respondent Self Perceptions of Skill, Training, and Employer Support
Summary
5. DISCUSSION AND CONCLUSIONS ...............................................................  85
   Introduction
   Results and Implications
   Suggestions for Managers
   Limitations of the Current Study
   Methodology
   Survey Instrument
   Recommendations for Further Study
   Conclusion

APPENDICES ..................................................................................................  98

REFERENCES ................................................................................................. 129
## LIST OF TABLES

Table 1: Desired Sample Proportions by Type of Service Center .......................... 42
Table 2: Desired Sample Proportions by Age ..................................................... 44
Table 3: Factor Analysis of Items 5-16 ............................................................. 48
Table 4: Comparison of Usage Means Grouped by Age Range ............................ 67
Table 5: Acceptance Means by Age Group ....................................................... 69
Table 6: Group Means for Survey Items 13-16 by Selected Age Groups .............. 70
Table 7: Correlations Between Age and Responses to Survey Items 13-16 .......... 71
Table 8: Mean Acceptance Scores for Selected Experience Ranges ..................... 75
Table 9: Education Level Ranks ....................................................................... 78
Table 10: Education Level Compared to Mean Acceptance Score ...................... 79
Table 11: Comparison of Mean Acceptance Scores by Date of First Certification .. 83
LIST OF FIGURES

Figure 1. The Technology Acceptance Model .................................................. 12

Figure 2. An extended version of the Technology Acceptance Model showing placement of external variables and measures of acceptance and use .......................... 15

Figure 3. A comparison by age group of the present sample with data supplied by the Automotive Service Association (ASA) .............................................................. 55

Figure 4. Respondents indicating that they were certified by type of certification held ............................................................... 58

Figure 5. Number of respondents indicating daily use of selected computer-based resources ........................................................................................................ 59

Figure 6. Number of respondents indicating that a resource was unused or unavailable ........................................................................................................ 60
CHAPTER I
INTRODUCTION

Introduction

It is a commonly held belief that this is an information age, that is, an age in which information has become more valuable to business than capital goods or physical plant. It is an age in which industrial concerns jettison manufacturing operations while growing the intellectual side of the business, e.g., design, marketing, financial services.

As ideas have become more valuable than iron, steel, and concrete, there has been a concomitant rise in the value of information and increasing numbers of occupations are becoming information-based. This, in turn, is creating a demand for more highly educated and educable workers. The more highly educated a person is the more likely he or she is to be employed in an information-based occupation. The United States Census Bureau (2004) presents statistics showing that of 19,079,000 managers in business and finance, 15,154,000 or 79.4% had attained at least some college education. Of 2,723,000 in the professions, 2,447,100 (89.9%) had received some college education. In contrast, of 9,074,000 production workers, only 2,855,000 (31.5%) had attained some college education and of 7,763,000 construction workers, the number having had some college education was 2,188,000 (28.2%).

The demand for educated workers is reflected in the premium paid for advanced levels of education. In 1993, the median income for a male high school graduate was $21,782. A male college graduate holding a bachelor’s degree earned $37,474 per year (National Center for Educational Statistics, 1995). By the year 2001, the mean income
levels had increased to $28,343 for high school graduates and 49,985 for those possessing a bachelor’s degree (National Center for Educational Statistics, 2003). What had been a 72.0% gap between the earnings of college graduates and non-college graduates in 1993 had become a 76.4% gap by 2001.

The information-based economy is driving, and being driven by, increasingly complex technology. Toasters contain microprocessors to properly brown toast. A major electronics company advertises a pair of binoculars built with microprocessor-controlled prisms, guaranteed to provide a stable image regardless of the movements of the user. The average automobile of the early 21st century contains more onboard computing power than a spacecraft that went to the moon in the 1960s (Molla, 1997).

Those who have to keep these complex devices in working order are finding that they need access to, as well as the ability to understand and process, vast amounts of information to adequately perform their jobs. Using the automobile as an example, General Motors’ combined automotive service manuals contained 5,000 pages of text in 1965. As of 1998, the total page count increased to 120,000, and was expected to climb to 200,000 pages within two years (Krebs, 1998). To handle this flood of information, automobile manufacturers, service organizations, and information vendors have created and deployed a vast amount of advanced information technology.

The present study examines the acceptance of information technology by the people who maintain the mechanisms upon which society depends. The specific population studied is technicians in the automotive service field.
Note that generally, the male pronoun will be used to describe the sample. United States Government sources report that only 1.3% of automobile service technicians in the country are currently female (United States Census Bureau, 2005). While this number is growing, no female technicians were employed at the sites that were contacted during the study, hence there were no females within the current sample. Were this study to be repeated within the next 5 to 10 years, the researcher expects that female respondents would be found in the sample.

Problem Statement

The market for information technology and information resources in support of the automotive service industry is large and growing. As mentioned above, the amount of information required to properly service modern automobiles is immense and increasing each year. The personal computer, in the form of a diagnostic workstation, has become a standard part of the service technician’s toolkit. To handle the volume of information, print sources have given way to CD-ROM and DVD-ROM databases and web-based resources. Automotive service technicians can participate in Internet-based discussion groups with some, such as the International Automotive Technicians’ Network (iATN), being limited to highly qualified and experienced technicians (International Automotive Service Technicians’ Network, 2005). Manufacturers have created manufacturer/dealership intranets with the ability to make direct links between on-board automobile computers, the local service technician, and an automotive engineer located at the factory. Hybrid products combining networks, databases, and
graphics applications have been created to provide seamless interaction between repair outlets, parts catalogs, and insurance claims operations.

These new technologies represent a large investment. For smaller service outlets, particularly independents, investments in advanced information technologies may represent a sizeable barrier to entry into the field or to remaining competitive. At the least, they represent substantial ongoing costs.

Research Question and Hypotheses

This study addressed the following research question: How do the factors of age, work experience, and education/certification level affect automotive service technicians’ acceptance or lack of acceptance of information technology?

Three hypotheses were developed in relation to these factors:

H1 As technician age increases, perceived usefulness of information technology decreases, leading to a lower level of acceptance of information technology.

H2 As technician level of work experience increases, perceived usefulness of information technology decreases, leading to a lower level of acceptance of information technology.

H3 As technician level of education increases, both perceived usefulness and perceived ease of use of information technology increase, leading to a higher level of acceptance of information technology.

In Hypothesis 1, the inverse relationship between age and perceived usefulness does not necessarily assume a simple age-related aversion to new technology among
older workers. Rather, the researcher posits that older technicians who received their initial training/education and worked a substantial portion of their careers prior to the widespread use of information technology are likely to perceive a lower level of usefulness of the technology and therefore to exhibit a lower level of acceptance.

Inversely, younger technicians who have grown up with and felt comfortable with computers from an early age are likely to perceive that the technology possesses a higher level of usefulness. In fact, they may grow to rely on the computer at all times rather than just when needed (Appendix D).

The theoretical basis of the study is an extension of Davis’ Technology Acceptance Model (1989). It was expected that age, experience, and education or certification level would have a discernible effect on the level of acceptance and usage of information technologies as measured by such observable behaviors as usage frequency and usage volume.

For purposes of this study, usage frequency is defined as the number of times that electronic information resources are used during a specified period. Usage volume is defined as the proportion of repair jobs in which electronic information resources are consulted and the length of time per use.

Methodology

The study began with two in-depth interviews and surveys of the literature to establish the environment and provide a background of understanding. The first interview took place in an automotive service facility. A master technician was
interviewed and observed to obtain a better understanding of the systems and how they are actually used in the day-to-day workplace.

The head of a community college automotive service technology program was next interviewed. The second interview provided background on an automotive service program curriculum, with an emphasis on training in the use of computer-based information resources.

A sample of service establishments was then selected. Sites were selected based on type of service center, that is, new car dealership, non-manufacturer chain, or independent shop. A survey instrument was administered to individual service technicians at these establishments.

Summary

With the increasing complexity of technology, those charged with maintaining it must contend with an expanding array of service information. This is well illustrated by the automotive industry whose manufacturers and information providers have created powerful advanced systems and resources to support the work of service technicians. Do technicians actually make full use of these resources or do they bypass the resources in favor of manual techniques?

Through this study the researcher attempted to determine the level of acceptance of computer-based information technology and factors that may negatively affect that acceptance.

Definitions of Terms

The following are definitions of terms used in the context of this study:
Automotive Service Technician: A person who repairs and maintains automobiles or their subsystems.

Automotive Service Establishment: An establishment with service technicians and the equipment necessary to maintain or repair automobiles or their subsystems.

Dealership: A sales and service location for automobiles (generally used to refer to new automobile dealerships).

Manufacturer: A commercial enterprise that designs and builds automobiles.

Perceived Ease of Use: The degree to which a prospective user believes that a system requires no effort to operate (Davis, F.D., Bagozzi, R.P. & Warshaw, P.R., 1989; Dillon & Morris, 1996).

Perceived Usefulness: The degree to which a prospective user believes that use of the system improves his/her performance (Davis, F.D., Bagozzi, R.P. & Warshaw, P.R., 1989; Dillon & Morris, 1996).

User Acceptance of Technology: The demonstrable willingness of a user to employ information technology for the tasks that it is designed to support (Dillon & Morris, 1996).
CHAPTER 2
REVIEW OF THE LITERATURE

Introduction

The literature review provides a brief exposition and overview of the development of the Technology Acceptance Model (TAM) and its theoretical antecedents. TAM is used as the theoretical basis of this study. The automotive service field and its applicability to the purposes of the study are also examined.

User Acceptance of Technological Innovation

In his book Diffusion of Innovations (released in its 4th edition in 1995) Rogers defines innovation as “an idea, practice or object that is perceived as new by an individual or other unit of adoption.” This concept of innovation does not do justice to its importance to the advancement of society. In fact, innovation, particularly technological innovation, has been crucial to the growth, maturation, and development of society and its underlying support structures. Innovation has allowed our society to increase agricultural production, providing food for a growing population. It has made it possible to move ever-increasing numbers of people quickly, conveniently, and safely. It has provided methods for efficiently handling large volumes of information. In short, technological innovation is both a result of and a vehicle for the continued advancement and development of civilization.

The creation and diffusion of new technologies and methods is for naught if the intended audience does not make use of it. If farmers do not use new, disease-resistant strains of seed, if teachers do not use advanced instructional techniques and
technologies, if medical professionals and service technicians do not use new information technologies, the massive investments made by industry, institutions, and governments are ill-spent and society is poorly served. While it may seem obvious that promising new technologies and techniques are accepted and used, researchers have long pondered over the question of why people are frequently unwilling to use systems that could significantly increase productivity (Davis, Bagozzi & Warshaw, 1989). In terms of the acceptance and use of information technologies, the revolution from mechanical to computer-based control of machine functions and the concomitant rise in the amount of supporting information that must be gathered, processed, and retrieved, have given this question added importance.

A number of approaches have been used to look at the reasons technological innovations are either accepted or rejected and to see how they propagate through a given population.

**Diffusion of Innovations**

Concepts developed in the study of diffusion of innovations are applicable to the problem at hand. Perhaps the best-known proponent of the theory of diffusion of innovations is Rogers. Rogers conceived of the diffusion of innovations as a communication process very similar to the model developed by Shannon and Weaver. The process, as he envisioned it, contained four main elements:

1. The innovation itself: an idea, practice, or object.

2. A communication channel: a link between one who has knowledge of the innovation and one who does not.
3. Time: the length of time taken by an individual to adopt an innovation, the rate of adoption among a given population, and the placement of an individual adopter within the process from early to late.

4. A social system: Rogers defines this as “a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal (1995, 23).” Members of the social system may include individuals and formal/informal groups.

As with Shannon and Weaver’s communication model, the diffusion process is concerned with the reduction of uncertainty. As individuals learn about potential innovations, they become uncertain. Most adopters reduce uncertainty by consulting with peers and colleagues. Those who seek out more authoritative sources tend to be earlier adopters, while those who rely on the opinions of friends, neighbors, family, or other peers, tend to adopt later in the process (Chang, 1998). Chatman (1991) found similar results in her research into information seeking behavior among people at the bottom of the socioeconomic ladder. Those with less formal education and fewer economic resources tended to rely on informal information sources, including acquaintances. Perhaps parallels can be drawn between less sophisticated adopters of innovations (later adopters) and less sophisticated seekers of information.

Rogers (1995) points out the difference between incremental and radical change and suggests that computer-based technologies fall into the latter group. Radicalism in this context refers to the amount of knowledge necessary for an individual to adopt an innovation. Radicalism increases as the amount of knowledge required for adoption
increases. Radical innovation carries with it the risk of a higher level of resistance and non-adoption.

Clearly, diffusion of innovations theory, while general in nature, offers interesting insights that can be applied in the area of diffusion of information technology over given populations of users. However, Dillon and Morris (1996) point out that it doesn’t explicitly deal with individual acceptance of technology.

*The Technology Acceptance Model*

The conceptual model underlying this study is the Technology Acceptance Model (TAM). Proposed by Davis in his 1985 PhD dissertation, the model was intended to “improve our understanding of user acceptance processes, providing new theoretical insights into the successful design and implementation of information systems,” and secondly, to “provide the theoretical basis for a practical ‘user acceptance testing’ methodology that would enable system designers and implementers to evaluate proposed new systems prior to their implementation.” As Dillon and Morris (1996) state, the goals were to predict information system acceptance and to diagnose problems before a system was implemented.

In creating TAM, Davis built on the Theory of Reasoned Action (TRA), proposed by Fishbein and Ajzen, originally specified by Fishbein in 1967 (Davis, 1986). The goal of TRA was to predict and understand an individual’s behavior. Key to this is the assumption that an individual controls his/her own actions and that the individual’s intention to perform a given behavior is predictive of actual performance (Ajzen & Fishbein, 1980).
TRA can be expressed with the formula:

$$BI = A + SN$$

where $BI$ is the respondent’s intention to perform a behavior, $A$ is the respondent’s attitude, and $SN$ is the subjective norm concerning the behavior in question (Davis, F.D., Bagozzi, R.P. & Warshaw, P.R., 1989). TAM retains the assumption that the intent to perform a behavior is dependent upon attitude, but drops the subjective norm because it was not perceived to be an important predictor of intention in the context of information technology (Dillon & Morris, 1996).

The revised model can be expressed as follows:

$$BI = A + U$$

substituting $U$, perceived usefulness, for the subjective norm ($SN$). TAM can be represented pictorially as follows:

![Diagram of TAM model]

*Figure 1. The technology acceptance model.*
TRA is a general theory applicable across a wide variety of fields. Researchers using the theory must first identify beliefs appropriate to the situation under investigation (Davis, F.D., Bagozzi, R.P. & Warshaw, P.R., 1989). Ajzen and Fishbein (1980) suggest using an interview process to determine five to nine beliefs, for example, beliefs about the capabilities of a technology, using the most frequent responses provided by representatives of the group under study.

On the other hand, TAM, having been designed specifically for information systems research, uses two beliefs established in the model: perceived usefulness and perceived ease of use. Perceived usefulness is defined as the degree to which a prospective user believes that use of the system will improve his/her performance. Perceived ease of use is defined as the degree to which a prospective user believes that a system will be free of effort (Davis, F.D., Bagozzi, R.P. & Warshaw, P.R., 1989; Dillon & Morris, 1996).

Key to TAM’s capability as a diagnostic tool is that it takes into account the effect of external variables on internal beliefs, attitudes, and intentions (Davis, F.D., Bagozzi, R.P. & Warshaw, P.R., 1989). External variables are theorized to have an effect on perceived ease of use (E), and in conjunction with E, to have an effect on perceived usefulness (U). A major question concerns specific external variables. Davis et al. suggest that training and education in the use of a system may have an effect on E. They also state that features such as menus, icons, mice, and touch screens have a documented effect. Hubona and Whisenand (1995) in their study validating TAM, questioned the implications of common user interfaces such as Microsoft’s Windows
toward the role of E in the model, and found that there was, in essence, no effect because E maintained its predictive value.

One of the perceived weaknesses of TAM is its reliance on attitude toward use or intention to use and/or self-reported usage rather than more direct measures of actual use. Some researchers, such as Taylor and Todd (1995), attempt to deal with this problem by collecting information both on users’ intentions and actual usage data over a period of weeks. There is some question as to the validity of relying on intention to perform a given behavior as an indicator of actual performance of the behavior. Through efforts such as Taylor’s and Todd’s, TAM has been extended to look at actual behavior to determine whether it correlates with attitude toward use or intention to use.

The current study was based on an extended version of TAM. The extended model has been used in previous studies to show the place of inputs (external variables) and the expected output (usage). Three external variables were examined: age, work experience, and education/certification level. Behavior was measured both in terms of attitude or acceptance and self-reported usage frequency. The version of TAM used in the context of this study is illustrated below.
Previous studies have been conducted to investigate the influence of external factors on acceptance of technology. For example, Hubona and Kennick (1996) examined the effects of age, job status, and education on perceived ease of use and perceived usefulness using this extended version of TAM. Hubona and Geitz (1997) carried this further by examining job category, system experience, and computer experience as external factors. While the effect of age is re-examined in the present study, experience and education are looked at in a different way. Whereas previous research examined the effect of training and experience related to the use of a particular technology and its effect on attitude and usage, the present study looks at professional education and experience and its indirect effect on the acceptance of information technologies.
The Hypotheses and External Variables

The objective of this research project was to determine the effect of three external variables on the respondents’ usage of advanced information technologies in the performance of their employment duties. Three hypotheses were posited, each related to a specific external variable:

**Hypothesis 1:** As technician age increases, perceived usefulness of information technology decreases, leading to a lower level of acceptance of information technology.

The external variable in this case is age. Previous research has concentrated on age as a factor in the decision making, learning, and usage of information technology resources. These researchers examined only the physiological aspects of age. For example, Taylor (1975) was interested in the information-processing and decision-making abilities of older managers. It was found that older managers were no less mentally facile than younger workers. Their more accurate judgments more than offset a longer decision time.

The hypothesis is not referring to age in terms of a physiological effect. That is, it is not expected that respondent A at age 30 will be less accepting of information technologies than he/she was at age 25. Instead, it is expected that respondent B at age 60 will be less accepting of information technology than respondent A at age 30 because respondent B obtained much of his/her training and experience before such technologies were widely used. Conversely, respondent A was probably exposed to the technologies from the time of initial training and considers their use to be a normal part of working life rather than an innovation.
I expected both U and E to be affected by age as used in this context. As mentioned in detail later in this chapter, the critical developments that led to the rise in importance of information technologies in the industry under study all came to fruition in the early 1970s. There was a transitional period between the mid 1970s and approximately 1990 when the complexity of the job increased and information tools were becoming more important. Respondents in their 50s and 60s most likely began their careers at a time before the new information tools were available and before they were needed. Younger respondents were presumably educated, trained or certified in an era when the new tools had become important and were probably exposed to them in their classes. Given the greater level of exposure to information technology on the part of younger workers, have the older workers accepted the new technologies to the same extent that younger workers have? What are the implications to continuing certification programs if this has not occurred?

**Hypothesis 2**: As technician level of work experience increases, perceived usefulness of information technology decreases, leading to a lower of acceptance of information technology.

In this case, perceived usefulness is independent of age. Someone who began a profession in midlife may have substantially less professional experience than one who began directly after secondary school or community college graduation. Taylor’s (1975) research pointed out that experience did have an effect in relation to age in decision-making abilities. For example, older managers were able to more accurately diagnose the value of information. This was attributed to a greater experience level and was
independent of the physiological aspects of increased age. The question in the context of this study is, as a worker becomes more experienced on the job, will he or she be more likely to rely on past experience and less likely to rely on information technology, regardless of past exposure to technology and experience with its use?

**Hypothesis 3**: As technician level of education increases, both perceived usefulness and perceived ease of use of information technology increase, leading to a higher level of acceptance of information technology.

The assumption is that heavily educated/trained individuals have had more exposure to the new technologies than those with less training. This should affect perceived ease of use, allowing users to concentrate on issues related to usefulness (Thompson, Higgins & Howell, 1991). Instructors’ attitudes toward the technology would hopefully also lead to raised levels of perceived usefulness on the part of the user. Training reduces the level of uncertainty surrounding an innovation, hopefully lowering resistance to the new innovation (Rogers, 1995).

**The Research Population: Automotive Service Technicians**

Technology has advanced rapidly over the past few decades. As the products of that technology increase in capability and decrease in size, the task of maintaining and repairing them has become more complicated. In what has been called the Information Age, the information worker is considered to be in the ascension. However, defining just who is and who is not an information worker is becoming more difficult. Certainly, the traditional knowledge-based professions are still in existence and continuing to grow in importance. Information technology professionals, financial experts, and
communications specialists have grown in demand and earning power. A number of fields that historically have not been identified as knowledge-based have seen education and training requirements tightened and salaries and demand increase. On the other hand, semiskilled factory laborers, traditionally among the most highly paid workers throughout the 20th century, particularly since World War II, have seen their earnings and numbers drop.

Hence, a number of trades are moving into the class of knowledge worker. This has resulted from the increasing complexity of technology, changes in the regulatory environment, and the resulting need for more highly trained and educated individuals. The research population selected for this study is one such group: the automotive service profession.

The automotive service profession is well suited to a study of the acceptance of information technology by workers for a number of reasons:

1. The field has a well-established history of formal education and certification. The National Institute for Automotive Service Excellence (NIASE), established in 1972, developed the first nationally recognized automobile service certification program (Yemaneab, 1998). As of June 2005, NIASE had certified approximately 420,000 individual automotive service and parts professionals (National Institute for Automotive Service Excellence, 2005). Vocational training programs have been offered by public schools for decades, numerous proprietary schools are in existence, and a thriving business in correspondence courses and self-study materials has existed since the early part of the 20th century.
2. The vast scope of the automotive industry (multiple brands, models, versions) and the increasing complexity of vehicle systems, brought about by pollution and fuel efficiency concerns and widespread use of electronics, have made the use and availability of formal information resources critical to the success of the field.

3. Computer technology has been widely applied to problems ranging from diagnostics to inventory to training.

4. Invisible colleges of technicians exist and have been strengthened through innovations in information technology such as the Internet. An example is the International Automotive Technicians’ Network (iATN) (International Automotive Technicians’ Network, 2005). The iATN has a membership of 49,145 professional automotive service technicians from 135 countries.

5. The field is large enough and generates revenues sufficient to justify the development of complex technological solutions to problems.

As the United States Bureau of Labor Statistics points out in its *Occupational Outlook Handbook* (2005), the automotive technician’s job has evolved into an occupation requiring not only the ability to understand the complex mechanisms that automobiles have become, but also the ability to navigate the information resources that are required to obtain the information necessary to repair them.

It may be helpful at this point to discuss the development of the automobile and the role of that development in the transformation of the mechanic of old into the information-literate professional of today.
The Development of the Automobile

The automobile can be thought of as what Rogers (1995) refers to as a technology cluster. A technology cluster consists of one or more distinguishable elements of technology that are perceived as being closely interrelated. The cluster of innovations that became the automobile included the wheel, the wagon (which provided overall form, brakes, suspension), and portable sources of motive power, such as the steam engine, the electric motor, and the internal combustion engine.

French, Austrian, and American inventors produced automobiles powered by internal combustion engines in the 1860s and 1870s, and automobile manufacturing in Europe began in earnest by the early 1890s (Encyclopedia Americana, 2005).

By 1902, the French version of the automobile became the dominant form of its basic structure (i.e., motor forward, enclosed passenger compartment behind) (Mashaw & Harfst, 1990). Although there was much room for variation from manufacturer to manufacturer, the major systems that made up the automobile (drive train, brakes, steering, suspension) remained similar from its inception through the late 1950s, albeit with continuing refinement.

Major Changes in the Industry

Three trends that arose in the 1960s and 1970s combined to quickly make automobiles more complex:

1. Increased government regulation addressing both safety and environmental issues.
2. Increased concerns about fuel efficiency brought about by the oil price shocks of 1973-1974.
3. Adoption and extensive use of electronic/microprocessor technology in many aspects of automobile design and service.

**Environmental Concerns**

Environmental issues, such as the automobile’s contribution to air pollution, have been a part of the public consciousness for many years. As American realist author Booth Tarkington began his 1914 novel *The Turmoil*:

There is a midland city in the heart of fair, open country, a dirty and wonderful city nesting dingily in the fog of its own smoke. The stranger must feel the dirt before he feels the wonder, for the dirt will be upon him instantly. It will be upon him and within him, since he must breathe it . . . At a breeze he must smother in whirlpools of dust, and if he should decline at any time to inhale the smoke he has the meager alternative of suicide.

During the early years of industrial growth, such pollution was tolerated and even looked upon positively as a symbol of economic well-being. During the 1940s and 1950s, the smog of Los Angeles was the subject of jokes by entertainers such as Jack Benny. By the 1960s, however, with an overall improvement in the standard of living and educational attainment of the population, perspectives had changed to the point where the government was pressed to deal with the problem.
**Safety Concerns**

Safety in the design and operation of automobiles has been of concern since early in the 20th century. The technology of safety-related systems, such as brakes and steering, was gradually refined during the first half of the 20th century.

The publication of safety advocate Ralph Nader’s *Unsafe at Any Speed* (1965) caused the American public to question the commitment of automobile manufacturers to public safety. In truth, the motor vehicle death rate had declined at a rate of approximately 3.5% per year from 1947 to 1960 because of the improvements mentioned above. These improvements were the result of competition between the automobile manufacturers. From 1960 to 1965, however, death rates rose on average 1% per year. Because many safety features were offered as options, cost-conscious buyers often refused to order them. To address this problem, Congress passed the National Motor Vehicle and Safety Act in 1966. The act mandated that a number of safety innovations become mandatory by the 1968 model year (Peltzman, 1975).

*Adoption of Electronic/Microcomputer Technology and Pollution Control*

The first adoption of electronic technology in automobiles was the car radio in 1932 (Consumer Electronics Manufacturers’ Association, 1998). Audio systems remained the major use of electronics in automobiles until the 1970s. At that time, the federal government greatly tightened pollution standards. Pollution devices such as the Positive Crankcase Ventilation (PCV) valve had been in use since the early 1960s. To these were added such devices as the Exhaust Gas Recirculation (EGR) system, introduced in 1973, and the catalytic converter, made mandatory in the 1975 model year. Although these
early pollution control efforts reduced emissions, they also reduced engine performance (Brown, Daines & Rickert, 1976) and increased the complexity of engines.

During the early 1970s, the Organization of Petroleum Exporting Countries (OPEC) began to increase crude oil prices, partly in reaction to the 1973 Yom Kippur War, and partly in response to a shift in supply and demand. This led to the oil price shocks of 1973-1974 (Rybczynski, 1976). At this point, the issue of cleanliness of vehicle operation was placed in opposition to fuel efficiency and performance.

Traditionally, automobile engines were tuned, or adjusted, to operate perfectly under a single set of conditions in order to improve emissions, efficiency, and performance. A minor tune-up involved the adjustment or replacement of certain engine parts, such as the ignition points, rotor, spark plugs, and condenser, as well as adjustments to engine idle speed and valve timing (Shabbot, 1977). The adjustments were made under certain specific conditions (a given engine speed, humidity, temperature), making average performance a compromise between the optimal and the real world. In other words, optimal performance was possible only under exactly the same conditions as existed at the moment when the engine was tuned. As with any mechanical device, as the engine was operated, certain components, such as the ignition points, rotor, condenser, and spark plugs, would wear out of specification. The result was a gradual deterioration of performance over time. This was a concern because tune-ups were generally performed only once per year.

Advanced electronics were first applied to solve this problem in the form of the transistor ignition system (Toboldt & Johnson, 1977). Transistor ignition systems did a
much better job of switching power to the spark plugs on and off with the added advantage of eliminating moving parts, such as the ignition points and rotor, lengthening the time during which tune-up adjustments remained effective.

Currently, an onboard computer, the equivalent of a powerful desktop PC, controls engine operations. Among many other things, the onboard computer performs a continual tune-up, constantly adjusting to changes in environmental conditions, component wear, and engine speed. Engine controls have developed to the point where they can actually alter a vehicle’s valve timing while the vehicle is in operation (Taninecz, 1996). This allows the modern automobile to operate cleanly and efficiently under a variety of conditions while maximizing available power.

The automotive electronics of today have grown into extremely complex applications of microprocessor technology, expanding to control systems throughout the automobile. Applications include:

- Engine sensors
- Automatically adjusting suspension systems
- Security systems
- Impact/Collision avoidance systems (radar-based)
- Sophisticated entertainment and communications systems
- On-board diagnostics (including the ability to link with a service center’s computers to speed diagnostics)
- Vision-enhancement systems
The majority of automotive electronics systems are engine control devices. Next in number and importance are the systems that control safety features, such as anti-lock brake systems and airbags. These are followed by luxuries such as automotive sound systems, security systems, and remote keyless entry. Cadillac offers an advanced night-vision enhancement system on its DeVille automobile. The greatest areas of continuing development include global positioning systems, vision-enhancement systems, and collision-avoidance systems (Taninecz, 1996).

The Rise of the Automobile Service Technician

Automobiles are mechanical devices and, as such, are prone to wear and breakdown. As with most other mechanical devices, specialized service personnel evolved to maintain and repair them. When mechanical systems were simple, a basic understanding of mechanical principles and the ability to fabricate or repair simple parts were all that were required to set up shop as an automobile mechanic. The backgrounds of early automobile mechanics frequently included experience in areas such as bicycle repair, gunsmithing, and farm machinery repair: carriage shops became auto body shops and smithies became welding shops. Livery stables were very suitable as garages, although the transition from horse to machine was difficult enough that the facility’s ownership frequently changed when the horses were moved out and automobiles were moved in (Jakle & Sculle, 1994).

At an early point in the adoption of the automobile in the United States, information resources dealing with their repair and maintenance began to appear. Motor Magazine, now a part of Motor Information Systems, a division of Hearst
Publications, was founded by Hearst in 1903, the same year as the founding of the Ford Motor, Buick Motor Car, and Cadillac Motor Companies (Motor Information Systems, 2005). Originally published as a consumer magazine, it had metamorphosed into a trade publication by 1924. By the 1920s, Motor had begun to issue a large number of other information resources for the automotive service industry. Self-study guides, correspondence courses, and treatises for owners, chauffeurs, and mechanics appeared by the second decade of the twentieth century.

As the twentieth century progressed, formal education and certification programs appeared. Vocational training appeared in high schools at the end of the 19th century (Hyde, 1997). Formerly, high schools had functioned mainly as college-preparatory institutions. Vocational training became the agreed-upon place for those who could not succeed in an academic environment. Unfortunately, this attitude has persisted until fairly recent times (Weber, 1997).

Proprietary trade schools arose to provide courses in automotive repair and maintenance. Over time, many provided certification and/or an associates degree upon completion of courses of study. Today, most community college districts offer automotive repair programs, usually certified and supported by major manufacturers. The Dallas County Community College District (DCCCD), for example, has three different degree programs leading to an associates degree in applied sciences in various automotive service specialties (Dallas County Community College District, 2005).

Trade and professional organizations were created. These groups offered certification both for individuals and for educational programs. The oldest certification
program for individual service technicians is the program sponsored by Automotive Service Excellence (ASE). ASE provides certification in 40 specialized areas, as well as a master mechanic certification. To be certified, a technician must pass a test and provide proof of two years of relevant work experience. The newly certified technician must be retested every five years. The tests are stringent—approximately one third of test takers fail the first time they take the tests (National Institute for Automotive Service Excellence, 2005).

Hyde (1997) performed a study in which automotive service managers were asked to rank the NATEF list of basic competencies for beginning technicians based on relative importance. She reported that while all competencies were considered to be important, those related to electronic and electrical system diagnostics and repair were considered to be most important. The study suggests that this is most likely a result of the radical increase in the number of computer-controlled systems in automobiles. In 1990, only 18% of automotive functions were controlled by computers. By 1994, that figure had increased to 83%. Karbon (1995) refers to this as a digital transmogrification of the automobile.

Electronic Technology In the Service Center

The changes in technology within the automobile have been matched by changes that have occurred on the shop floor.

The automotive service technician of today has a wealth of information technology resources available to solve service problems. The massive print service manuals of a bygone age have been replaced with sophisticated databases on CD-ROM,

In the late 1990s, a voice-controlled, wearable computer was tested at three Cadillac dealerships. The Teltronics Mentis computer was worn by the technician. A portable monitor was hooked to the bumper or fender of the car. The computer was equipped with advanced speech recognition technology and allowed a technician to simply tell it about a problem. The system displayed text, animation, and video instructions to help the technician to diagnose and repair a problem (Guyette, 1998).

Advanced data communications systems are also revolutionizing the work performed by automotive service technicians. The International Automotive Technicians’ Network (iATN), operated by the National Institute for Automotive Service Excellence, is an online discussion group with membership limited to master mechanics. Individuals are creating websites and discussion groups in which professional technicians can discuss new repair techniques or particularly difficult diagnostic problems. Moran (1996) points out that before the advent of these types of discussion groups, interaction between technicians could only occur at conventions and seminars. Not much could happen at these because few repair shops allowed their technicians to discuss problems with peers at competing shops.

Ford Motor Company installed a company intranet called FocalPt in 1997. The satellite-based system, linking 15,000 dealers worldwide, was intended to provide
showroom to junkyard support. One advantage of the system was that an automobile’s repair history was available to dealers throughout the system. This was particularly useful to those who had breakdowns on trips far from home (Wagner, 1997).

Ford also created the Fordstar system in the mid 1990s as a means of providing distributed learning opportunities throughout the Ford dealership network, including 6,000 dealerships in the United States, Canada, and Northern Mexico. Courses on the compressed video satellite system were to include at least 15 minutes of interactivity per hour of instruction with an interaction opportunity every five minutes. An anonymous “flag” button let any of the potentially hundreds of students communicate with the instructor to let him/her know that additional clarification was needed (Steele, 1995).

Education

The automotive service profession has come to resemble the medical profession. Educational requirements have been established, certification and periodic recertification have become the norm, and formal information resources have become richer and more widely available to the profession. Weber (1997) points out that the days of the self-trained mechanic are over. While such a person, using a trial-and-error method of repairing automobiles may still get a job, career advancement and professional respect would be impossible to attain.

The National Automotive Technicians Educational Foundation (NATEF) is the accrediting body for automotive service educational programs. While traditional manual
skills remain in the program, the standards contain an additional applied academics component. Applied academics include:

- Language arts and communications
- Mathematics
- Science

Within the language arts and communications section, service technicians are expected to develop a reading strategy for all written materials, including shop manuals, service manuals, and so on. They are expected to learn to understand verbal and nonverbal cues to better communicate with customers and management. They are expected to “write clear, concise, complete, and grammatically accurate sentences and paragraphs.”

The mathematics section states that service technicians are to understand basic mathematical principles, be familiar with basic algebraic concepts, work with probability, proportions, and some geometric functions. The science component specifies that the technician will have a basic understanding of the scientific principles behind the operation of the automobile and its systems (National Automotive Technicians Education Foundation, 2001).

The chair of an automotive service management program at a local community college reports that incoming students who type at a speed of less than 20 words per minute must take a remedial typing class because a slow typing rate will affect the efficiency with which a technician can input and receive data from computer systems (Appendix D).
The evolution has been quite acute between an earlier era that relied less on formal standards and education and the current era in which education, communication, and use of information resources have become critical. This suggests that the automotive service profession should be an excellent candidate for a study on the acceptance of information technology by a population of users.

Summary

Davis’ Technology Acceptance Model can be used to describe the relationships between age, experience, and education and the acceptance and use of technological innovations. An extended version of that model was proposed for purposes of this research project.

The automotive service profession is an excellent group on which to apply this model. The automobile has undergone much development and change, with complexity growing at an accelerated pace over the past 30 years. The amount of information necessary to support the service of ever more complex automobiles is expanding apace, and educational programs are well established and well defined.
CHAPTER 3

METHODOLOGY

Introduction

The purpose of this study was to prove or disprove the three hypotheses presented in chapter 1, namely, that education level, age, and experience have an effect on the acceptance and usage of information technology by automotive service technicians. This chapter discusses the design of the study.

Research Design

The study was a two-part design, incorporating both qualitative and quantitative elements. The first part of the study was qualitative, consisting of interviews, while the second part of the study was quantitative, consisting of the administration of a survey instrument.

The interviews in the first part of the study were extensive and in-depth, intended to provide contextual information on the workplace environment, the computer-based information systems used there, and automotive technology education programs at the community college level.

Part two of the study consisted of survey research measuring the effect of the independent variables, age, experience, and education, on the dependent variable, acceptance and use of technology. Automotive service centers were selected on the basis of size and type to provide a good cross-section of respondents in an effort to obtain a diverse sample representing varying levels of age, education, and experience.
Data Collection

*Human Subjects Approval*

A letter of consent (Appendix B) was provided to meet Institutional Research Board requirements. While the researcher felt that this was a low-risk project, the one potential risk was the possibility of adverse action taken by supervisors/managers based on the responses given by individuals concerning their acceptance and use of information technology on the job.

To address this concern, supervisors were not given access to raw data. Also, while individual responses were coded to allow later follow-up contact by the researcher, access to the codes was closely guarded by the researcher and survey materials will be destroyed two years after the study is complete.

*Part 1: Context Interviews*

There were two context interviews:

*Automotive service environment.* The researcher interviewed a service technician and observed use of information technology tools in a service center. While reading about the technology and innovations used in the automotive service environment was helpful, interviewing a service technician and seeing the technologies in the context of the workplace on a typical day provided the researcher with an understanding that went beyond abstract knowledge.

Automobile manufacturers have expended great sums to develop information systems to support authorized dealers’ service centers. The large dealership selected for the study was an optimal venue for an in-depth observation/interview of this type.
Educational programs. The researcher interviewed the chair of an automotive service program at a local community college in the Greater Cincinnati area.

The emphasis in the second interview was to learn more about certification and degree programs in automotive technology with an emphasis placed on training in the use of computer-based information technology. This helped the researcher to develop a better understanding of the relationships between formal training and certification and the acceptance/use of computer-based information resources.

The narratives resulting from the texts were used to improve understanding of the results obtained in the survey. Summaries of the interviews are attached as Appendices C and D.

Part 2: Survey Questionnaire

In part 2, a survey instrument (Appendix A) was administered to a selected sample of automotive service technicians. The survey instrument was created by the researcher specifically for this study and had not been used or tested prior to this study. The survey was self-administered. Where possible, the researcher met with technicians as a group, explained the survey, waited for technicians to complete it, and then collected the completed surveys. In some cases, due to the cost of idle time to technicians and shops, the researcher explained the survey, departed, and then collected the completed surveys at a later time.

Instrument design. The survey instrument consisted of 23 items intended to measure the dependent technology acceptance variables, usage and perceptions of
ease of use and usefulness, as affected by the independent variables, age, experience, and education/certification.

The first four items were multiple choice. Item 1 measured the frequency of use of selected information technologies and item 2 and frequency of use of selected noncomputer-based information resources such as those in print and microform formats. These items corresponded with the concepts of volume and frequency of use as depicted in the extended version of TAM.

Items 3 and 4 were intended to determine how and where respondents first learned to use computers and whether the respondent owned a computer at home. These factors are related to the concept of ease of use (E) as described in both the standard and extended versions of TAM.

Items 5 through 16 were Likert-type scales measuring the respondent’s attitudes for or against computers by asking whether he agreed or disagreed with a series of statements concerning computers, their value, and alternatives to their use. Items dealing with the relative value of computers (“Computers are over-rated in automotive service.”) were intended to gain insight into perceived usefulness (U). Items dealing with skill with and access to computers (“I feel that I am well trained in using computers at work.”) were intended to gain insight into perceived ease of use (E) on the part of respondents.

Multiple-choice items 17 and 18 collected information on the respondent’s education and certification. Item 18 had subsections in which the respondent could
signify if he held certification, and if so, in what areas, when he received initial
certification, and if he was periodically re-certified.

Items 19, 20, and 21 obtained information relating to age and experience, both in the field and at the present workplace.

Items 22 and 23 were intended to obtain demographic data on gender and race. Although these factors were not specifically addressed in the present study, they may be of interest in future analysis of the data.

An open-ended comments item was included at the end of the survey.

*Pilot test.*

The survey instrument was tested during the pilot phase of the study in early 2005. The site used for the test was a large family-owned new car dealership in the Greater Cincinnati/Northern Kentucky area. A total of five respondents volunteered to take the survey. The respondents filled in their surveys voluntarily.

The results revealed some minor problems with the survey instrument. After revisions were made, the survey was reviewed by an educator in the automotive service field. Suggested additions were incorporated into the survey instrument.

*Survey Administration*

The revised survey instrument was administered during the summer and early fall of 2005. Representative shops were selected, initial contact was made with management, and visits were made to explain the survey to managers. Permission to administer the survey to employees was gained, and a time scheduled to administer the survey. As mentioned above, in some cases the survey was administered to an entire
group and then immediately collected. In other cases, surveys were distributed for technicians to complete at their leisure, and then retrieved at a later time.

**Sampling**

It is important to create a sample that will produce results that represent a population. This section discusses the selection of respondents for each part of the research project.

**Context Interviews**

Purposive sampling was used to select respondents based on type of workplace, knowledge, and experience in each of the two areas to be investigated. Purposive sampling is discussed at depth later in this chapter. No attempt was made to randomly select the respondents. For purposes of the initial in-depth interview, selection of a technician was made in consultation with the service manager of a large new car dealership. A master technician who also had a high degree of skill in working with computers was chosen.

**Survey**

In general, researchers try to minimize bias in the selection of a sample through various forms of probability sampling. At the base of probability sampling is the simple random sample, defined by Krathwohl (1993, p. 127) as a technique in which “all possible samples of a given size have an equal opportunity of being selected.” This method greatly reduces the possibility that researchers will skew results through their selection of a random sample. Random sampling was not used for this study because it
was problematic in this occupational context and less likely to deliver the balance of factors necessary for data analysis.

*Purposive sampling.* The researcher felt that for purposes of the present project, the sample must include an assortment of respondents with varying levels of experience, age, and education level in order to adequately measure the effects described in the hypotheses.

For this reason, purposive sampling was used to select survey respondents. Purposive sampling involves the use of judgment on the part of the researcher, with a deliberate effort to obtain representative samples by including typical groups in the sample (Kerlinger, 1986).

In the case of the present population, automotive service technicians, a number of difficulties make the use of a true random sample difficult. First, one must obtain a listing of the population in question. There are two major professional associations serving the automotive service industry, the Automotive Service Association (ASA) and Automotive Service Excellence (ASE). ASA is an association of service establishments. ASE is an association of certified technicians.

Random sampling through the ASA list is problematic in that the size and makeup of the population is masked. That is, the list of members provided by ASA is a listing of service establishments, not individual technicians. Any random sample derived from that list would have been a random sample of the member service centers, not of individuals. Conceivably, a totally random selection of service centers could have produced a non-representative grouping of technicians, making it much more difficult to
have obtained a representative sampling of those at various levels of education, training, experience, and age level. Population size would have been very difficult to determine.

Obtaining a listing from ASE was another option. ASE is an accrediting body that certifies both technicians and service centers. ASE members are certified and the population would, therefore, have been limited to certified technicians. Because one of the variables under examination was education/certification, it was critical that the sample include representation from both certified and uncertified technicians. To illustrate, the *Underhood* survey of automobile service technicians was administered using the ASE membership list, limiting the population to ASE-certified technicians only. This weakness is mentioned by Sunkin in his discussion of the survey (2001).

*Sample size.* To adequately test the effect of the three named criteria on acceptance and use of technology, the researcher believed that the sample obtained had to include adequate representation from a range of types of service establishments as well as service technicians representing a range of age, education, and experience.

Determining the appropriate size of a purposive sample relies on the judgment of the researcher to obtain a sample representing a diversity of values for the independent variables. The normal probabilistic methods for determining sample size cannot be used.

At an early point in the study, the researcher obtained a listing of service centers in the Cincinnati, Ohio area that were members of the Automotive Service Association (ASA). A total of 96 service centers appeared on the list. Adding to this a conservative
estimate of dealership service centers in the Greater Cincinnati/Northern Kentucky area, independent shops in Northern Kentucky and chain service centers in the area could easily result in a total of 180 service centers.

In addition, the researcher was made aware that larger government entities maintain their own service centers. These include city and county shops. For larger municipalities, these centers employ large numbers of technicians, contain sophisticated equipment, and operate at a level consistent with commercial shops servicing multiple brands and types of vehicles.

It was estimated that, on average, each shop would employ three to five service technicians. Various sources point to numbers between 30 and 120 as being workable sample sizes that can be used with standard statistical measures. The researcher selected a sample size of 60 in the belief that this number of respondents would result in a group that could be made inclusive of sufficient numbers of respondents across the spectrum of age, experience, and education. With an estimated average of three to five technicians per service center, 12 to 20 service centers would need to participate. With at least 180 service centers in the Cincinnati/Northern Kentucky area, this number was believed attainable.

To build a sufficiently diverse sample, the researcher created a list of criteria and minimum numbers of respondents per criterion necessary to build a diverse sample. Matches with desirable criteria were determined both from the type of service center being contacted and from answers to the survey instrument.
The type of service center in which a technician works has an effect on usage of computer resources due to differences in the scope of repairs, employer emphasis on having the latest computing equipment, access to proprietary information and tools, and emphasis on training. Table 1 lists the types of service centers included in the study and the proportions of respondents to be selected from each type.

Table 1

<table>
<thead>
<tr>
<th>Desired Sample Proportions by Type of Service Center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Service Center</td>
</tr>
<tr>
<td>New Car Dealership</td>
</tr>
<tr>
<td>Chain Repair Shops</td>
</tr>
<tr>
<td>Independent Service Centers</td>
</tr>
<tr>
<td>Government</td>
</tr>
</tbody>
</table>

New automobile dealerships are technology rich, with systems representing the significant investment of automobile manufacturers. Chain repair shops, such as Midas, Sears, or other national or regional chains, often utilize extensive technology, concentrate on a group of repairs or products, such as tires or batteries, for the majority of their business, and stress certification, albeit with an emphasis on their main area of concentration. It was thought that independent shops would generally have less technology than the chains and dealerships, due to the investment needed, generally
have fewer technicians, and may emphasize training and certification to a lesser extent than other settings.

The researcher discovered municipal/government shops when data collection began. They are often quite elaborate and handle a wide variety of jobs and service multiple makes of vehicles. For example, one large city garage repairs equipment ranging from lawnmowers to fire engines. As observed, their workforces tend to be more diverse than those of commercial shops. For these reasons, the researcher determined that municipal garages would be included in the study and that their respondents could be substituted for those of independent shops and chains.

A number of sources in the literature indicate that the average age of technicians tends to be weighted toward those in their 40s. Accordingly, the researcher considered it necessary to limit the number of technicians in the 40 to 49 year old age group. This was later validated by information supplied by Denise Caspersen of the Automotive Service Association (personal communication, September 20, 2005) which indicated that 30% of technicians employed in ASA member shops are in the 40 to 49 year old age group.

Since varying levels in usage and acceptance based on age is the basis of one of the hypotheses, it was seen as important to specify a minimum number of respondents in the over 50 age group. Technicians 50 years old and older came into the profession before the great influx of computer-based information systems. However, the researcher found very few people in this age group in the sites that he surveyed.
Accordingly it was determined that at least 5 of the respondents should be 50 or more years of age.

Younger technicians are another important group to include because they were literally born into the computer age. Table 2 lists the desired sample proportions based on age.

Table 2

*Desired Sample Proportions by Age*

<table>
<thead>
<tr>
<th>Age</th>
<th>Desired Number of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;40 years old</td>
<td>&gt;=20</td>
</tr>
<tr>
<td>40 – 49 years old</td>
<td>&lt;=30</td>
</tr>
<tr>
<td>50+ years old</td>
<td>&gt;=5</td>
</tr>
</tbody>
</table>

The effect of education and certification on acceptance and use were also being tested. Therefore, it was important that both certified and non-certified technicians be surveyed. Accordingly, it was determined that at least 5 of the respondents would be non-certified.

Data Analysis

*Context Interviews*

Data for part 1 was collected through a pair of interviews and on-site observations. The interviews were summarized and included in the paper as individual appendices. The content of the interviews was used by the researcher to develop a
better understanding of the automotive service industry environment and to clarify points within the current paper.

*Survey Questionnaire*

The research hypotheses being tested in this project involved relationships that can be tested through bivariate statistical analysis. Usage was self-reported using a 5-point scale ranging from “Daily” to “Not Available.” For purposes of analysis, numeric values were assigned to each choice, ranging from 4 for daily use, 3 for weekly use, in descending order to 0 for “Not Available.”

To measure the perceptions of ease of use and usefulness of computers, several Likert-type scales were used. These were 5-point scales, ranging from “Strongly Disagree” to “Strongly Agree.” The items were created as sets of 4 statements suggesting positive attitudes toward computers (items 5, 6, 9 and 10), 4 suggesting negative attitudes (items 7, 8, 11 and 12), and 4 which gauged skill, training, and levels of management support of computing activities (items 13 through 16). The responses to the 4 positive statements were assigned numeric values ranging from 1 (“Strongly Disagree”) to 5 (“Strongly Agree”). The numeric values were reversed when scoring the 4 negative statements, that is, the values were assigned from 5 (“Strongly Disagree”) to 1 (“Strongly Agree”). One respondent’s responses were dropped from the analysis because he had entered “Strongly Agree” for each item. This resulted in conflicting scores because the positive and negative items were interspersed. Means were then obtained to provide an overall computer acceptance rating for each respondent.
The Spearman *rho* correlation was calculated for each relationship being tested. The Spearman correlation coefficient is a version of the Pearson correlation formula, intended for use with ordinal data. A standard test for statistical significance was used to investigate whether the results were statistically significant. Statistical calculations were performed using *SPSS for Windows*.

Since the hypotheses are directional and effect fairly subtle, 1-tailed tests were used to indicate significance. Also due to the predicted subtlety of effect, the researcher determined that levels of $p \geq .05$ would be considered to be statistically significant for the purposes of this study.

One last word concerning the statistical analysis: There is some controversy among statisticians over the use and value of means when analyzing ordinal data. Kerlinger (1986, p. 403) provides a strong argument for treating ordinal data as though they were interval data. That is, he suggests that researchers can assume equal intervals between the ordinal data points, “but to be constantly alert to the possibility of *gross* inequality of intervals.” Using this assumption, the researcher believes that the use of means and the Spearman *rho* provided meaningful data concerning the possible relationships between the variables in the present study.

Methodological Issues

*Sampling*

The study was most likely be affected by the following limitations:

To keep the scope of the survey within reasonable limits, service establishments chosen were limited to a localized geographic region, thereby creating a convenience
sample. While the researcher feels that the sample was representative of the population as a whole, there is a possibility that regional factors may have skewed results.

If the group of service center types from which respondents were drawn had not been diverse enough, it was felt that results could have been skewed. The researcher feels that the use of purposive sampling did provide sufficient variety in the types of service establishments from which were drawn the respondents to the survey.

Validity

Content Validity

A carefully constructed purposive sample can produce results similar to one created with probability sampling techniques. Topp, Barker & Degenhardt (2004) examined illicit drug use patterns, comparing two datasets: one derived using probability and the other derived through purposive sampling techniques. The similarities between the datasets in terms of demographic and drug use characteristics were reportedly striking and suggest that purposive samples can be sufficiently representative to produce results that can be generalized across populations.

One potential check for validity and a representative sample is comparison with other studies seeking similar information. Sunkin’s 2001 survey for Underhood Insider provides useful comparative data. In addition, Denise Caspersen of the Automotive Service Association (ASA) shared demographic data which exhibited a breakdown in age groups similar to that of the present sample. Accordingly, data from the ASA was compared with the age makeup of the present survey and comparisons with the Sunkin
survey were drawn in chapter 4 of this paper. The comparisons suggest that the purposive sample was representative of the field as a whole.

Another check for validity is to submit the instrument to an expert in the field, in this case the automotive service field, to see if items are appropriate to the subject in question. The survey instrument was briefly reviewed by a service manager in a large new car dealership preceding the pilot administration. After making minor revisions as a result of the pilot administration, the instrument was reviewed by the chair of an automotive service program at a large, urban community college. Additional items were added to one of the questions due to input from the reviewer.

Yet another technique for determining the validity of a survey instrument is to perform factor analysis on a portion of the instrument. The researcher performed a post hoc factor analysis on items five through sixteen using data obtained during the administration of the instrument.

As mentioned earlier in this paper, questions five through sixteen were designed with two factors in mind: perceptions of the value of the technology, measuring usefulness, and perceptions of facility and access, measuring ease of use. A post hoc factor analysis suggested the existence of three distinct factors. The test items were grouped as follows (the actual test items appear in Appendix A):

Table 3

<table>
<thead>
<tr>
<th>Factor Analysis of Items 5-16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Items</td>
</tr>
<tr>
<td>Factor 1</td>
</tr>
<tr>
<td>Factor 2</td>
</tr>
<tr>
<td>Factor 3</td>
</tr>
</tbody>
</table>
Further analysis suggested that the items grouped under Factor 1 were related to the concept of ease of use (E). The test items dealt with issues such as skill level, management’s encouragement of computer use, quality of training, enjoyment of computer use, and whether or not the computer assists in solving problems. The researcher suggests that the issues represented by these items are related under the concept of ease of use. Higher self perceptions of skill and training lead to confidence, which is intensified when management is perceived to be supportive of an activity. A high perceived level of ease of use should lead to a positive attitude toward the technology, and pride and enjoyment in the mastery of its use. The researcher feels that the items under Factor 1 do, indeed, have the intended effect of measuring perceived ease of use.

The items grouped under Factor 2 were related to the concept of usefulness. Items 9, 11 and 12 dealt specifically with accuracy, both directly, and in comparison with paper-based information sources and a respondent’s coworkers and colleagues. If computer technology is not perceived of as accurate, perceptions of usefulness will most definitely be low. Item 13 addresses access. If the technology is not accessible, it is less useful.

The items grouped under Factor 3 also appear to be related to the concept of usefulness. All three items dealt with the level at which a technician relies on the technology over experience. Are computers important or are they simply an over-rated technology? While Factors 2 and 3 measured usefulness, there was a subtle difference
in degree between an admission that computers do what they are supposed to do and the value in which they are held by the respondent.

In summary, the items did appear to address the two concepts for which they were intended. It is interesting that the concept of usefulness, taken from the TAM model, appeared to be split along a subtle but definite border between perceptions that the technology was accurate and of value to the respondent.

*Test Effect*

There are other potential threats to validity. Respondents may overstate their skills to presumably enhance their standing in the eyes of the researcher. Respondents may fear that survey results will be provided to their supervisors. If a respondent fears that lack of acceptance of technology is looked upon negatively by management and that his negative comments may be viewed by the supervisor, he may be less than candid in providing responses.

*Researcher Effect*

Another potential limitation to validity may come as a result of the physical presence of the researcher. Respondents may have felt under those circumstances that they were working under the eye of the researcher and may have been self-conscious. While physical visits may result in a higher response rate, the presence of the researcher may lead reluctant respondents to provide information that is less than accurate. On the other hand, in some cases, due to the potential labor costs involved in basically shutting down a shop for 20 to 30 minutes, the survey was explained and the researcher left the site, returning at a later time to retrieve responses. This may have
Reliability

Item Response Consistency

The survey instrument used for this study is an original instrument designed for purposes of the study. The instrument was pilot tested with a small group of automotive service technicians in order to check its (1) potential validity, or ability to measure what it was designed to measure, and (2) potential reliability, or ability to elicit responses consistently (i.e., without confusing respondents).

The results of the pilot test indicated several minor problems with the instrument. Editing the items in question improved the consistency of responses. The researcher believes that the results of the pilot study indicated that the instrument did test for the criteria for which it was intended, results were consistent, and that data provided was sufficient to draw conclusions appropriate to the purposes of this study.

Split Half Analysis

It is important that a survey instrument measure the factors under investigation in a reliably consistent manner. To further test reliability, the researcher used split half analysis to investigate the internal reliability of the instrument. Items 5 through 12 were evenly split into two parts, the first part consisting of the positive items, that is, items 5, 6, 9, and 10, and the second part consisting of the negative items, 7, 8, 11, and 12. The correlation between the two halves was .518 with Spearman-Brown coefficients of .682 equal length, and .682 unequal length. The Guttman split half coefficient was .679.
Cronbach’s Alpha

Items 5 through 16 were then analyzed, yielding a Cronbach’s alpha of .866 (.870 based on standardized items).

Summary

The study was constructed in two parts: in-depth interviews with experts in the field and administration of a survey instrument to automobile technicians.

Purposive sampling was used to construct the sample. It was felt that this method created a more representative sample set than would have been possible using traditional random sampling techniques.

Validity was tested using factor analysis. Reliability was tested through a pilot administration of the test, split half analysis and Cronbach’s alpha tests.
CHAPTER 4
DATA ANALYSIS AND RESULTS

Introduction

This chapter presents the results of the study, including both the context interviews and the survey results, providing an overview of the sample demographics and group responses, then proceeds with an application of the variables of age, experience, and education to the hypotheses. An analysis of the results of survey items 13 through 16 is provided, discussing relationships between usage and individual self perceptions of skills, training, availability of up to date computers, and employer support of computer use.

Context Interviews

Two context interviews were conducted. The first interview provided valuable insights into shop procedures and the electronic information resources used by technicians in their daily work. The second provided background information on education and certification programs with an emphasis on instruction in the use of information technology.

The narratives resulting from the texts were used to improve understanding of the results obtained in the survey. Summaries of the interviews are attached to this dissertation as Appendices C and D.

The Sample

The sample consisted of 62 technicians drawn from service centers in the Greater Cincinnati/Northern Kentucky area during the summer of 2005. A purposive
sample was built using various screening criteria to create a group that was representative of a variety of ages, levels of experience, and types of workplace. Three respondents were rejected when it was found that they had not filled out and signed their letters of consent. Hence, the total number of respondents included in the study was 59.

Demographics

Gender and Ethnicity

In terms of gender and ethnicity, the group was very homogeneous. All of the respondents were male. Fifty-seven (96.6%) were White, non-Hispanic while 2 (3.4%) were African-American. The heads of the automotive service programs at two local community colleges indicated that this reflects the makeup of their student bodies, one stating that there were no females and very few minorities in his program and another stating that of 300 automotive technology students, only 10 were female. According to the Statistical Abstract of the United States, (Bureau of the Census, 2005), of 884,000 automotive service technicians, just 1.3% were female. While females have made some inroads into the profession, as a whole, automotive service technicians continue to be predominantly male. According to the same statistical source, minorities made up 26.8% of the total population of automotive service technicians. Considering the range of sites chosen, it is surprising that the sample included only two African-American respondents.
**Age and Experience**

The mean age of the respondents was 36 years with a range of 18 to 60. The median age was 35. Approximately 32.2% of the respondents were 40 years of age or older. Just 8.5% of the respondents were over the age of 50.

A good point of comparison to help determine if the sample is representative of the population in terms of age was provided by a representative of the Automotive Service Association (ASA), the major trade association for automotive service providers. The greatest variation can be seen in the upper and lower ends of the range of ages—that is, the 19-24 and the 51+ age groups. In general, the researcher believes that the comparison suggests that the sample is sufficiently representative of the population as a whole to provide results that would be predictive of the population.

*Figure 3.* A comparison by age group of the present sample with data supplied by the Automotive Service Association. The ASA data was collected February 2005.
On average, members of the group had worked for their present employers for 8.2 years, with a range of from 2 weeks to 36 years. Median longevity was 5.7 years. Eleven of the group (18.6%) had worked for their present employers for fifteen or more years. Seven (11.9%) had worked for their present employers for less than a year.

The mean number of years of experience in the automotive service field, including employment at the present employer was 16.8 years. The median was 16.0 years with 6 of the group (10.2%) reporting 30 years or more of experience. The range was .3 years to 40 years.

The age at which respondents first entered the field was obtained by subtracting the number of years of experience from current age. The mean age of entry was 19.3 years, with a range of 13 to 33.5 from youngest to oldest. This is strikingly similar to results published in the 2001 Professional Automotive Technicians’ Survey, in which the mean age of entry into the field was reported as 19.4 years of age (Sunkin, 2001). The respondent who began working in the profession at age 13 reported that he had dispensed gasoline and performed odd jobs at his father’s service station.

Approximately 61.0% of the respondents entered the field before their 20th birthday.

Education

All but 2 individuals (3.4%) indicated that they had graduated from high school, with 26 (44.1%) having graduated from a vocational high school. Seventeen, or 28.8% stated that they had at least attended some college, with 8 (13.6%) holding an associate’s degree and 1 respondent (1.7%) holding a bachelor’s degree. Three of the respondents (5.1%) reported that they held associate’s degrees, majoring in
automotive service technology. Seven (11.9%) of the respondents indicated that they had majored in automotive service technology while attending college, not necessarily graduating.

Certification

Forty-five (76.3%) of the respondents indicated that they were certified. Of these, only 3 (6.7%) reported that they had been certified prior to 1985, the point at which computerized engine controls began to come into use. Twenty-six (57.8%) percent were certified after 1990 and 13.3% were certified after 2000. Thirty-two respondents (71.1% of those certified) indicated that they had been re-certified within the past five years.

Concerning the types of certification held, 73.3% of those certified indicated that they held Automotive Service Excellence (ASE) certification. Seventeen respondents, or 51.5% of those holding ASE certification, reported that they were ASE Master Technicians.

Of the respondents holding certification, 35.6% reported that they were certified by a manufacturer. This is often the case with technicians who work for a new car dealership. Of the respondents reporting manufacturer certification, 75% do work for new car dealerships. Five (11.1%) of those reporting that they were certified stated that they were certified by their employers.

Six respondents indicated other types of certification. Of these, two indicated that they held heavy truck certification, one indicated that he held double ASE Master Certification (both ASE Mechanical and ASE Collision and Refinishing Certification). One
indicated that he held certification as an Emergency Vehicle Technician (EVT). EVT is a highly specialized certification building on certification as an ASE Master Technician.

![Bar chart showing respondents certified by type of certification held]

*Figure 4. Respondents indicating that they were certified by type of certification held.*

**Use of Computer-Based Resources**

The reported usage of computer-based resources varied widely by type of resource. Interestingly, even those only maintaining tires and changing oil often had reason to use databases to look up optimal air-pressure, required oil weight, or part numbers.

Figure 5 shows the overall numbers of respondents who reported daily use of selected resources in descending order by frequency of use.
Figure 5. Number of respondents indicating daily use of selected computer-based resources.

Usage, of course, depends on availability, and some resources were not available at all shops. Figure 6 shows the number of respondents reporting that they either never used resources or that specific resources were not available in their workplaces.
Some computer-based resources are ubiquitous within the industry. Almost all shops now have PCs, diagnostic workstations, and access to either generic or manufacturer-specific databases. Usage and availability of these resources was universally high. Databases are generally shipped and accessed from CD-ROMs or DVD-ROMs. The relatively large number of respondents indicating that they either never used these media or that they were not available in their shops was perhaps due to the fact that most techs do not actually see or handle the media itself. Generally, whenever a technician is using an offline automotive service database, he is also using CD-ROM or DVD-ROM technology.

In our connected age, the responses showing that common Internet-based resources were unavailable in a substantial number of shops were surprising. A sizable
number of respondents (20.3%) indicated that they had no access to the Internet while on the job. Lack of access to databases on the World Wide Web was reported by 25.4% of respondents while 37.3% reported a lack of access to Internet discussion groups. Nineteen respondents (32.2%) indicated that they had no access to e-mail.

This was in sharp contrast to information obtained in the first context interview (Appendix C), in which the technician indicated that he and his colleagues had access to broadband-connected PCs and diagnostic workstations. From my observations, the Internet was used to access service bulletins, company-provided databases, and e-mail. Computer diagnostic workstations were attached to the broadband data network and were used for this access. In addition, one technician had access to his own networked personal computer. Other networked personal computers were available for general use throughout the dealership.

*Use of Print and Other Information Resources*

Of the various print-based information resources, only two were used by substantial (more than 10%) numbers of respondents on a daily basis: service manuals (23.7%), and graphics or charts (14.3%). While the employees of one large dealership reported that management continued to purchase service information in both print and electronic formats, others, representing a competing manufacturer, stated that print was no longer used and that electronic access was now the only means available to them.

Graphics and charts remain an issue in the electronic world. It is often more convenient to glance at a wall chart or to carry a printed chart or graphic to a vehicle.
RPO code books, which list the codes corresponding to factory options and configurations, were used at least occasionally by 44.1% of the respondents with only 3 (5.4%) reporting daily use.

Surprising to some who may remember the extensive use made of microfiche technology to keep track of automobile parts inventories is the fact that the technology appears to have disappeared from the industry. Only 6 respondents (10.3%) reported at least occasional usage while the remainder (89.7%) reported that they either never used microfiche readers or that the readers were not available in their workplaces.

First Exposure to Computers and Home Computer Ownership

Respondents were asked to indicate where they had first learned to use computers. Note that some respondents gave multiple responses. The largest group of respondents (42.4%) indicated that they were first trained in the use of computers in high school or college. Interestingly, 8.5% indicated that their first exposure to computers was in elementary or middle school. Nineteen (32.2%) indicated that they were trained on the job while the home was selected by 30.5%. Three respondents (5.1%) indicated that they first learned to use computers as a component of manufacturer-supplied training courses while only one person (1.7%) indicated that his first computer training was within the ASE certification process.

Respondents were then asked whether they owned a personal computer at home. Of those who responded to the item, 52 (91.2%) reported that they owned a home computer. This compares to the most recent government data available (United States Department of Commerce, 2004), which indicated that 61.8% of households in
the United States owned personal computers as of 2003. In that report it was pointed out that the rate of increase had slowed between 2001 and 2003. This suggests that the respondents in the current sample enjoy a substantially higher proportion of PC ownership than the U.S. population as a whole.

*Group Acceptance of Computers*

Items five through sixteen consisted of a series of Likert-type scales, each seeking to measure agreement with statements concerning computers. Positive and negative statements were interspersed to avoid bias.

The assignation of score values to the responses is described in chapter 3. A mean score for each item was obtained, and then a mean of the means calculated. This provided an overall score for all respondents. A scale was devised to indicate the range of acceptance of computer-based information resources, ranging from strong resistance (0), representing low perception of usefulness and ease of use, to strong acceptance, (5), representing strong positive perceptions, with 3 representing a neutral attitude.

The overall ranking for the group as a whole was 3.6, indicative of a mildly positive attitude toward computers in the workplace. The low group rank observed was a slightly negative 2.6 for item 7, “When diagnosing a problem, I usually rely on my experience to solve the problem instead of using a computer.” In contrast, scores for items 5 (“I like to use computers”) and 6 (“Computers are important to me in my job”), received scores of 4.1 and 4.5. Confirming this positive attitude toward the technology, responses to the negative item 8 (“Computers are over-rated in automotive service”) indicated a high level of disagreement (4.1 using the transfigured scale described in
chapter 3). Looking at the group as a whole, it appears that all recognize the need for computer-based systems in the workplace and that the majority of information-seeking is being done using computer-based information systems.

Items 13 through 16 were intended to provide information about respondents’ perceptions of their own skill levels and of the level of support and encouragement provided by management. The mean score for item 13 ("We have excellent access to the latest computers in my shop") was neutral at 3.05.

Item 14 ("I feel that I am well trained in using computers at work"), received an overall mean rating of 3.29, again only slightly better than neutral. The response for item 15 ("Management encourages me to use computers in my job"), returned a mean score of 3.57, showing a bit more agreement, but still not a conclusively positive response. Item 16 ("I am an expert in the use of computers in my work"), showed a slight tilt toward disagreement with a mean score of 2.71. The mean of the means of items 13 through 16 was a somewhat neutral 3.16 tending to the side of agreement.

Acceptance and Usage

Key concepts in the Technology Acceptance Model are perceived ease of use, perceived usefulness, and usage, measured either as intention to use or actual usage. For purposes of the present study, usage is measured as self-reported frequency of use of selected computer-based information resources.

The philosophy behind TAM is that increased levels of perceived usefulness and ease of use will lead to an increase in the intention to use, or for purposes of this study, an increase in actual use. It is of interest to note that the strongest correlation observed
in the course of the study was that between acceptance and usage (Spearman $rho=.659$, $p<.01$ (1-tailed)) suggesting that the two factors are indeed related—perhaps inter-related in such a way that as strong levels of perception of ease of use and usefulness raise usage, the increased usage may also further increase users’ perceptions of ease of use and usefulness.

The Hypotheses

**$H_1$: Age Related to Acceptance and Usage**

Hypothesis 1 posited that as technician age increases, perceived usefulness of information technology decreases, leading to a lower level of acceptance of information technology.

**Usage**

The first item on the survey asked respondents about their use of several computer-based information resources. These included computer diagnostic workstations, PCs, Internet access, CD-ROM, DVD, electronic databases, electronic databases on the World Wide Web, internet discussion groups, e-mail, portable computers, electronic service bulletins, and other items (to be specified by the respondent).

Since PCs and diagnostic workstations are practically universal in the workplace, the researcher chose several computer-based information resources whose use would suggest that a respondent was an advanced computer user. Included in the analysis were Internet access, electronic databases and electronic databases on the World Wide Web, Internet discussion groups, e-mail, and electronic service bulletins.
The use of resources is dictated by their availability. To control for availability, respondents were removed from analysis if they indicated a lack of availability of any resource (N/A). Out of the full sample of 59 technicians, 34 remained in the group to be analyzed after the removal of responses indicating that one or more of the selected resources were not available in the workplace.

Weights were applied to the responses, with a value of 4 assigned to daily use, 3 to weekly use, and so on, as described in chapter 3. Each respondent’s entries were summed and a mean was obtained. The means were then correlated with the ages of the respondents and SPSS was used to determine whether or not a significant correlation existed. The Spearman \( \rho \) was used to determine a correlation between the two variables.

To prove the hypothesis, an inverse correlation would need to be shown. A slight inverse correlation of \(-0.072\) with a 1-tailed significance level of \(.343\) was calculated. This low level of correlation coupled with a low level of significance suggests that a significant correlation does not exist in the population. However, the existence of a negative relationship in the sample, albeit slight, did suggest further analysis.

Three groups of responses were extracted from the group of 34 and placed into three age-specific ranges: 45 years and older, 30-39 years, and 25 years and younger. The groups were not intended to be comprehensive, but rather were intended to represent the old, young, and middle age groups of the sample. The mean for each technician’s responses was obtained and a group mean was obtained for each age group. Table 4 shows the results of this analysis.
Table 4

*Comparison of Usage Means Grouped by Age Range*

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Number of Respondents</th>
<th>Group Usage Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 years and older</td>
<td>5</td>
<td>2.35</td>
</tr>
<tr>
<td>30 to 39 years</td>
<td>15</td>
<td>2.84</td>
</tr>
<tr>
<td>&lt;=25 years</td>
<td>5</td>
<td>2.63</td>
</tr>
</tbody>
</table>

The data indicated that technicians in the oldest age group, 45 years and older, showed a tendency to use the selected computer-based resources less often than those in younger age groups. Technicians in the 30- to 39-year old group tended to use these resources most often while those in the youngest age group used them slightly less frequently than the middle group, but more frequently than those in the oldest group.

While an inverse relationship clearly exists between those in their 30s and those over the age of 45, usage dips slightly for those younger than 25, although usage in the lowest age group does remain above that of the oldest age group.

Why would this apparent inverse correlation between age and usage not carry through from those 30 to 39 years of age to those in the 25 and younger group? Generally, those in the lowest age group are new to the field. Since the majority of technicians come into the field directly from high school, many of these individuals lack technical training and take on the most menial of tasks within the shop environment, such as changing tires or changing oil. This is confirmed by the fact that only one respondent in the 25 years and younger group was certified. While they may still be
expected to use computers to find information, such as tire inflation pressures or part
numbers, they would have no reason to make more advanced use of the technology.
Based on my observations and discussions with technicians, many young, untrained
technicians gradually become dissatisfied with their low pay and lack of advancement
and begin developing their skills through certification and education. Illustrating this, in
the group of 30- to 39-year old technicians used for this analysis, only two were
uncertified. Hence, as the complexity and value of tasks performed increases due to an
increase in skills and certification, more advanced use is made of computer resources.

To investigate the dampening effect on the Spearman rho by the curvilinear
characteristics of the data, responses from those under the age of 30 were stripped
from the group. Spearman correlations were obtained for the data first including those
that indicated that there were items that were unavailable. An inverse correlation of
-.273 was obtained, significant at the .05 level, 1-tailed. Responses indicating that
certain resources were unavailable were then removed and another correlation was
obtained. An inverse correlation of -.240 at a significance level of .129 was shown.
While the correlations were stronger once the once those 30 and younger were
removed from the sample, the final correlation, after filtering the responses for
unavailability of resources, was not strong enough to reject the null hypothesis.

Acceptance

As described in Chapter 3, numeric weightings were applied to the responses to
items 5 through 12. Means were then obtained for each respondent’s entries. To
support the hypothesis a negative correlation should exist between age and acceptance.
A Spearman correlation of -.234, at a significance level of .05 (1-tailed) was obtained when correlating age with the responses for items 5 through 12. An inverse correlation of -.309, significant at the .01 level (1-tailed) was obtained by correlating age with the responses to items 5 through 16. These were significant correlations and suggest a statistically significant inverse relationship between age and acceptance of computer technology.

The sample was broken down into the same age groupings used to analyze the relationship between age and usage. Means were obtained for each group. Table 5 lists the group means associated with each age group.

Table 5

Acceptance Means by Age Group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Group Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 years and older</td>
<td>3.47</td>
</tr>
<tr>
<td>30-39 years old</td>
<td>3.62</td>
</tr>
<tr>
<td>25 years and younger</td>
<td>3.60</td>
</tr>
</tbody>
</table>

Again, the highest mean was exhibited by the 30- to 39-year old technicians, although the difference in means between the 30 to 39 group and the 25 and younger group was extremely narrow. The 45 and older group was again at the bottom of the means in terms of acceptance, although the difference was small and all three groups were slightly positive in terms of their outlook toward computers.

Items 13 through 16 were intended to address the respondent’s perceptions of the state of computing in the workplace, management’s attitudes toward computer
usage, and a self-assessment of the respondent’s skill level. Interestingly, using the same three groupings by age, the means of responses showed a definite inverse relationship between agreement with the statements and age.

Table 6

*Group Means for Survey Items 13-16 by Selected Age Groups*

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Group Means</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 13: We have excellent access to the latest computers in my shop.</td>
<td></td>
</tr>
<tr>
<td>45 years and older</td>
<td>2.91</td>
</tr>
<tr>
<td>30-39 years</td>
<td>3.12</td>
</tr>
<tr>
<td>25 years and younger</td>
<td>3.33</td>
</tr>
<tr>
<td>Item 14: I feel that I am well trained in using computers at work.</td>
<td></td>
</tr>
<tr>
<td>45 years and older</td>
<td>2.91</td>
</tr>
<tr>
<td>30-39 years</td>
<td>3.31</td>
</tr>
<tr>
<td>25 years and younger</td>
<td>3.83</td>
</tr>
<tr>
<td>Item 15: Management encourages me to use computers in my job.</td>
<td></td>
</tr>
<tr>
<td>45 years and older</td>
<td>3.27</td>
</tr>
<tr>
<td>30-39 years</td>
<td>3.65</td>
</tr>
<tr>
<td>25 years and younger</td>
<td>3.67</td>
</tr>
<tr>
<td>Item 16: I am an expert in the use of computers in my work.</td>
<td></td>
</tr>
<tr>
<td>45 years and older</td>
<td>2.27</td>
</tr>
<tr>
<td>30-39 years</td>
<td>2.65</td>
</tr>
<tr>
<td>25 years and younger</td>
<td>3.33</td>
</tr>
</tbody>
</table>
In each case, the youngest group indicated the highest level of agreement with each of the statements. Most telling were the responses to item 16. This item had the widest gap between the responses of the oldest and youngest groups. It would appear that the 45 year and older group feels less secure than the younger groups in terms of computer skills, although an alternate conclusion may be that increasing maturity leads one to make a more reasoned assessment of one’s capabilities.

Correlations were run between age and the means of the responses for each of the items. The Spearman correlation coefficients for each item were:

Table 7

*Correlations Between Age and Responses to Survey Items 13-16*

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Spearman rho</th>
<th>Significance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 13</td>
<td>-.151</td>
<td>.131 (1-tailed)</td>
</tr>
<tr>
<td>Item 14</td>
<td>-.377</td>
<td>.01 (1-tailed)</td>
</tr>
<tr>
<td>Item 15</td>
<td>-.221</td>
<td>.05 (1-tailed)</td>
</tr>
<tr>
<td>Item 16</td>
<td>-.336</td>
<td>.01 (1-tailed)</td>
</tr>
</tbody>
</table>

While an inverse correlation was suggested for item 13, the correlation was not statistically significant. However, the inverse correlations for items 14, 15, and 16 were significant and point to an inverse relationship between age and the issues in question.

It is possible that in item 13, respondents may have been cautious in their responses because the question had to do with the shop environment created by management. In fact, one respondent failed to answer this question. Although the
respondents had been assured that the information would not be seen by their supervisors, they may have been slightly uncomfortable with this question.

Item 14, which asked about the respondent’s perceptions of his training, elicited a significant inverse correlation between age and agreement with the statement. It is clear that older technicians feel somewhat insecure about the level of their computer training while younger technicians are much more positive.

Item 15, dealing with management’s encouragement of computer use continued the same pattern of inverse correlation, albeit at a slightly reduced rate. All three age groups reported slight positive attitudes in this category. It is possible that respondents were again being cautious in commenting on a condition under the control of their employers.

Strong evidence of an inverse relationship between age and perceptions of one’s facility with computers was evidenced in item 16. It was very clear that older technicians rated their computer skills negatively while younger technicians rated their skills positively. It was interesting that both the 45 and older and the 30 to 39 year old groups viewed their skills in a negative light while those 25 and younger considered their skills in a generally positive light.

H1 Summary

Although the analysis failed to show a significant correlation overall between age and usage, the researcher believes that the significant inverse correlation shown once the youngest respondents were removed from the analysis provides evidence to reject the null hypothesis.
Further buttressing this position is the significant inverse correlation shown between age and acceptance. Significant inverse correlations were shown between age and the responses to items 5 through 12, and between age and the responses to items 5 through 16. The significant inverse correlations shown between age and the responses to items 14, 15 and 16 also suggest that age is a factor in perceptions of ease of use, and hence, to the overall acceptance of computer technology.

The results reported above agree with those of Hubona and Kennick (1996). In this earlier study, a significant inverse correlation of -.240 was shown between age and the factor “ease of use.” The researcher feels that this provides further confirmation that age is, indeed, a factor in the acceptance of computer technology.

**H2: Work Experience Related to Acceptance and Usage**

Hypothesis 2 posited that as technician level of work experience increases, perceived usefulness of information technology decreases, leading to a lower level of acceptance of information technology. This was based on the thought that as they moved through their careers, technicians would increasingly rely on their observations and experience and less on computers.

The same group of technologies used to test the possible relationship between age and usage was used to test the possible relationship between experience and usage, that is: Internet access, electronic databases, electronic databases on the World Wide Web, Internet discussion groups, e-mail, and electronic manufacturers’ service bulletins.
As was done in the analysis for H1, weightings were applied to the responses, and responses indicating lack of availability of resources were again removed from the analysis because if a resource is unavailable, it cannot be used regardless of desire. A mean usage score was obtained for each respondent and SPSS was used to obtain a Spearman correlation coefficient between the usage means and each of three factors: length of time in the profession, longevity with present employer, and age of entry into the profession.

There were no significant correlations between any of the three measures of experience and usage. As with the previously described analysis, the sample was broken into groups, but no relationship between level of experience and usage was observed.

Next, each of the three measures of experience was compared to the acceptance means as obtained through questions 5 through 12 of the survey instrument. Although analysis showed no significant correlation between longevity with present employer or the age of entry into the profession and acceptance, the strongest correlation, a Spearman correlation of -.208 with a significance level of .058 (1-tailed) was identified between length of time in the profession and acceptance, as measured by items 5 through 12. Length of time in the profession was then correlated with items 5 through 16. A statistically significant correlation of -.270, significant at the .05 level (1-tailed) was obtained.
The sample was then broken into groups based on the time respondents had served in the profession and means of the acceptance scores were obtained for specified time ranges. The results appear in Table 4.

Table 8

*Mean Acceptance Scores for Selected Experience Ranges*

<table>
<thead>
<tr>
<th>Experience in the Profession</th>
<th>Mean Acceptance Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 9 years</td>
<td>3.68</td>
</tr>
<tr>
<td>10 – 19 years</td>
<td>3.67</td>
</tr>
<tr>
<td>20 – 29 years</td>
<td>3.38</td>
</tr>
<tr>
<td>&gt; 30 years</td>
<td>3.31</td>
</tr>
</tbody>
</table>

The inverse correlations along with the inverse relationship shown between the ranges of experience and the mean acceptance scores suggest that experience in the profession and acceptance of computer technology are inversely correlated. There appears to be a definite, albeit subtle, inverse relationship between the level of a respondent’s experience and acceptance of computers.

A significant inverse correlation, $\rho=-.333$, $p<=.01$ (1-tailed), was observed between length of time in the profession and agreement with item 14. Experience in the profession and level of agreement with item 16 were also inversely correlated with a Spearman correlation coefficient of -.279 at the .05 level of significance (1-tailed). Smaller correlations of -.178 and -.169 were shown for items 13 and 15, although neither correlation was statistically significant.
There appears to be an inverse relationship between length of time in the profession and perceptions regarding computer skills, training, and management support, with significant inverse relationships between experience and training or skills. That is, as experience increases, respondents were more apt to call into question the quality of training received and of their own skills.

H2 Summary

As was the case with H1, there was a lack of apparent correlation between experience and usage level. However, a statistically significant inverse correlation was shown to exist between the mean acceptance scores and experience as measured by length of time in the profession. This was confirmed by breaking the sample into groups based on ranges of experience and comparing the group acceptance means.

Significant inverse correlations were also observed between length of time in the profession and self assessments of training and skills as measured by items 14 and 16. On the other hand, no significant correlations could be shown between age at entry to the field or longevity with current employer and either the measures of usage or acceptance.

The inverse correlations between experience as represented by length of time in the profession and the various measures of acceptance suggest that H2: should be accepted and the null hypothesis rejected. It appears that experience is inversely correlated with acceptance of computers, if not demonstrated by an effect on usage.
H3: Education Related to Acceptance and Usage

Hypothesis 3 posited that as technician level of education increases, both perceived usefulness and perceived ease of use of information technology increase, leading to a higher level of acceptance of information technology.

Survey question 17 asked for each respondent’s highest level of education, ranging from “High School (Did Not Graduate)” to “Master’s Degree.” To perform the analysis for this hypothesis, responses were grouped by level of education. That is, all who indicated that their highest level of education was “High School (Did Not Graduate)” were placed in a group, followed by those indicating “High School Graduate,” and so on. Those who responded that they majored in automotive service technology at a particular level were placed at the high end of that level. Hence, those who specified “Vocational School” and checked “Courses in Automotive Repair,” were placed at the higher end of the “Vocational School” group.

Next, a numeric weighting was created for each level of education. The numeric rating scale appears in Table 5. As with the usage analyses done for H1 and H2, the group of computer-based resources were used to test H3, again dropping all responses which indicated lack of availability of one or more of the resources. The weightings and means used in the earlier analyses were compared to respondents’ educational level, as indicated by the rankings.
Table 9

*Education Level Ranks*

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School, Did Not Graduate</td>
<td>1</td>
</tr>
<tr>
<td>High School/Vocational School Graduate</td>
<td>2</td>
</tr>
<tr>
<td>Vocational School (Courses in Auto Repair)</td>
<td>2.5</td>
</tr>
<tr>
<td>Some College</td>
<td>3</td>
</tr>
<tr>
<td>Associates Degree</td>
<td>4</td>
</tr>
<tr>
<td>Associates Degree (Major in Auto Repair)</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The Spearman *rho* was employed to indicate possible correlation between education level and usage. No significant correlation was found.

Certification represents another measure of education. To remain certified by the Association for Service Excellence (ASE), a technician must retrain and re-certify every few years. Certification also occurs in stages, that is, certification can take place in various specialties (brakes, suspension) and ASE offers a Master Technician level of certification for those who complete certification in all specialties. A technician can become certified in one or more specialties, adding additional specialties over time, and perhaps eventually becoming a master technician.

A certification scale was created using the responses to survey question 18. A respondent received one point for each type of certification held (Associate’s Degree in Automotive Service Technology, ASE, other), and one point for each subject in which he
was certified. A point was also added if the respondent was a Master Technician and the points were totaled. The total scores were then compared to the usage means using SPSS. A Spearman correlation coefficient of .273, significant at the .05 level (1-tailed) was observed. It appears that certification is positively correlated with the amount of usage of computer-based resources. That is, the greater the level of certification, the more often a person makes use of computer-based information resources.

Education level was then compared to acceptance as measured by items 5 through 12. The education grouping and ranks described above were used in this analysis as well. The following table shows the results.

Table 10

Education Level Compared to Mean Acceptance Score

<table>
<thead>
<tr>
<th>Education Level</th>
<th>Mean Acceptance Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School, Did Not Graduate</td>
<td>3.56</td>
</tr>
<tr>
<td>High School/Vocational School Graduate</td>
<td>3.28</td>
</tr>
<tr>
<td>Vocational School (Courses in Auto Repair)</td>
<td>3.77</td>
</tr>
<tr>
<td>Some College</td>
<td>3.67</td>
</tr>
<tr>
<td>Associate’s Degree</td>
<td>3.72</td>
</tr>
<tr>
<td>Associate’s Degree (Major in Auto Repair)</td>
<td>4.08</td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>3.63</td>
</tr>
</tbody>
</table>
It may be of interest to point out that one of the two respondents who indicated that he had not graduated from high school indicated that he had attended a vocational school, taking courses in automotive service technology. He also indicated that he was heavily certified. This may have skewed the mean for “High School (Did Not Graduate)” to the high side. On the other hand, the individual reporting that he had a bachelor’s degree was certified in only 2 areas. Since he was the only one in that educational level, he may have skewed this rank to the low side. Deleting these two extremes results in a range of Mean Acceptance Scores running from 3.19 among the high school graduates, to 4.08 among those holding Associate’s Degrees with majors in Automotive Service Technology.

It is interesting to note the increased acceptance levels of those who had taken courses in automotive service at the high school level and those who had majored in automotive service technology at the Associates degree level from those who had graduated from high school or college without this specialized study. High school and vocational school graduates who had taken courses in automotive technology enjoyed a group mean acceptance score of 3.771 compared to 3.28 for those who had not taken courses in automotive technology, while college graduates holding the Associates degree with a major in automotive service technology held a group mean of 4.08 compared to a group mean of 3.72 for those who held Associates’ degrees without the automotive service major.

Respondents’ mean acceptance scores were then correlated with education level. The Spearman formula was used, resulting in a correlation of .348, significant at a
.01 level (1-tailed). The correlation suggests a positive relationship between education and acceptance, that is, as level of education increases, acceptance of computers increases as well.

Certification was then correlated with acceptance. The scale used to compare certification level with usage was also used to compare certification level with acceptance means. A correlation of .392, significant at the .01 level (1-tailed) was observed, suggesting that certification level and acceptance of computers is correlated.

**H3 Summary**

While there was no correlation between education level and usage, the positive correlations between certification and usage, certification and acceptance, and education level and acceptance suggest that H3 be accepted and the null hypothesis rejected.

**Respondent Self-Perceptions of Skill, Training, and Employer Support**

Some of the more interesting results of the study occurred in analysis of items 13 through 16. These were a series of 4 statements, seeking responses of agreement or disagreement.

While usage did not correlate with age, experience, or level of education, the strongest correlations observed in this study occurred when usage was correlated to the responses on each of items 13 through 16.
Item 13: We have excellent access to the latest computers in my shop.

The Spearman *rho* correlation coefficient between the responses to this item and the usage means was .560, significant at the .01 level (1-tailed), indicating that as respondent agreement with this statement increased, usage also increased.

Item 14: I feel that I am well trained in using computers at work.

Level of agreement with this item correlated with usage at .579, significant at the .01 level (1-tailed), indicated that as respondents were more satisfied with their level of training, usage also increased.

Item 15: Management encourages me to use computers in my job.

The correlation for this item was .481, significant at a level of .01 (1-tailed) indicating that as respondents perceptions of management support increased, their use of computers also increased.

Item 16: I am an expert in the use of computers in my work.

The Spearman correlation coefficient for this question and usage was .538, significant at the .01 level (1-tailed). As respondents’ confidence in their own skills increased, usage also increased.

Significant inverse correlations were shown between experience and agreement with items 14 and 16. Item 14 showed a correlation of -.333, significant at the .01 level (1-tailed), and item 16 showed a correlation of -.293, significant at the .05 level (1-tailed). Perhaps greater experience leads to stricter self-assessment of computer skills and training level.
Comparisons were made between agreement with items 13 through 16 and the year that a respondent was first certified. Respondents were selected from the sample based on their initial year of certification. Those who were certified prior to 1990, prior to the time when electronic systems began to become common on automobiles, were placed in one group. Those certified after 2000 were placed in a second group. Means were obtained for each item and for each group. The results appear in Table 8.

Table 11

*Comparison of Mean Acceptance Scores by Date of First Certification*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Item 5</td>
<td>3.82</td>
<td>4.67</td>
</tr>
<tr>
<td>Item 6</td>
<td>4.64</td>
<td>4.50</td>
</tr>
<tr>
<td>Item 7</td>
<td>2.64</td>
<td>3.17</td>
</tr>
<tr>
<td>Item 8</td>
<td>4.18</td>
<td>4.50</td>
</tr>
<tr>
<td>Item 9</td>
<td>2.82</td>
<td>3.00</td>
</tr>
<tr>
<td>Item 10</td>
<td>3.36</td>
<td>3.83</td>
</tr>
<tr>
<td>Item 11</td>
<td>3.18</td>
<td>3.67</td>
</tr>
<tr>
<td>Item 12</td>
<td>3.55</td>
<td>2.83</td>
</tr>
<tr>
<td>Item 13</td>
<td>2.91</td>
<td>3.50</td>
</tr>
<tr>
<td>Item 14</td>
<td>3.00</td>
<td>4.00</td>
</tr>
<tr>
<td>Item 15</td>
<td>3.45</td>
<td>4.17</td>
</tr>
<tr>
<td>Item 16</td>
<td>2.36</td>
<td>3.33</td>
</tr>
</tbody>
</table>
In general, those who were first certified before 1990 showed less agreement with the four statements than those who were certified after 2000. To determine whether these differences were significant, a T-test was run using SPSS. Of the sets of means, only the responses to Item 5 were different to a statistically significant level with significance levels of .027 and .016 (2-tailed). Item 5 asked the respondent to agree to the statement “I like to use computers.” The results suggest at least a subtly higher level of acceptance among those who were certified within the last 5 years, during a time when computers had become completely intertwined with the automobile and its servicing.

Summary

The study sought to prove three hypotheses. The researcher believes that the results suggest that all three hypotheses should be accepted and the null hypotheses rejected. Statistically significant correlations were found between all three of the external factors being tested and acceptance, with the strongest correlations between education or certification and levels of acceptance. Significant positive correlations were also found between usage and items 13 through 16.
CHAPTER 5
DISCUSSION AND CONCLUSIONS

Introduction

The final chapter discusses the implications of the research results, relating the results to the model and to prior research. Limitations of the study are cited and calls for further research are made.

Results and Implications

The present study began with a set of assumptions: namely, that acceptance and usage of computers would be negatively affected by a respondent’s age and experience but positively impacted by education.

While the results failed to show significant correlations between age and usage, or between experience and usage, they did show significant inverse correlations between age and acceptance, and between length of time in the profession and acceptance. Combined with the inverse relationships exhibited by a comparison of group means stratified by age and usage, and length of time in the field with acceptance, the researcher believes that a case has been made for the acceptance of H1 and H2 and rejection of the null hypotheses.

Anecdotal information suggests that these assumptions may reflect reality. When the researcher commented to technicians in the field that he was having a difficult time finding respondents for his survey who were 50 years of age or older, he repeatedly was told that most of the older technicians had either retired or moved on to other specialties due to an inability, or lack of desire, to function within the new model of
automotive service in which computers play a critical role. Lowered perceptions of usefulness and ease of use would explain the dearth of older, more experienced technicians within the sample and may help to explain the fairly homogeneous responses to the questions concerning usage of electronic resources.

According to the results of the study, the key factor in the acceptance or rejection of computers by automotive service technicians appears to be education. There were significant positive correlations between certification and usage, between education level and acceptance, and between certification and acceptance, suggesting that H3 should also be accepted and the null hypothesis rejected. These relationships bear out the results of other research into the problems of user adoption of computers. As reported earlier in this dissertation, Rogers (1995) refers to computers as an example of radical change, requiring the user to develop a fairly advanced knowledge of the technology in order to successfully adopt it. Thompson, Higgins, and Howell (1991) and Stanford (1996) suggest that training may be a key element in improving the acceptance of computers by building perceptions of usefulness.

Put in terms of TAM, education affects perceptions of usefulness as well as ease of use. As one becomes better trained in the use of a technology, one becomes more familiar and comfortable with it. Exposure in the classroom and endorsement by the instructor would also increase the user’s perception of the usefulness of the technology. Again, according to TAM, both of these factors should increase actual usage of the technology.
Secondary and post-secondary education provide several benefits that help automotive service technicians become familiar with the tools and techniques of their trade, including computers. Education at these levels has the potential to provide basic skills such as reading, mathematics, and critical thinking which will help the technician as he works to attain specialized knowledge throughout his career. As with so many professions in the 21st century, technicians would also benefit from a much better grounding in information literacy skills. Acceptance means showed a general and quite marked increase between high school graduates (3.19) and those holding Associate’s degrees with a major in Automotive Service Technology (4.08). However, the acceptance mean for the one person holding a bachelor’s degree (3.63) suggests that simply holding a higher degree does not equal better acceptance. Rather, more specialized education (e.g., automotive service courses, an automotive service major) leads one to a better understanding of tools and techniques.

Education in the formal sense can take a technician just so far. As a bachelor’s or master’s degree in business is seen by many potential employers as simply evidence that a candidate is trainable, education within the formal school structure is finite, generally ending at some point, whether with a high school diploma or college degree or certificate. The researcher believes that the current study suggests that certification has perhaps the greatest value in helping technicians to become more facile and comfortable users of computers and other advanced technologies.

Certification programs, in particular those offered by ASE, provide structured instruction and current information. Most importantly, technicians must be recertified
every few years, guaranteeing exposure to the latest concepts and techniques on an ongoing basis. The positive correlation between certification and acceptance suggests that certification is an important factor in building and maintaining technician acceptance of computer technology.

Corroborating the results regarding education and certification were the fairly strong correlations between usage and the responses to items 13 through 16, that is, the items concerning management support and self perceptions of training and skills.

On the other hand, Hubona’s and Kennick’s 1996 conference paper describes a significant negative correlation between age and perceptions of ease of use and usefulness (acceptance), but fails to display a significant positive correlation between education and acceptance. While some aspects of that study are strikingly similar to the present study, differences between the population selected for that project, office workers, and that selected for the present study, automotive service technicians, as well as differences between the electronic resources used, e-mail and word processing packages for the Hubona study and a wide range of database products, diagnostic tools, and collaborative resources, may be the factors which led to the different conclusions of the two studies.

E-mail and word processing are perhaps the most widely used software applications in existence. Both applications can be effectively used with a fairly low level of training. On the other hand, the products used by automotive service technicians in their daily jobs involve the need to learn searching strategies, complex interactions between technician, computer, and automobile, and, in general, require a significant
investment in time and effort in order to put them to effective use. In addition, the office workers surveyed for the Hubona paper were not necessarily highly trained or specialized professionals, at least in terms of the technologies that they used.

Automotive service technicians are in a dynamic profession and ongoing education and certification are required for its members to maintain skills and their places within the profession. Therefore, the importance of education and certification in facilitating acceptance and use of computer technology may well be dependent on the population under examination.

Theoretical Implications

The theoretical basis of this dissertation is an extended version of Davis’ Technology Acceptance Model (TAM). TAM was developed to deal specifically with the acceptance of information technology and has been widely investigated over its more than 20 year history. An area of strong interest for researchers has been the input side, namely those external factors that can affect the outputs of acceptance and usage. This paper examines three external factors: age, professional experience, and education.

The current research has reinforced earlier research, including Hubona and Kennick’s (1996) observation that an inverse relationship appears to exist between age and acceptance of computer technology. The inverse correlation of -.234 p<.05 observed in this study stood in agreement with Hubona and Kennick’s observed correlation of -.0240 p<.005. Apparently, age does indeed serve as a predictor of levels of both ease of use and usefulness, again stating that this is not seen as a physiological effect, but rather a psychological effect based on an individual’s life experiences as a
result of the level of ubiquity of computer technology and the person’s exposure to it throughout the formative years of that person’s life.

The external factor of experience has been examined previously, generally in the form of experience with whatever technology is under investigation. The present paper looks at the concept of experience in the context of experience in the profession rather than experience in the technology supporting that profession. The researcher believes that the differences between these two concepts of experience are critical and that to fully understand the acceptance model, both types of experience need to be examined.

To fully understand experience as it is used as a concept within this paper, it is necessary to contrast experience with the technology and experience in the profession. Experience in the use of the technology itself would be expected to translate into increased acceptance, as described by Hubona and Geitz (1997). Higher levels of experience in the use of the technology would be expected to increase perceptions of ease of use and usefulness as an individual developed a higher level of comfort with the technology and a higher level of confidence in his or her own skills in the use of the technology.

In contrast, in the context of this paper, experience was understood as experience in the profession. As experience in the profession increases and a technician develops an internal storehouse of observations—unique symptoms, problems solved, and so on—the technician would be expected to develop higher levels of self confidence in his diagnostic skills and collected knowledge. This would, in turn, affect his perceptions of the usefulness of technology in an inverse relationship, with levels of
perceived usefulness decreasing as level of professional experience, and hence, self-confidence, increases.

Of course, in today’s workplace, increasing professional experience will most likely translate into increased experience and familiarity with information technology as well. Possibly, level of experience with the technology, affecting perceived ease of use, is in opposition to level of experience in the field as a whole, affecting perceived usefulness of the technology. The observed inverse correlations in the present study would tend to support the latter statement, suggesting that the negative effects of increased work experience may prove stronger than the positive effects of increased experience in the use of the technology, without intervening action.

Further research into these aspects of experience could prove interesting, particularly if the two types of experience could be isolated to better determine their effect on acceptance of a given technology. It would also be interesting to observe the efficacy of various interventions that could be undertaken to strengthen the positive effects of familiarity and comfort with technology versus the negative effects, such as complacency and a decreasing perception of the value of technology, as an individual’s overall professional experience increases.

Information professionals are increasingly convinced that the most successful workers of the future will be those who have the skills necessary to effectively navigate our rapidly growing and ever more complex information resources. As mentioned earlier in this paper, the researcher believes that a strong case could be made that automotive service technicians fit under the category of information worker in this information-
intensive age. Would technicians benefit from intensive instruction in effective searching, information evaluation, and other information literacy skills?

The results of this survey suggest that there is a positive correlation between education, particularly certification, and acceptance. Basic skills in the use of technology are provided as a part of education and certification programs. It is suggested that more highly educated technicians develop a better appreciation for the usefulness of computer technology as their information technology skills increase and as instructors demonstrate the capabilities of the systems. To a certain extent, instructors may also increase positive perceptions on the part of students explicitly or implicitly by imparting their own positive attitudes toward the technology.

In terms of TAM, an information-literate professional should possess higher perceptions of ease of use through familiarity with advanced search skills and the resultant ability to better find and evaluate information, and should also possess higher perceptions of usefulness as information-seeking productivity increases. Interestingly education did not correlate significantly with acceptance in Hubona and Kennick’s (1996) research. Contrasting that earlier study with this one suggests that differences in the populations being surveyed as well as in the way that education was defined may have combined to bring about a much different outcome in the present research.

Certification, in particular, appears to affect acceptance with a positive correlation of .348 p<.01. An interesting possibility for future research into the predictive value of TAM would be to test the effect of intensive information literacy instruction on automotive service technicians’ acceptance of computer technology. It
may also be of value to examine the effect that increased information literacy skills have on technician productivity.

TAM is a useful model for approaching the issues surrounding acceptance of information technology. Although it has been in existence for 20 years and has been well-researched, it continues to offer possibilities for us to develop better understanding, and potentially, more effective use, of our substantial investments in information technology through examination of the external factors that may affect acceptance, and by extension, usage.

Practical Implications

As mentioned earlier in this dissertation, there are a number of stakeholders concerned with the level at which automotive service technicians both accept and effectively use advanced information technologies. The theoretical insights acquired through this study can be applied to that issue.

An inverse relationship appears to exist between age and acceptance of computer technology. As Taylor (1975) pointed out, this does not appear to be a physiological decrease in mental facility due to age. There were certainly individual respondents in the upper portion of the age range of the present survey who reported high levels of acceptance and daily usage of selected information technologies. Rather, the relationship appears to be based on overall life experiences and perhaps a reticence to abandon skills learned to meet the needs of a less information-intensive environment. In an era of less complex automotive systems and less-extensive information resources, technicians were expected to rely on their experience and
troubleshooting skills rather than on external systems. As is the case in all fields, many technicians may fear the unknown, feeling that they cannot master the new techniques and that their hard-won skills may be devalued in the new environment.

Can the effects of age be addressed? Perhaps intensive training in information literacy would help to build self-confidence and an increasing level of perceived ease of use among some technicians. Familiarity and increased comfort level with the technology may break the cycle of fear and resistance that may otherwise prevent effective acceptance and use of the technology.

Experience in the field was also inversely correlated with acceptance of computer technology. One possibility is that increased experience in the profession may result in a heightened self confidence which could lead to more reliance on one’s own memory and diagnostic skills with lowered perceptions of the usefulness of computers. This would place professional experience in opposition to experience with technology.

Managers may be able to offset possible negative effects of professional experience by increasing the availability of advanced technology as technicians become more skilled and experienced. If new technological tools and capabilities are seen as a perquisite accruing to those with higher levels of knowledge and skill, technicians may perceive a greater value in computers resulting in increased acceptance.

The significant positive correlation between professional certification and acceptance suggests that managers would be well advised to encourage their technicians to seek certification and to keep their certifications up-to-date and in force. It was seen that automobile manufacturers have built proprietary distance learning
networks to keep their dealerships’ technicians trained in the latest repair techniques. Owners/managers of independent shops, chains, and municipal or government shops should take steps to encourage their technicians to pursue certification. Managers should make employees aware that certification is valued.

Limitations of the Current Study

Methodology

The study used purposive sampling, in which the researcher was responsible for creating a representative sample based on various criteria. The sample selected was also geography-bound, being limited to technicians operating in the Greater Cincinnati/Northern Kentucky area. Although the researcher strove to create a truly representative sample, and feels that comparisons demonstrate sufficient diversity based on age, experience, education, certification, and type of workplace, a larger sample, drawn from a variety of geographic locations might provide a better representation of the population as a whole.

It is possible that the survey results may show a “halo effect” in which respondents may have made assumptions concerning the expectations of the researcher, that is, assuming that the researcher would consider answers indicative of heavy use and positive attitudes toward computers to be “good” and less use and ambivalent or negative attitudes toward computers to be “bad.” This “halo effect” might explain the fairly flat levels of usage reported across the sample.
Survey Instrument

While the survey instrument was pilot-tested prior to the beginning of the study, reviewed by an educator in the field, and revisions made, there were two small anomalies. Two items, 3 and 17, which were intended to elicit single responses, instead received multiple responses from some respondents. In the case of item 3, the multiple responses did not appear to affect results. In number 17, the researcher simply selected the highest level of education checked, thereby obtaining the information originally requested. The researcher believes that neither item materially affected the overall results of the survey or the credibility of the data obtained from the two items in question.

Recommendations for Further Study

The present study provides interesting insights regarding the acceptance and use of computers in the automotive service field. While the results pointed to the acceptance of the three hypotheses, further research is needed to confirm the strength of these relationships.

Another interesting possibility for further study was suggested by the usage data describing resources that technicians reported as being unavailable in their workplaces. These include Internet access and access to automotive databases on the Internet. A number of technicians indicated that the management of their shops discouraged use of electronic communications and information sharing technologies, such as discussion lists and e-mail. A study examining the value provided by specialized discussion lists, such as the iATN or manufacturers’ discussion lists, as well as open discussion forums
or e-mail, could provide important information to managers considering whether or not to use these potentially powerful information resources.

**Conclusion**

While the present study focuses on a particular segment of the workforce, it is important to realize that the segment serves as a proxy for many other groups as well. From the early 19th century, when weavers revolted against factory-owners’ adoption of automated weaving equipment, to the late 20th century when English typesetters finally gave up their fight against modern computerized typesetting equipment, some employees have resisted the application of new technologies. Developing a better understanding of the reasons for rejection or acceptance can help us to continue to grow productivity, but, perhaps more importantly, will help us to maintain a strong workforce in the face of a growing need for people who can understand and work with our ever-increasingly complex technology. Most importantly, successfully dealing with the issues regarding adoption of new technologies can assist us in helping employees to remain productive members of their trades and professions, reducing the human costs resulting from the failure to update skill sets and remain competitive in the work environment.
APPENDIX A

SURVEY INSTRUMENT
### Survey: Use of Computers by Automotive Service Technicians

The topic of this study is the use of computer information tools by automotive service technicians. Why do some technicians use those tools and why do some not use them? The goal of the researcher is to develop a better understanding of how and why computers are used in automotive service centers, providing some insight on how these resources may be better used.

The information you provide on this form will be kept confidential. Information will be used in a research study conducted by a doctoral student at the University of North Texas.

Please place completed form in the locked box located in the office, or mail to:
Information Technology Survey
Anne J. Almeida, Assoc. Provost for Library Services
Stealy Library
Northern Kentucky University
Highland Heights, KY 41029

1. How often do you use computers at work? (Check 1 box for each item)

<table>
<thead>
<tr>
<th>Computer diagnostic workstation in the service bay</th>
<th>Daily</th>
<th>Weekly</th>
<th>Seldom</th>
<th>Never</th>
<th>Not Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td></td>
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<tr>
<td>Internet access</td>
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<td>CD-ROM</td>
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<td>DVD</td>
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<td>Electronic Databases (Motor's, Chilton's, etc...)</td>
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<td>Databases on the World Wide Web</td>
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<td>Mechanics' Internet discussion groups</td>
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<td>E-mail</td>
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<tr>
<td>Portable computers (laptops, tablets, PDAs)</td>
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<tr>
<td>Electronic Manufacturers' service bulletins</td>
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<tr>
<td>Other:</td>
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</tbody>
</table>

2. How often do you use non-computer-based information at work? (Check one box for each item)

<table>
<thead>
<tr>
<th>Print (paper) service manuals</th>
<th>Daily</th>
<th>Weekly</th>
<th>Seldom</th>
<th>Never</th>
<th>Not Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>Print (paper) Graphics, charts</td>
<td></td>
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<tr>
<td>RPO Code Books</td>
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<td>Microfiche/Microfilm readers</td>
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<td>Videotape</td>
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<tr>
<td>Other:</td>
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</table>
3. Where did you first learn to use computers?

- In high school/college [ ]
- In ASE certification courses [ ]
- In manufacturer-supplied training courses [ ]
- On the job [ ]
- At home [ ]
- Other [ ]

4. Do you have a computer at home?

[ ] Yes   [ ] No

Please respond to the following questions by circling the number that best matches your opinion, based on the following scale:

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

5. I like to use computers.

6. Computers are important to me in my job.

7. When diagnosing a problem, I usually rely on my experience to solve the problem instead of using a computer.

8. Computers are over-rated in automotive service.

9. Computers give me the most accurate information vs. paper manuals or the advice of co-workers.

10. Computers help me to do a repair right the first time.

11. When I need information about a problem, I go to paper service manuals instead of using a computer.

12. I usually first ask my co-workers about a problem before going to a computer.

13. We have excellent access to the latest computers in my shop.

14. I feel that I am well trained in using computers at work.

15. Management encourages me to use computers in my job.

16. I am an expert in the use of computers in my work.
17. What is the highest level of education that you have achieved?

- High School (Did Not Graduate) [ ]
- High School Graduate [ ]
- Vocational High School [ ]
- Some College [ ]
- Associate's Degree [ ]
- Bachelor's Degree [ ]
- Some Graduate Level Study [ ]
- Master's Degree [ ]
- Courses in Automotive Repair [ ]
- Major in Automotive Repair [ ]

18. Are you certified as an Automotive Service Technician? [ ] Yes [ ] No

A. If yes, year when originally certified: ________________

B. What type(s) of certification do you hold? (check all that apply)

- Associate's Degree w/ Certification [ ]
- ASE Certification [ ]
  - Automatic Transmission & Transaxle [ ]
  - Brakes [ ]
  - Electrical/Electronic Systems [ ]
  - Engine Performance [ ]
  - Engine Repair [ ]
  - Heating, Ventilation & Air Conditioning [ ]
  - Manual Drive Train and Axles [ ]
  - Suspension/Steering [ ]
- ASE Master Technician [ ]
- Manufacturer's Certification [ ]
- Employer's Certification [ ]
- Other: ________________________________

C. Are you periodically re-certified? [ ] Yes [ ] No

   i. If yes, date of latest re-certification: ________________

19. How long have you been an Automotive Service Technician/mechanic?

   _____ years _____ months

20. How long have you been with your present employer?

   _____ years _____ months

21. What is your age: _____ years

22. What is your gender: [ ] Male [ ] Female

23. What is your ethnicity: [ ] White (non-Hispanic) [ ] Asian

   [ ] Hispanic [ ] Other ________________________

   [ ] African-American
UNIVERSITY OF NORTH TEXAS COMMITTEE FOR
THE PROTECTION OF HUMAN SUBJECTS

RESEARCH CONSENT FORM

Subject Name: ___________________________ Date: ___________________________

Title of Study: The Adoption and Use of Electronic Information Resources by a Non-Traditional User Group: Automotive Service Technicians

Principal Investigator: Arne J. Almquist, Doctoral Student
Faculty Advisor: Dr. Linda Schamber
Institution: School of Library and Information Sciences
            University of North Texas

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the proposed procedures. It describes the procedures, benefits, risks, and discomforts of the study, as well as your right to withdraw from the study at any time. It is important for you to understand that no guarantees or assurances can be made as to the results of the study.

Purpose of the study and how long it will last: This study looks at the relationship between age, experience, and education/certification and the acceptance and use of computers by automotive service technicians. The time commitment for individual participants should be 15-30 minutes. You may be asked to participate in a follow-up interview of approximately 30 minutes.

Description of the study including the procedures to be used: The study will occur in three parts: (1) The researcher will visit a typical automotive service center to observe and to develop a better understanding of the work environment. (2) Questionnaires will be distributed to service technicians. (3) Interviews with selected service technicians will be done based on responses from the questionnaires.

Description of procedures/elements that may result in discomfort or inconvenience: None of the procedures should result in discomfort for participants. The time taken to fill out the survey and the follow-up interviews (for those selected) may be perceived as inconvenient by participants.

Potential Risks: The one potential risk foreseen by the researcher is the possibility that negative action could be taken by supervisors/managers based on the responses given by individuals concerning their use of information technology on the job. To avoid this risk, supervisors/managers will not be given access to raw data. While individual responses will be coded to allow later follow-up contact by the researcher, access to the codes will be closely guarded by the researcher. Subjects will be chosen from shops employing multiple technicians, reducing the possibility that individuals could be identified simply by their responses.

Research Consent Form – Page 1 of 3

Participant’s Initials _______
Benefits to the participants or others: This study will not result in a direct benefit to the participant. It is anticipated that the study will help us to better understand why auto technicians do or don't accept and use computers in their work. Significant investments are made each year by industry, in the form of equipment and information resources, and by technicians in the form of training and schooling. Better understanding of the reasons for acceptance and use of information technology will result in an indirect benefit to the participant by increasing the value of that person as an employee. Industry will benefit through better return on investment and customers will benefit through increased satisfaction.

Confidentiality of research records: Confidentiality of participants' responses will be strongly protected. In the first part of the study, individuals will not be identified by name. Surveys will be coded by company and name to allow follow-up contact; however, the Researcher will retain the coding key and will not share it with other parties. Survey instruments and identifying codes will be destroyed within two years after the completion of the study.

Review for protection of participants:

This research study has been reviewed and approved by the UNT Committee for the Protection of Human Subjects (940)565-3940.

RESEARCH SUBJECT'S RIGHTS: I have read or have had read to me all of the above.

The Principal Investigator, Arne J. Almquist, has explained the study to me and answered all of my questions. I have been told the risks or discomforts and possible benefits of the study.

I understand that I do not have to take part in this study, and my refusal to participate or to withdraw will involve no penalty or loss of rights or benefits or legal recourse to which I am entitled. The researcher may choose to stop my participation at any time.

In case there are problems or questions, I have been told that I can call Arne J. Almquist at (859)572-5483, or Dr. Linda Schamber at (940)565-3568, Associate Professor, School of Library and Information Sciences, University of North Texas. I understand my rights as a research subject, and I voluntarily consent to participate in this study. I understand what the study is about and how and why it is being done. I have been told I will receive a signed copy of this consent form.

Participant’s Name (please print)

Participant’s Signature

Date

Research Consent Form – Page 2 of 3  Participant’s Initials _____
For the Principal Investigator:

I certify that I have reviewed the contents of this form with the person signing above, who, in my opinion, understood the explanation. I have explained the known benefits and risks of the research.

Principal Investigator’s Signature ___________________________ Date ____________

Ame J. Almquist
Doctoral Student
School of Library and Information Science
University of North Texas

Please Return to:
Ame J. Almquist
Assoc. Provost for Library Services
Steele Library
Northern Kentucky University
Highland Heights, KY 41099

APPROVED BY THE UNT IRB
FROM 12/4/04 TO 1/15/05

Research Consent Form – Page 3 of 3

Participant’s Initials _______
APPENDIX C

SUMMARY OF CONTEXT INTERVIEW: THE SHOP ENVIRONMENT
On January 5, 2005, I visited the service center at a local new car dealership to observe and interview a service technician on the subject of computers used on the shop floor. While I had prepared for the session by reading extensively about the various systems used, there is no substitute for seeing equipment in use and receiving explanations and description from an expert.

The service technician, holding certification from ASE and certified by his automobile manufacturer as a master technician, had great interest in and knowledge of microcomputers. He indicated that he had built and extensively modified the computer that was at his work area and that he kept the dealership’s two diagnostic workstations in good repair.

The technician told me that the manufacturer supplies data in three formats: print manuals, a database supplied on DVD, and an extensive web site. He indicated that the dealership subscribes to the data in all three formats. The DVD product is fastest, is updated on a regular basis, and is easy to use. The data on the DVD product is duplicated on the website. Response does tend to be slower, so technicians prefer the DVD product for extensive searches.

Print manuals were exclusively used for diagnostics prior to the arrival of the electronic systems. They are still used, mainly for diagrams and schematics. The manuals are seen as being more portable—they can be taken to the vehicle more
readily than can the diagnostic computer systems or the technician’s personal computer. While schematics and diagrams can be printed for use at the vehicle, the networked printer is in an office at some distance from the shop floor. For this reason, it is not convenient to print these items for use on the shop floor.

The service manuals consist of standard 3-ring binders which are each about 3 to 4 inches thick. Contained in the manuals are schematics, pictures, diagrams, and diagnostic aids, referred to as “Pinpoint Tests,” which provide step-by-step sequences to determine the solution to a given problem. Information is updated on a regular basis in the form of replacement pages. The technician indicated that pages were often not received or, if received, were frequently not placed in the binder. This meant that obsolete or incorrect data was frequently left uncorrected in the days of the paper manual.

While the paper manuals have been superseded for the most part by electronic data formats, the manuals are still available and are preferred by some service technicians.

Service information is mainly provided through a manufacturer-supplied database product. When the manufacturer first began offering data electronically, access was provided through a proprietary company network operating over a satellite telecommunications system. This was in the days before broadband access became ubiquitous. The dealership was fully wired with twisted pair data cable at that time. The data cabling is now connected to a broadband connection into the public landline system. Response compared to the earlier satellite system is said to be much improved.
The service database is a comprehensive product providing a wide variety of service data to the technician. It is made available either on DVD or through a website.

The basic database product, whether accessed on DVD or on the web, allows searches based on Vehicle Identification Number (VIN), year and model, or by symptom code. Entering the VIN provides information specific to the vehicle, including extended warranty information. It also provides a record of all dealer-performed repair work that has occurred during the previous 12 months. This includes work performed both at the home dealership and in other dealerships across the country. This service record is the equivalent of a human medical record. Having the data at hand makes the servicing technician’s job a bit easier—he/she can see what solutions may have already been tried in diagnosing a problem and then can either rule them out or see if they may have been a contributing factor in the problem at hand.

Another interesting feature is a “Special Service Messages” section, which includes hints taken from the field experience of working technicians. This knowledge base is just one of multiple ways that the experience of service technicians can be shared and leveraged across multiple technicians and circumstances.

The modern automobile contains a great deal of computing power, much of it dispersed across various operating elements. Certain electronic parts are equipped with flash memory containing information necessary for the operation of the part. Just as the ROM in a personal computer contains information necessary to boot and operate the computer, the part, and hence, the automobile, will not operate properly unless the information in that part’s memory is up to date. Both the DVD and online versions of
the proprietary database have provisions to update each part’s firmware to the latest revision.

An electronic part contains other information in its memory. This may include VIN, configuration of the automobile—including the identity of other computerized parts, measurement of operating conditions, and configuration settings for the part. Again, if this information is non-existent or incorrect, the part will not function in the vehicle.

The diagnostic database includes a feature referred to as “As Built.” This feature allows the technician to look up the configuration of a particular vehicle as it was configured when it left the assembly line. A new part can then have this information downloaded into its memory from the database.

The service technician stated that the various “smart” elements of the modern automobile communicate with one another through a rudimentary network. He mentioned that new parts come with a blank memory. He stated that he has seen such parts, after having been installed in a vehicle and that vehicle operated briefly, download certain information elements, such as the VIN, from other parts in the automobile without external intervention on the part of the technician.

The online version of the database provides additional tools. Most important is an online forum for service technicians. This forum is limited to technicians working at the manufacturer’s licensed dealers. Technicians can log in and ask questions about particularly vexing problems, provide hints and tips based on experience, and provide answers to others’ problems. The service technician indicated that there is a genuine
desire on the part of participating technicians to help one another. In addition to the forum for technicians, there are also forums for service advisors and for parts staff.

Technicians can use a technical hotline for additional assistance. The hotline can be accessed by computer as well as by telephone and e-mail. The technician indicated that it was often just as easy to access the hotline through the telephone as it was to access it using a computer.

Another feature is an online tool to help determine standard labor time and costs. Tools may be ordered through the site.

The database provides technicians with a preview of new models and potential service issues. This gives technicians the ability to become familiar with service aspects of a new model before the automobile actually appears in dealership showrooms.

The service technician indicated that one problem that exists with the online version of the database is that its interface changes frequently, with little apparent reason. Diagrams migrate from PDF to HTML format with resultant changes in the way that the diagrams are navigated. Categories are moved. Information becomes more difficult to find. All in all, however, the technician sees the move from paper to electronic to have been a major improvement in accessing service data.

Diagnostic Systems

The technician next began to discuss the various generations of computerized diagnostic systems that have been and continue to be used to more quickly and accurately pinpoint problems than the manual methods of yesterday.
Computerized engine controls first began appearing in production cars in the early 1980s. The early modules were primitive compared to the intelligent parts of today. The first diagnostic tester was a handheld unit which retrieved 2 digit “service codes” from the onboard module. A manual would then be referenced to determine the meaning of the code.

Interestingly, if a test device was not available, a technician could retrieve the code using a standard analog voltmeter. This piece of equipment has been a staple of the electronic technician’s tool kit for many years and simply measures the level of current and voltage and checks the continuity of a circuit. Using the voltmeter, the technician would check for a series of pulsations in voltage. For example, a service code 32 would be indicated by three pulses, a five second pause, and then two additional pulses.

In the late 1980s, the manufacturer released a PC-based diagnostic workstation. The underlying PC was an 80386-based computer with CD-ROM drive and color touch screen monitor. The machine was housed in a standard rolling tool cabinet. The workstation that I observed had numerous tool drawers, all filled with various cables and connectors.

The workstation was a great improvement over the earlier handheld device since the computer would test various systems and provide more detailed information on the problem than the two digit code formerly provided.

The technician would perform the following steps to do a computerized analysis of the problem:
1. Obtain codes with the key off and engine off—hard fault or continuous codes.

2. Key on, engine off—failures that have occurred in the past but do not currently exist.

3. Key on with engine running—the computer “exercises” outputs and then monitors inputs to verify whether a reading is in range.

These steps were much less tedious than the previous methods of either running pinpoint tests or obtaining a code and then running pinpoint tests. With the computer diagnostic workstation, many of the pinpoint tests were eliminated along with much dirty and uncomfortable work. It is important to note that not all manual checks are eliminated. The computer cannot tell, for example, if there is water in the fuel tank. This still requires a physical check.

The computer does not do all of the work for the technician. The process is not instantaneous and the system does not automatically provide an answer. Depending on the readings, the computer may still suggest a pinpoint test, however, the system does provide much richer information and does eliminate steps.

One interesting item mentioned by the technician was that the manufacturer formerly required service centers to leave the workstation running at all times. This allowed the manufacturer to download information, in the form of logs, from the workstations. Ostensibly, this was used by engineers to spot trends that might point to service defects or other issues. The technician indicated that there was a fear among some technicians that the manufacturer was also using the technology to check up on technicians.
The technician noted that the manufacturer ceased supporting the system in 2000. Many dealers discontinued its use. The technician indicated that his dealership had considered removing the unit from service but that he had argued that it should be kept for the reason that the next generation system was incompatible with automobiles containing older onboard computers. The workstation supports automobiles produced from 1986 through 2000. In essence, if the first generation system was abandoned, the dealership would have been unable to service older automobiles.

The technician estimated that 90% of the automobiles serviced by the dealership were manufactured after 1996. He suggested that this was due to the fact that dealership service is perceived to be expensive and that owners of older vehicles were keeping their vehicles due to economic need and generally took their cars to independent service centers.

Interestingly, the technician stated that the dealership would not perform diagnostic service on vehicles that were built in the era before onboard electronics. For example, although the vehicle is less complex than today’s models, a classic model from the 1960s would not be serviced since the diagnostic routines required would be much too labor intensive. Also, the range of models and years is wide enough over a 15 year period. The knowledge required to address the service issues in a 40 or 50 year range of years, each with multiple models, would be too great for the technician to work efficiently.

In 2001, the manufacturer released a second generation diagnostic workstation. That machine was based on an Intel Pentium processor running at 223 MHz and came
with a flat panel monitor. The system apparently started out to be laptop based. What resulted was a dockable device very similar to the current Tablet PC. The cabinet was smaller than the earlier generation but still based on a large tool case.

The newer machine could be undocked from its base, which served as a charging station and provided a network connection. Once removed from its base, the computer could be carried to a vehicle and attached to the vehicle’s onboard diagnostic connection.

The machine runs the same basic tests as the earlier generation, albeit at a faster speed. A built-in oscilloscope function is provided. Model years supported run from 1994 to the present.

A major enhancement is the ability to rewrite software to fix a mechanical problem that would formerly have required a repair. The technician provided an example: A transmission is removed from an automobile. During the course of a repair, a small spring is replaced. By accident, the new spring is slightly stiffer than the original. This results in a plunger not actuating. Rather than opening the transmission and physically replacing the spring, the logic in the transmission can be reprogrammed through the diagnostic workstation so that additional force is applied to the plunger to allow it to compress the spring.

The newer system also automatically prompts when on-vehicle firmware is outdated and new versions are available for download.

Another system that is used when a job must be done very quickly is a handheld device that uses flash memory card technology to store vehicle-specific data. If a
particular vehicle is not listed, the thin card can be updated with the appropriate data by slipping it into an appropriate slot on the diagnostic workstation. The handheld device uses a simple LCD display to display diagnostic readings.

Although the diagnostic workstations provide more information and provide it in an easy to read screen display, the handheld can be hooked up and a code retrieved while the more elaborate machines are still booting up and configuring.

The handheld unit can be used in place of the diagnostic workstation to update the information contained on vehicle modules. You can download data from the internet to a floppy disk, transfer the floppy to the diagnostic workstation, download to the flash memory card, put the card into the handheld device and then update the module on the vehicle. While this is a roundabout way of obtaining the same result available by simply attaching the vehicle to diagnostic workstation, there are circumstances where this is a welcome workaround during equipment or communications failures.

The technician indicated that diagnostic work was limited to the automobile brand sold by the dealership. When another brand is brought into the dealer’s shop, for example, a used car sold by that dealership, but of another brand, the work is generally subcontracted to another shop. The layout of parts between various makes differs quite a bit, but a major problem is the difference in diagnostic codes and diagnostic equipment. Due to experience and specialized knowledge, manufacturer-trained technicians generally stay within a particular manufacturer’s brand family, although they may move from shop to shop within that brand.
The codes and equipment connector formats were proprietary to various manufacturers in the early days of computerized diagnostics. In the mid 1990’s, the federal government mandated standards in the type and location of the diagnostic connectors on all automobiles and mandated that diagnostic codes be made available to shops outside of dealership networks.

The reason for these changes was to prevent dealerships from using diagnostic information to create an unfair business advantage over independent garages. The technician stated that while codes have been standardized, the codes that are available to independent service centers are more generic than those available to a manufacturer’s service centers. For example, the average motorist can now access service codes through diagnostic workstations available at many auto parts stores. While these machines will provide a readout that describes a general problem, there may be potentially multiple circumstances causing the error. The generic diagnostic equipment may not pinpoint the problem to one or two parts. As a result, you may replace a part to address a code provided by the store’s equipment and then find that the error still persists. The equipment in a manufacturer’s service center will retrieve more detailed codes that would tend to focus in more closely on the actual problem.

Issues With the Use of Computers in Diagnostic Work

The technician stated that while computers have greatly streamlined and improved the service process and have provided more detailed information, there are negative issues.
First is the aforementioned issue of obsolescence. As onboard electronics and diagnostic systems change and improve, there comes a point at which new diagnostic equipment is no longer compatible with older onboard systems.

Pre-computerized automobiles can still be serviced, either by the owner or a specialist, since their systems are mechanical. Required readings are taken with mechanical or electrical instruments and data on appropriate tolerances is widely available.

Automobiles equipped with early generation electronics are more problematic. As is the case with obsolete computer media and software, there may come a point where diagnostic equipment capable of reading the information from early onboard electronics is either unavailable or very expensive. This in turn may place a limit on the useful life of an automobile, regardless of its overall physical condition.

Computers in the automotive service shop bring a problem well known in white collar environments to the blue collar world: the risks of computer outage. The technician described problems that had occurred some few weeks before the interview took place. The newer diagnostic workstation developed a fault which resulted in a lack of network connectivity and the inability of the docking station to charge the PC. Technical support was called and the support representative walked the technician through numerous, complex steps. It was determined that the docking station was defective.

Unfortunately, the support representative told the technician that a replacement docking station could not be shipped for two weeks. Two weeks without the
workstation would have caused a major disruption in the service center’s workflow. While a handheld device would have sufficed for about 50% of service requests, the remaining service requests, particularly those concerning drivability, would have had to have been referred to other service centers or delayed until the diagnostic PC was repaired.

The technician was able to visit a neighboring dealership to make comparisons with their workstation and was able to effect a temporary repair that allowed the machine to function until the new part arrived.

Another issue mentioned by the technician concerned the way in which computer workstations obtain readings from the vehicle. Traditional analog devices directly measure actual, physical outputs. That is, current, voltage, temperature, fluid and air flow, and so on, are physically measured at the source.

Computer diagnostic equipment frequently derives its information from indirect sources. In certain tests, information is coming from an electronic rather than a mechanical source. This can lead to readings that may be deceptive.

For example, one test measures “relative” compression of each of the cylinders. The technician mentioned that you can remove one or more sparkplugs, causing zero compression, but the computer will register a mere lowering of compression on the affected cylinders. The compression test is not measuring pressure directly, but is deriving the information electronically from other modules causing the potentially deceptive readings.
Computer diagnostic workstations are not “magic.” At best, they extend the capabilities of a skilled technician. They are no substitute for skill, experience, and knowledge. They certainly streamline the diagnostic process, although you can still end up at a point where multiple options must be tried.

The Technician’s Personal Insights

Asked how he had developed his computer interest/expertise, the technician responded that he had entered the field directly from high school while working for his present employer. Working as an uncertified mechanic, he performed low-skill tasks such as replacing brake linings, mounting tires, and performing oil changes.

With the arrival of computers in automobiles, he noticed that few technicians seemed to possess skills in the areas of electronics and electricity and decided that he would specialize in those segments of the automotive field.

He purchased his first computer from a friend who worked at an electronics store. He found that machine to be unreliable and ended up tinkering with it to improve it. Over time, he began to build his own computers and has upgraded his present workstation through several generations of components. He also has been entrusted by his employer to maintain and upgrade the diagnostic workstations, troubleshooting the equipment and replacing a number of components, including disk drives and memory.

By specializing and becoming certified in electronics and drivability, he has seen his income increase and is doing work that is much more enjoyable than that which he performed when he entered the field.
Computer technology is expensive. The newer of the two diagnostic workstations that I saw cost the dealership several thousand dollars when new in 2000. The shop had only two diagnostic workstations. While they overlapped in terms of the years and models of automobiles covered, in most cases, this limited availability to one technician at a time.

Traditionally, automotive service technicians purchase their own tools. Due to the high cost of the technology and the need for up to date information, employers purchase information and associated equipment. These include the computers and associated equipment, data networking, network access, and information subscriptions (including website access, DVD, and print manuals).

Suggested Improvements

The technician suggested that a number of onboard vehicle components are actually connected by a rudimentary data network and that they actually share data. He suggested that the time might be ripe for Wi-fi connectivity in automobiles. This could simplify work on the shop floor with the ability to establish a wireless connection between an automobile and diagnostic equipment.

While observing use of the portable diagnostic computer, I observed that the new Tablet PCs would be a perfect fit in this environment, allowing a technician to more easily transport the diagnostic machine to the vehicle, providing access to online schematics and diagrams without printing, among other advantages.
APPENDIX D

SUMMARY OF CONTEXT INTERVIEW:

A COMMUNITY COLLEGE AUTOMOTIVE SERVICE PROGRAM
Location: Community College Automotive Service Program

Interviewee: Program Chair

On June 20, 2005, I met with the chair of the automotive service program at a large, urban community college. During the course of an afternoon, we discussed various aspects of the program.

The chair’s experience includes certification as an ASE Master Technician. He indicated that he taught for 7 years in a high school system and for 10 years in an industry-sponsored training program. From that point until the present, he has taught at the community college.

Asked to compare his community college program with a high school program in automotive service, he stated that high school programs generally provide certification in four of the ASE areas while the college programs provide certification in all eight. All work, in either setting, is taken from the same task lists provided by the National Automotive Technicians Education Foundation (NATEF). Programs at both levels are certified by the NATEF.

At the community college level, students have the option of pursuing an Associate’s degree or certification without a degree. The Associate’s degree at this particular institution is an Associate’s Degree in Applied Business.

The degree program differs from the certificate program due to the requirement of general education and business core courses for the Associate’s Degree. Of the
students enrolled in the automotive service program, the chair estimated that 30-35% of enrolled students would actually go on to complete a degree.

When asked to contrast the career paths for certified or degreed students, the chair stated that while virtually all of the graduates would start as technicians, degreed students had more options for career growth. The possibility that a degreed student will eventually own his/her own service facility is high.

All students throughout the college are required to obtain two years of work experience during the course of their educational program. This is provided through co-op assignments with local employers. It was mentioned that students will occasionally co-op, decide that money is more important than further education and then drop out of school and take a permanent position. The chair stated that such students generally find that their position stagnates both in terms of compensation and challenge and eventually they will seek certification or a degree.

The age demographics for the college’s automotive service program are interesting. The chair estimated that the average age of the general student population at the college is 28 years. In the automotive service program, the average age was estimated at 24-25 years. It was commented that some students go to work directly from high school programs and quickly realize that they need additional training.

Some of the students in the program hold four year degrees. The chair stated that he had seen a number of people with accounting degrees in particular. He also stated that, in general, older students appeared to have a much higher level of discipline, and hence, were often better students than the younger students.
When asked about the age of older students, the chair stated that there were a few students in each class that were more than 30 years old. In particular he mentioned that he had had one student in his 60s who had retired from another profession. This individual owned several automobiles as a hobby and wanted to learn the skills necessary to service his own vehicles.

As the use of computers has expanded in the automotive field in general, and in the automotive service field in particular, it would be expected that training in the field would undergo a change as well. The chair was asked about changes in his program since the early 1970s when he underwent certification.

The chair stated that the program was constantly in a state of change to meet the needs of industry. A section in electronics has had to be added to each subject. For example, brakes, formerly a mechanical system, now have an electronic element in the form of antilock braking systems (ABS). A section has been added to cover the electronic aspects of braking systems.

Formerly, the program took five terms to complete; it now takes four. The total number of credit hours required for graduation is 110. Electronic Accessories, formerly an elective, is now a required course.

Computer modeling is used much more in the classroom today than previously because of the increased availability of hardware and software. As information, in the form of databases, has moved into electronic format, it has become much more expensive in the opinion of the chair. Equipment used in the classroom includes a video
system (used to display small parts to the class), and an electronic student response system.

What computer training and exposure does the average student receive? According to the chair, about 40% of assigned tasks involve the use of a computer in some way. All students are signed up for the International Automotive Technicians’ Network (iATN), an internet discussion forum. Note that students do not post questions to the network until they have been reviewed by the instructors.

Students use the standard database tools of the field. In the first class in the program, students are taught basic information retrieval skills such as mousing and search strategies, as well as the use of paper service manuals and handheld computers. The latter may be very simple machines with two or three keys or a numeric keypad. In addition, students get a lot of hands-on experience with computers in their general education and business courses. For those students who type at less than 20 words per minute, a keyboarding class is required.

The chair indicated that the automotive service program is general, not concentrating on a specific make of automobile. All students have to co-op during their time in the program, and some will be assigned to new car dealerships, meaning that they will have to specialize on a particular brand of automobile. The courses themselves are not manufacturer-specific. However, some manufacturers’ training materials are used in the courses.

The philosophy of this particular department is to teach students how a given type of system works. The functions of basic systems are basically the same regardless
of make, just wired or arranged differently. Students are taught to understand the processes behind the system.

Germene to the study at hand is students’ acceptance of computer technology. The chair indicated that, unlike the past, virtually none of today’s students come into the program with much experience in working on automobiles. They do come into the program with a good deal of experience with computers. It’s rare to find a student who has never used a computer. Rather, in the opinion of the chair, the majority of the students use computers more than they should. They want the computer to do the work for them. They don’t rely enough on their experience.
REFERENCES


