User's Influence on
Energy Consumption with Cooking Systems
Using Electricity

By

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Dissertation submitted to the Faculty of the

Virginia Polytechnic Institute and State University

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Housing, Interior Design and Resource Management

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April, 1997
Blacksburg, Virginia

Key Words: Energy, Consumer, Cooking System, Cooktop, Cookware

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(ABSTRACT)

The research purpose was to explain the user's influence on energy consumption with cooking systems using electricity. This research was conducted in two phases. The research objective of Phase I was to determine if relationships exist that explain the user's influence (i.e., user characteristics--knowledge, experience, practices, and user interaction--and appliance operating time) on the energy consumption of cooking systems using electricity. The ultimate aim of this research, the outcome of Phase II, was to identify categories of cooking style that explain the user's influence (i.e., user characteristics and appliance operating time) on energy consumption of cooking systems using electricity.

The data used to answer the research question consisted of video tapes of consumers preparing the research menu, a survey, and data recorded on a data collection sheet by the researcher (i.e., watthour consumption).

Simultaneous triangulation was used to answer the research questions. Phase I determined that energy consumption was correlated with knowledge, user interaction, practices, appliance operating time, cooking system interaction, goodness-of-fit, information, behavior, the user, and statistical interaction between the cooking system and goodness-of-fit. Independent variables explained 38.6% of the variation in energy consumption. However, when only the variables under the user's control were included in the regression model, just 25% of the variation in energy consumption was explained. Phase II determined the three most important factors that distinguish the five cooking style categories based on user characteristics (i.e., patient style, average

style, uninformed style, hurried style, and hurried style with no control) were: (a) percentage of the sample that left the heat source on after cooking, (b) percentage of the sample that did not match the diameter of the heat source and the diameter of the cookware when using high heat, and (c) percentage of the sample that fried using high heat. Additional variables that differed among categories were: reusing hot elements, use of retained heat, and use of medium heat settings. In summary, important factors in explaining variations in energy consumption include: inherent characteristics of the cooking system, user's knowledge, highest heat setting selected and matching the diameter of the heat source with the cookware diameter, leaving the heat source on after cooking, and selecting highest heat setting when frying.

In summary, important factors in explaining variations in energy consumption included inherent characteristics of the cooking system, user's knowledge, highest heat setting selected and matching the diameter of the heat source with the cookware diameter, leaving the heat source on after cooking, and selecting highest heat setting when frying.

Three categories of consumers cooking style were developed (i.e., low, average, high energy consumption) to summarize the data. The highest heat setting selected and leaving the heat source on after cooking was completed were factors that distinguished consumers among the three categories.

ACKNOWLEDGMENTS

The author has found that when resources were limited, others supplied resources to enable her to continue this degree. Therefore, the author recognizes people who have contributed to completion of this research and degree with sincere appreciation and gratitude to:

The Department of Housing, Interior Design, and Resource Management for financial support and use of the Residential Appliance Laboratory, instruments, and appliances.

Dr. Rebecca Lovingood, my major advisor, for facilitating the actualization of a dream and providing me with the tools necessary to achieve my future goals. She has opened doors that I never knew existed. I would like to thank her for her patience, energy, time, limitless ideas, endless support, encouragement, challenge, and friendship. Most of all, thank you for believing in me through it all.

Dr. Irene Leech, for her expertise with consumerism. Thank you for your support, encouragement, for always having time to listen, and for providing me with professional development opportunities.

Dr. Julia Beamish, appreciation is expressed for her patience, ideas, and support. In addition, appreciation is expressed for providing housing research and publication opportunities.

Dr. Kathleen Parrott, appreciation is expressed for her patience, listening, support, and for providing me an opportunity to do outreach education through Extension and publication opportunities.

Dr. Jesse Arnold, for his expertise with statistics. Thank you for your support and statistical assistance with this research and other research projects.

Appreciation is also extended to: Dr. Rosemary Goss for her support and assistance when writing for publication; Dr. Ruth Lytton for her support, assistance with publications, and for teaching me the importance of volunteering; and Dr. Janice Woodard, Dr. Nancy Barclay, and Dean Janet Johnson for their support and encouragement during this degree.

Further appreciation is extended to the department and college staff for their support and assistance. Specific staff members remembered are Joyce Bandy, Dove Robertson, Debbie Elkins, Sandy Graham, Gail Carroll, Connie Smith, and Butch Hilton.

Judy Midkiff is specifically appreciated for her unlimited support and continuous encouragement, for providing a vacation home, and for always bringing fun to town. Appreciation is also expressed to her family for their hospitality on holidays.

To my many friends that have come and gone through the graduate office doors, I have appreciated our opportunity to learn together. Appreciation is further extended to Donald Caudill for his never ending support and encouragement. For our many hours of discussion, sharing of ideas, and words of wisdom, appreciation is extended to Ali Al-Najadah. For their support and encouragement, I acknowledge: Leslie Johnson, Sandra Reynolds, John Grable, Barbara O'Neill, Pat Gorman, and Abbott Packard. I would also like to thank the Steel Magnolias for their never ending support, always listening, and giving me a hug when I needed it: Cindy Beacham, Cheryl Kieliszewski, Barbara McFall, and Shari Park-Gates.

Dr. Dorothy Mitstifer, the executive director of Kappa Omicron Nu, is appreciated for sharing of ideas, support, and encouragement.

Dr. Betty Young is appreciated for her support, encouragement, and for calls to offer words of wisdom.

To Roslyn Kerr, my advisor from the University of Maine at Farmington, appreciation is extended for her continuous support and encouragement, and for showing me the road.

I am grateful to the following organizations for their financial contribution to this degree: University of Maine at Farmington Alumni Association, Virginia Association of Family and Consumer Sciences, Kappa Omicron Nu, Association of Home Equipment Educators and the International Appliance Technical Conference, Graduate Student Assembly, and the College and University Section of the American Association of Family and Consumer Sciences.

Special appreciation is expressed to my parents Mr. and Mrs. Storer DeMerchant, my brother Storer Jr., and my sister Mary, for their endless ability to listen, support, and encourage me, as well as the many care packages, financial loans, health insurance, and airline tickets home. Without my family this adventure would not have been possible.

Poem to Start and End With--

"Here on the pulse of this new day
You may have the grace to look up and out
And into your sister's eyes,
And into your brother's face,
Your country,
And say simply
Very simply
With hope--
Good Morning."
(Maya Angelou, 1993)

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Introduction

Technological innovations have dramatically increased during the last 30 years. The number of choices available to consumers in cooktop and cookware design have significantly changed. Market choices of electric cooktops include conventional electric coil, solid element, radiant coil under glass ceramic, and halogen under glass ceramic. Choices of cookware material include steel, glass ceramic, heat resistant glass, aluminum, stainless steel, copper, and cast iron. Construction differences in cookware include gauge (thin, medium, heavy), applied finish (tin, porcelain-enamel, fluorocarbon, anodized--electrochemical), mechanical finish (hammered, stamped, clad, ply), and heat core (aluminum, cooper). Market choices of cookware use a base material in addition to one or more construction techniques. In addition, differences in cookware configuration include diameter of the opening and contact area; contact area that is flat, roughened, or concave; and the sides--perpendicular or curved.

A cooking system consists of the cooktop, cookware, and control device (Schott Glaswerke, 1984). Cooking system parameters influence each other and possibly may work against each other (Schott Glaswerke). It is not possible to develop a better cooking system by altering a single parameter without consideration of the relationships among parameters (Schott Glaswerke). When the load is constant, characteristics of cooktop, cookware, and the interaction within the system influence energy consumption (DeMerchant, Lovingood, & Leech, 1995; Goss & Lovingood, 1978; Lovingood & Goss, 1980). However, the consequence of user's cooking style has not been considered. Therefore, the purpose of this research was to determine the user's influence on energy consumption of cooking systems. The ultimate aim of this research was to identify categories of cooking style that explain the user's influence (i.e., user characteristics--knowledge, experience, practices, and interaction--and appliance operating time) on the energy consumption of cooking systems.

Justification

Why study energy consumption? Electricity is only one form of energy and is said to be the ultimate commodity (Lubove, 1994). "The residential sector accounts for approximately 20% of the national energy consumption in the United States. Of that fraction, the home appliances account for about 20%--or only about 4% of the total national energy use" (Weizeorick, 1993, p. 5). Four percent of the total and two-thirds of that used for space conditioning and refrigeration leaves very little to be used for cooking.

Why study the user's influence on energy consumption of cooking appliances if they use a small amount of energy? As Behrens (1977) stated, "from the functional stand point, majors (i.e., major appliances) are remarkably efficient machines. ...Any significant energy reductions will have to come through more efficient use of appliances" (Behrens, p. 6). The user of appliances is a significant variable in the energy efficiency equation, due to the user's habits in interacting with the equipment. Therefore, by understanding how the user influences the energy consumption of cooking systems and what factors explain the relationship between the user and energy consumption, educators can design programs to enable consumers to reduce energy consumption in cooking. This impacts total energy consumption via the transfer of knowledge to other more energy intensive situations.

Research that investigates cooktop and cookware, or cooking systems, is not new. For example, one of the earliest studies was conducted by Good in 1923 to investigate the thermal efficiency of stew-kettles of aluminum ware and enameled ware. In addition, numerous studies have been conducted at Virginia Tech and other universities to investigate the various aspects of the cooking system. Some of the more recent research determined the performance of the cooking systems when the user was controlled (Lovingood & DeMerchant, 1994; Martin, Lovingood, Long, & Schnepf, 1990). Lovingood and DeMerchant and Martin et al. each conducted three tests to evaluate the cooking systems' performance: evenness of heat distribution, speed of heating, and retained heat. Research also has been conducted to determine the relationships of consumers' knowledge, practices, and satisfaction with the interaction of cooking system components (DeMerchant, Lovingood, Leech, & Johnson, 1994). However, energy consumption was not the central focus of the aforementioned research and the researchers did not address how the user influences energy consumption.

Purpose of the Study

The contribution of this research is how the user interacts with cooking systems: (a) what relationships facilitate explanation of the energy consumption of a cooking system, and (b) what the user did that influences energy consumption of the cooking system, e.g., consumer's style.

The purpose of this study was to explain the user's influence on energy consumption with cooking systems using electricity. This research was conducted in two phases. The objectives of Phase I were:

1) to determine if relationships exist that explain the user's influence (i.e., user characteristics--knowledge, experience, practices, and user interaction--and appliance operating time) on energy consumption with cooking systems using electricity.
2) to determine the percent of variance in energy consumption that may be explained by the cooking system, appliance operating time, and user characteristics.

The objectives of Phase II were:

1) to identify categories of cooking style that consider the user characteristics and different cooking systems to explain the user's influence (i.e., user characteristics--knowledge, experience, practices, and user interaction--and appliance operating time) on energy consumption of cooking systems using electricity. Hence, the categories are based on user behaviors that influence energy consumption with cooking systems.
2) to identify categories of cooking style that consider just the user characteristics and appliance operating time to explain the user's influence on energy consumption of cooking systems using electricity. Hence, the categories consider the user's influence on energy consumption with cooking systems.

Research Questions

Phase I

1) Is there a relationship between user's influence (i.e., user characteristics--knowledge, experience, practices, and interaction--and appliance operating time) and energy consumption of cooking systems using electricity?
2) What percent of variance in energy consumption may be explained by the cooking system, appliance operating time, and user characteristics?

Phase II

1) What categories of cooking style explain the user's influence (i.e., user characteristics--knowledge, experience, practices, and interaction--and appliance operating time) on energy consumption with cooking systems using electricity when considering the user characteristics and different cooking systems?

2) What categories of cooking style explain the user's influence on energy consumption with cooking systems when considering just the user characteristics and appliance operating time?

Delimitations

Due to money and time constraints and limited availability of equipment, the following delimitations were established.

1) Existing video tape data were used. Therefore, observations were eliminated (i. e., there were missing data) due to the video camera accidentally being turned off or the video tape braking.
2) Video tapes were viewed once per observation (Obs=360) with a normal speed (60 frames per second) and fast-forward (three times normal speed) when possible.
3) Trained assistants analyzed the 360 observations on video tapes using a ratio of 25:1 to ensure reliability. Therefore, the researcher watched 25 observations and then the assistant watched the 25th observation.
4) Existing data collected from previous cooking system research were used. Consumers' knowledge and experience were determined from existing survey data.
5) Only electrical energy consumption data were used.

Limitations

The existing data had the following limitations which may affect generalizability of the results:

1) Only 15 participants were used in the investigation.
2) The participants were all young inexperienced cooks.
3) The cultural backgrounds of participants was African-American and Caucasian.
4) The research was conducted in only one area of the country. All 15 participants were Virginia Tech students. However, the participants were from California, Virginia, West Virginia, Arizona, Maryland, and the District of Columbia.
5) User's influence on energy consumption with gas ranges was not investigated; only electric energy consumption data was available.
6) Food quality was not measured for broccoli, white sauce, and carrots. A standard for food quality was not established; the standard for doneness was determined by each participant.

Operational Definitions

Dependent Variable

Energy consumption. Number of watthours required to complete the cooking process. The difference in watthour meter readings, recorded at the beginning and ending of the cooking operation, was calculated to determine the energy consumed.

Independent Variables

Energy sources. The specific cooktop types under investigation. Energy sources used in the investigation included conventional electric coil, solid element, radiant coil under glass ceramic, and halogen under glass ceramic.

Container materials. The specific types of cookware skillet and saucepan used in the investigation. Container materials used in the investigation included thin gauge aluminum, heavy gauge aluminum, heavy gauge aluminum non-stick, heavy gauge stainless steel with thick aluminum heat core, thin gauge porcelain-on-aluminum non-stick, and glass ceramic.

Cooking system. A specific combination of energy source and container material. Four energy sources combined with six types of cookware yielded 24 cooking systems.

Goodness-of-fit (cooking systems). DeMerchant (1993) determined goodness-of-fit when developing a compatibility scale for cooking systems. The diameter of the cooktop units and diameter of cookware base were measured and compared to determine goodness-of-fit. Results were quantified as the following: If neither the skillet nor the saucepan diameter corresponded with the heat source ≤ 1/4" then = 1 point; if either the skillet or saucepan diameter corresponded with the heat source ≤ 1/4" then = 2 points; and, if both the skillet and saucepan diameter corresponded with the heat source ≤ 1/4" then = 3 points.

Appliance operating time. Length of time between the on and off time for each cooking operation; total operating time is the summation of appliance operating time for each cooking operation.

User characteristics. The user characteristics under investigation for this research included knowledge, experience, user interaction with the cooking system, and practices. User interaction and practices are the overt behaviors exhibited by the consumers when using a cooking system. The variable user is the result of statistical interaction between user's information and user's behavior.

Information--knowledge. A measure of the information that consumers have about cooktops and cookware as determined by a pretest and posttest evaluation.

Information--experience. A compilation of encounters that consumers have undergone regarding cooktops and cookware (e.g., familiarity with cooking procedure, having purchased cookware, number of different types of cooktops and cookware regularly used).

Information--interaction term. The statistical interaction between the user's knowledge and the user's experience.

Behavior--interaction. A five point scale was developed by Lovingood, Bentley, Lindstrom, and Walton (1987) to describe the intensity of user interaction.

This research considered user interaction as the number of times consumers interact with or adjust the food, cookware, or cooktop controls. Manipulation of the food is the number of times that consumers stir, turn, or move the food in any way during the cooking process. Cookware manipulation is the number of times that a consumer moves or shakes the cookware in any way during the cooking process. Cooktop control manipulation is the number of times that a consumer adjusts the controls in any way during the cooking process.

Behavior--practices. Practices are a compilation of the behaviors exhibited by the consumers as they take advantage of functions or features of the cooking system that influence energy consumption, i.e., retained heat, preheated element, cover on cookware during cooking, heat source left on after cooking, and matched diameter of the cooktop and cookware's contact area.

Behavior-interaction term. The statistical interaction between the user's interaction and the user's practices.

CHAPTER II

Literature Review and Framework

The review of literature for this study explored related literature on cooking systems in order to establish a framework for the study and a justification for variable selection. The purpose of this research was to explain the user's influence on energy consumption of cooking systems using electricity. Hence, the literature review addressed energy consumption of cooking systems in general and is focused on independent variables in the following categories: cooking system, cooking activities, user characteristics--knowledge, user interaction--and appliance operating time. This research was viewed from a management perspective and was designed to investigate how consumers implement a plan within the management process. The unique contribution of this research is identifying how an individual's cooking style--a person's use of resources in cooking--impacts the resources of a household, namely, the energy consumption of a cooking system.

The objective of this section is to review the pertinent literature that provides support for the framework of the management process. The components of the framework serve as the outline for this section. Therefore, within the cooking system environment, the cooking activities and the sub-system variables under investigation are user characteristics, appliance operating time, and energy consumption.

Resource Usage

Management may be defined as the process of using resources to achieve goals (e.g., Goldsmith, 1996). A consumer's energy consumption practices/habits relate to management through the application of decision-making skills. A habit is the absence of fresh decision-making (Gross, Crandall, & Knoll, 1973). Goldsmith asserted that habits are often unconscious patterns of behavior.

According to Knoll (1963), management involves planning, implementing, and evaluating. However, Deacon and Firebaugh (1988) included planning and implementing which was further subdivided into actuating and controlling.

This research investigated the management constructs of actuating and controlling, the subparts of implementing. Participants were provided a plan--recipes and instructions--along with premeasured and weighed ingredients and were instructed to actuate the plan with each cooking system, i.e., to put the plan into effect. It was assumed that how consumers actuated the plan is influenced by their knowledge and experience, which further influenced the consumer's interaction--overt behavior or cooking style--to impact appliance operating time and ultimately energy consumption. For example, when the user cooks on high heat, there is a tendency for less control of the process requiring an increased amount of manipulation and energy to be utilized.

Controlling is checking actions and outcomes for conformity to plans and, if necessary, adjusting standards or sequences (Deacon & Firebaugh, 1988). The sequence of the activities and quantity of manipulation influences appliance operating time and energy consumption, e.g., did the participants dovetail activities or use retained heat during any activities. Each time the heat settings and food are manipulated, the user is attempting to control the process and thereby check actions and outcomes.

In summary, this research was designed to investigate how the user influences the outcome of cooking--energy consumption--as individuals implement plans--recipes--or more specifically, the actuating of plans and controlling that occurs while using cooking systems. Further, this research determined how consumers use their resources (i.e., knowledge, experience, interaction and practices with a cooking system) to achieve a goal--cooking. The next section will examine the research related to these variables.

Literature Related to Cooking Systems

Cooking System Environment

The cooking system environment contains the cooktop and cookware as well as the goodness-of-fit of the system investigated.

Cooking systems. Thermal efficiency of cookware was emphasized in early studies. It has been concluded that the gauge, diameter, and material all affect performance of the cooking system (Good, 1923; Landreth & Hutchinson, 1929; Monroe & Smith; 1934; Roberts, 1935; Sater & Peet; 1933; Swartz, 1931; Swartz & Jones, 1931). The recommendations from these studies were to use flat bottom cookware with a diameter that matches the diameter of the energy source and has perpendicular sides and a tight fitting cover. Howard (1978) validated the previous research when he found that a utensil which does not completely cover the element, or one which can only contact the element over a small area, is the least efficient.

Martin, Lovingood, Long, and Schnepf (1990) investigated cooking system interaction by considering the compatibility of the energy source (cooktop) and container material (cookware). They stated that if the bottom of the pan is to be heated uniformly, then heat must be transferred horizontally as well as vertically. Their investigation was conceptually grounded within the physical principles of heat transfer which indicate that a cooking system is composed of the inherent characteristics of the cooktop and cookware.

Laughon (1980) identified variables that influence energy and time required in cooking pan diameter and shape, pan material and gauge, use of covers, food load thickness, and food density. Through choices in cookware and its placement on the cooktop, the user of a cooking system will have a direct influence on each of the previously mentioned variables.

Cooking Activities

Turpin (1989) defined cooking as the achievement of desired food quality through temperature change. When food is cooked, heat induces a physical or chemical change. Various factors affect the resulting performance of the cooking system.

Weber (1958) stated that surface unit cookery is much more complex than other cookery because a wider temperature range is generally used, the number of foods is greater, and only the bottom of the cookware is exposed to the heat source. Four cooking operations that Weber identified were frying, warming, waterless, and boiling.

User Characteristics

Literature that investigates user interaction with cooking systems is extremely limited. For example, Saxton (1991) is the only author that addressed the concept of cooking behavior. He identified seven American "cooking behavior" segments based on cookware sales and global eating patterns as:

	Household %	Dollar %
Power Gourmets	8	21
Practical Gourmets	6	15
Bogus Gourmets	8	19
Basic Cook: Involved	21	26
Basic Cook: Uninvolved	11	8
Reluctant	22	8
Non-cooks	24	3

The cooking behavior segments have been labeled with percentages of American households per segment. Dollar percentage represents the percentage of the total number of dollars spent on cookware for each cooking behavior. Approximately 22% of the American households spend 55% of the total dollars spent on cookware purchases. Hence, the cooking behavior segments developed by

Sexton are a marketing tool based on cookware sales, compared to how consumers actually use the products that they purchase. Therefore, Saxton addressed the purchasing behavior of consumers, not user characteristics regarding usage of cooking systems.

Knowledge. DeMerchant, Lovingood, Leech and Johnson (1994) found that consumers' knowledge was significantly higher after consumers had cooked with 30 cooking systems. Furthermore, they found that knowledge, as a dependent variable, seemed to influence satisfaction with cooking systems.

User interaction. A user interaction scale developed by Lovingood, Bentley, Lindstrom, and Walton (1987) and later validated by Lovingood and Young (1988) and Young (1988) provides quantifiable means of assessing user interaction (1 = no user interaction; 2 = slight--put food on, turn at appropriate times; 3 = moderate--put food on stirring occasionally, manipulating food at appropriate times; 4 = frequent--stirring occasionally, manipulating food and readjusting control settings; and 5 = continual user interaction). However, when operationalizing the user interaction scale in a research project that included consumers, DeMerchant (1993) recommended that the scale be adapted as: (a) 1 = none or bored/ checking, (b) 2 = slight -- stir/turning, (c) 3 = moderate -- stir/turning, (d) 4 = frequent adjustment of controls, and (e) 5 = continual manipulation and/or adjustment of controls.

DeMerchant's (1993) recommendation to adapt the user interaction scale by Lovingood et al. (1987) is appropriate when determining consumers' attitudes. However, when observing consumers' overt behavior the Lovingood et al. user interaction scale is more appropriate, due to the lack of ability to distinguish between necessary stirring and stirring because of boredom.

DeMerchant et al. (1994) found there were significant differences in consumers' satisfaction among the cooking systems with the level of user interaction required as indicated by cookware cleaning and frying. However, when they used a thermalization cooking operation, there were not significant differences in consumers' satisfaction among the cooking systems due to necessary level of user interaction.

Appliance Operating Time

Goss and Lovingood (1978) compared energy consumption and time of a smooth-top and conventional electric range to prepare a 21-meal menu. They found only a 0.97 percent difference in energy consumption. In addition, Lovingood and Goss (1980) compared energy consumption and time for cooking a week's meals with a conventional range, a smooth-top range with thermostatically controlled surface units, a smooth-top range with nonthermostatically controlled surface units, and a countertop microwave oven in conjunction with each range. They found that using the microwave oven in conjunction with the conventional range used the least energy and time, while the nonthermostatically controlled smooth-top required the most time and energy. In addition, Laughon (1980) operationalized cooking time as appliance operating time when investigating energy and time required to prepare foods with a microwave oven and conventional range.

Richardson (1982) distinguished between total time and active time. She defined total time as the amount of time needed for all steps from the beginning to the end of product formulation; and active time as the amount of time for those steps which require full or partial attention of the worker. The amount of actual heating time for each food was noted. Active timing was started after all ingredients, equipment, and utensils were assembled in one place.

Energy Consumption

Enactment of the Energy Policy and Conservation Act of 1975 provided an impetus for research and the development of test procedures for residential appliances. Tests with water or an aluminum block have been used to simulate a food load and have been typical of the cooktop studies conducted in industry. Researchers in family and consumer sciences have generally utilized tests that might be more typical of consumer practices (e.g., Baragar, 1962; Goss & Lovingood, 1978; Hill & Anderson, 1983; Lovingood & Goss, 1980; McCord, 1970; Peters & Hunt, 1977; Pickett, 1962; Young, Lovingood, Goss, Johnson, Barclay, & O'Brien, 1994). It can be concluded from several controlled experimental studies conducted during the 1970s that the use of metal cookware, even with a porcelain enamel coating, increases energy efficiency unless the metal cookware is much thicker than the non-metal (McCord, 1970; Overby, Hobocienski, & Lewis, 1978; Peters & Hunt, 1977).

Research by Fechter and Porter (1978) at the National Bureau of Standards (NBS) is the only study found that was designed to determine the relationship between consumers' practices and energy consumption in cooking. In the NBS laboratory, 58 cooks prepared a seven-day menu using a gas or electric range (whichever they ordinarily used at home). In this investigation energy consumption varied as much as 50% among cooks on the same range for the same menu. However, DeMerchant, Lovingood, and Leech (1995) reported a variation as high as 120% among consumers using the same cooking system for the same menu. Due to past research findings, this research considers energy consumption to be influenced by the level of user characteristics-interaction, practices, knowledge, experience--and appliance operating time.

In summary, since the turn of the century household equipment research has been conducted on cooktops and cookware that was grounded in the physical principles of heat transfer. In addition, consumer's knowledge and interaction level have been variables used in past cooking system research. The only studies found that investigate energy consumption and appliance operating time have been conducted with a controlled user. Researchers that investigated energy efficiency with the same cooking system and menu but different consumers have found that consumers are an important variable. However, the previous research does not address how the user influences energy consumption of cooking systems.

Consumer's Cooking Style

Framework

User characteristics is a subsystem within the cooking system environment. User characteristics include the attributes that influence the outcome of the transformation that occurs when performing the task of cooking on energy consumption (Phase I). A consumer's cooking style is also the output of the larger system in Phase II. Categories of consumer's cooking style are an outcome after the transformation within the cooking system environment, as consumers' characteristics are divided based on differences in cooking activities and its sub-subsystems.

Phase I. The larger system--cooking system environment--uses non-human (e.g., energy and equipment) and human (e.g., user interaction) resources to accomplish a task--cooking (Figure 2.1). The human resources include consumer's knowledge, experience, practices, and interaction to create an individual cooking style. Non-human resources are cooktops, cookware, energy, and food. Tasks are performed within the context of cooking activities and are a subsystem of the cooking system environment. Four cooking operations--activities--are thermalization, waterless, boiling, and frying as identified by Weber (1958). Sub-subsystems within the cooking system environment that are the result of the transformation of the cooking activities are user characteristics, appliance operating time, and energy consumption. Knowledge, experience, practices, and interaction are subsets of the user characteristics sub-subsystem.

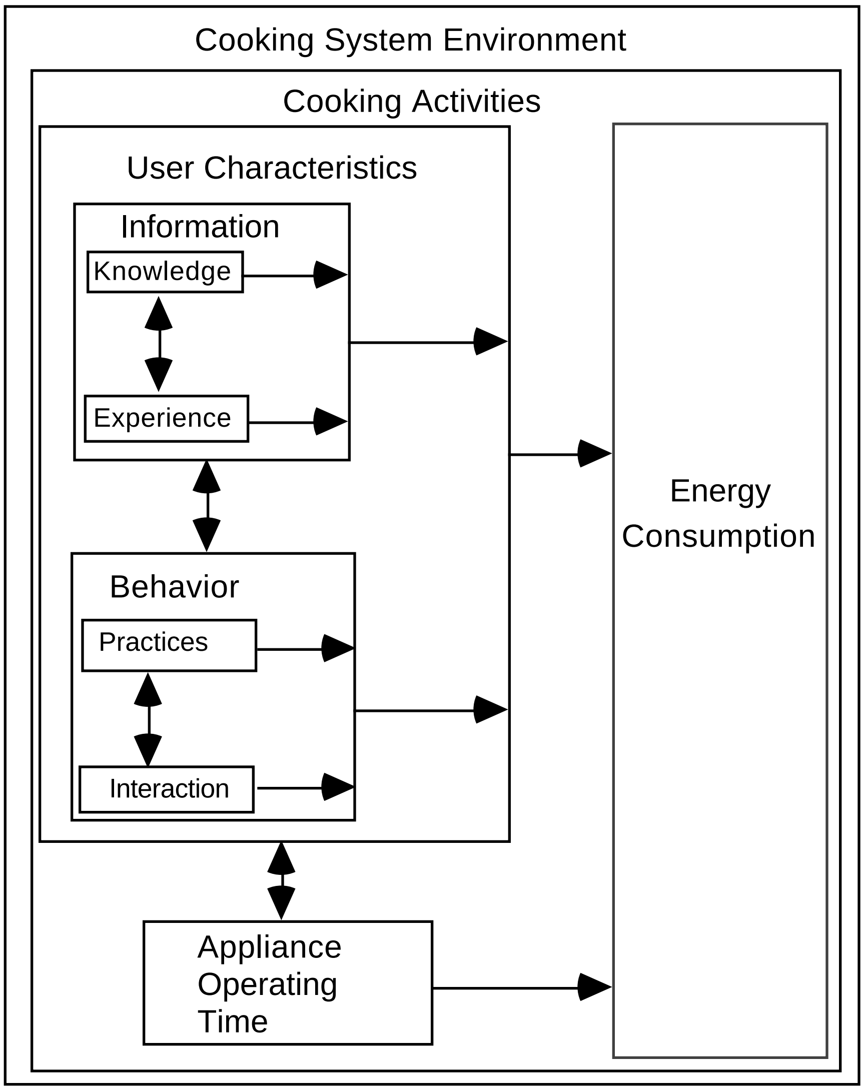


Figure 2.1. Framework of Phase I, user's influence on energy consumption with cooking systems as explained by user characteristics and appliance operating time.

User characteristics influence energy consumption of the cooking system due to the two-way connection between information (i.e., knowledge and experience) and behavior (i.e., practices and interaction). Steidl and Bratton (1968) stated that advanced information is important in skilled performance. Researchers have found a two-way relationship between knowledge and experience (Clark & Paivio, 1991; Hobson, 1991; Rappaport, 1987; Ribes-Inesta, 1991). In addition, researchers have determined there is a relationship between experience and knowledge, and overt behavior (Kruglanski, 1981; Rappaport, 1987; Windholz, 1987; Wolstein, 1977). Furthermore, user characteristics interact with appliance operating time to influence energy consumption. For example, knowledge influences the level of interaction and the level of interaction impacts on knowledge (e.g., the more the user interacts or uses the cooking system, then the more knowledge the user has regarding it). In addition, consumer's preference for degree of doneness and the ability to control the cooking process influences energy consumption via the user characteristics.

Phase II. In the cooking system environment non-human and human resources complete the cooking operation (Figure 2.2). Human resources utilized in the investigation include consumer's knowledge, experience, practices, and user interaction. Together these concepts compose the individual's cooking style. Cooktops, cookware, energy, and food are non-human resources. Four cooking operations (i.e., thermalization, waterless, boiling, and frying) are tasks performed and a subsystem of the cooking system environment. Variations in energy consumption are explained by user characteristics and appliance operating time within the context of the larger system--cooking system environment--and cooking activities.

Categories of cooking style are the outcome of Phase II. Cooking style categories synthesize the information from the larger system. Information (i.e., knowledge and experience) and behavior (i.e., practices and interaction) are user characteristics that influence energy consumption due to the relation between the variables.

Advanced information is important in skilled performance (Steidl & Bratton, 1968) . Researchers have found a two-way relationship between knowledge and experience (Clark & Paivio, 1991; Hobson, 1991; Rappaport, 1987; Ribes-Inesta, 1991). In addition, researcher has determined there is a relationship between experience and knowledge (Kruglanski, 1981; Rappaport, 1987; Windholz, 1987; Wolstein, 1977). Furthermore, there is a two-way interaction between appliance

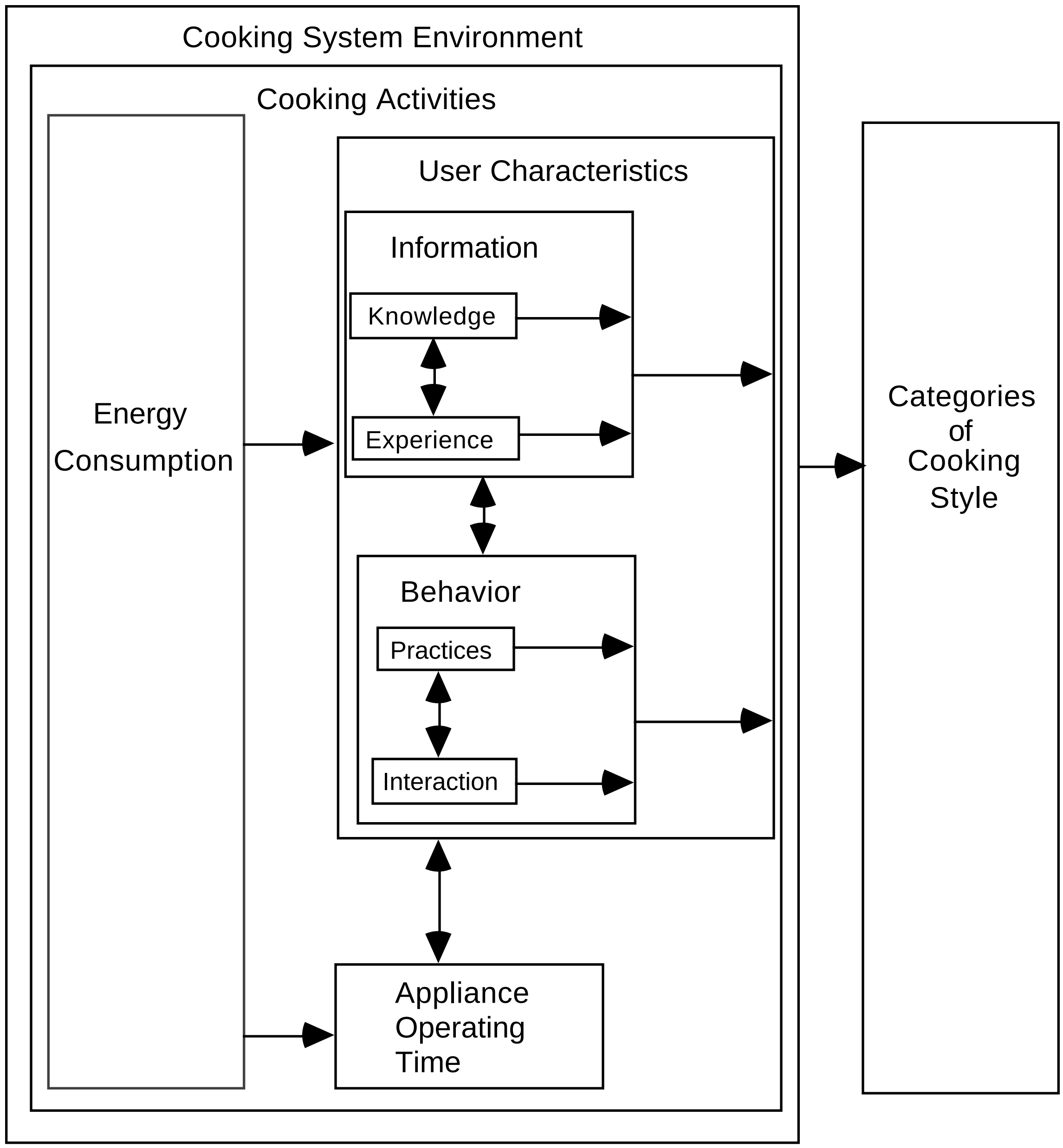


Figure 2.2. Framework of Phase II, cooking style categories as explained by user characteristics, appliance operating time, and energy consumption.

operating time and user characteristics. For example, if a cooking system is slow to heat up then the user is likely to adjust the control to accelerate heating time, or if the cooking system heats up more rapidly than anticipated the user will adjust the control to slow down the heating and may pick up the cookware to cool the system more rapidly to avoid overcooking the food. In addition, the consumer's preference for degree of doneness and the ability to control the cooking process influences energy consumption by the user characteristics.

Hypotheses

Correlation Analysis

The following relationships are based on the framework presented for Phase I and past literature. Each hypothesis tests a relationship expressed in the framework.

H_O:1 There is not a significant relationship between the consumer's knowledge and the energy consumption of cooking systems.

H_O:2 There is not a significant relationship between the consumer's experience and the energy consumption of cooking systems.

H_O:3 There is not a significant relationship between the consumer's interaction and the energy consumption of cooking systems.

H_O:4 There is not a significant relationship between the consumer's practices and the energy consumption of cooking systems.

H_O:5 There is not a significant relationship between appliance operating time and the energy consumption of cooking systems.

Multiple Regression Analysis

The following hypotheses test the combination of variables to describe the user's influence on energy consumption with cooking systems using electricity. Hypothesis 6 investigates the user's influence:

H_O:6 Variance in energy consumption is a function of: appliance operating time, knowledge, experience, user interaction, practices, information, behavior, user, total model and specific variables used to create statistical interaction and composite variables.

Hypothesis 7 considers variables that influence energy consumption that the user controlled and that the user did not control:

H_o:7 Variance in energy consumption is a function of: container material, energy source, goodness-of-fit, appliance operating time, knowledge, experience, user interaction, practices, information, behavior, user, total model, cooking system, cooking system and goodness-of-fit, and specific variables used to create composite and statistical interaction variables.

CHAPTER III
Methodology

Overview of Methodology

The purpose of this study was to explain the user's influence on energy consumption with cooking systems using electricity. To accomplish this purpose two separate investigations were conducted and have been organized in two phases. During Phase I the user's influence was quantified to determine relationships that explain variations in the energy consumption of cooking systems using electricity. In Phase II, two sets of cooking system categories were developed to describe (a) the user characteristics and cooking systems that explain variations in energy consumption, and (b) what a group of 15 users typically do that influences where their average energy consumption level falls on a continuum of energy consumption.

Existing data were used to answer the research questions. The existing data consisted of: video tape data (Appendix A) of consumers preparing the research menu (Appendix B), a survey (Appendix C), and data recorded on a data collection sheet by the researcher (i.e., watthour consumption, Appendix D). Survey data revealed consumers' knowledge and experience with cooking systems (Appendix B). Video tape data were reviewed to determine: the appliance operating time needed to prepare the research menu designed to exemplify specific cooking operations (i.e., boiling, frying, thermalization, and waterless) and the amount of user interaction with food, cookware, and cooktop controls. The video tape data were further used to determine other practices of cooking style (i.e., using retained heat, covering the cookware during cooking, and matching the diameter of the cooktop elements to the diameter of the cookware's contact area--goodness-of-fit).

Simultaneous triangulation was used to answer the research questions. According to Creswell (1994) simultaneous triangulation answers the qualitative and quantitative research question at the same time in the study. He further stated that the results of the qualitative questions should be reported separately and should not necessarily relate to or confirm the results from the quantitative study. This study used existing data that included descriptive analysis and quantitative analysis, in order to fully describe the consumers and relationships among the variables.

<u>Description of the Data Base</u>

A description of the data base is essential to understanding the strengths and weaknesses of the existing data and how the data can be manipulated to answer the research questions. DeMerchant (1993) conducted research to determine consumers' knowledge, practices, and satisfaction with cooking systems' interaction. Fifteen consumers prepared one menu (Appendix B) on each cooking system following specific procedures (Appendix D). Five types of cooktops and six types of cookware were used to form 30 cooking systems (Appendix E for electric cooktops).

Energy Sources	**Cookware**
<u>Electric</u>	<u>Metallic</u>
Conventional Electric Coil	Thin Gauge Aluminum
Solid Element	Heavy Gauge Aluminum
Radiant Coil under Glass Ceramic	Heavy Gauge Aluminum with Non-stick Finish
Halogen under Glass Ceramic	Stainless Steel with an Aluminum Heat Core
<u>Gas</u>	Porcelain on Aluminum with Non-stick Finish
Traditional Gas Flame	
	<u>Non-metal</u>
	Glass Ceramic

Consumers used each of the 30 cooking systems in a random order. The total number of observations was 450. The menu was based on Weber's (1958) surface cooking operations with servings for four:

Food	**Cooking Operation**
Crepes	Frying
White Sauce	Thermalization
Chicken in White Sauce	Warming (Rethermalization)
Broccoli (Frozen)	Waterless (Minimum Water)
Carrots	Boiling

A three part survey was developed to determine: pretest knowledge and usage trends (Appendix B), cooking system satisfaction, and posttest knowledge and preferences. Part one of the survey was completed during the participants' orientation to the laboratory. Participants completed the 30 cooking system investigations and part two of the survey, regarding their satisfaction, over a period of time that ranged from one week to two months. The third part of the survey was completed at the end of the cooking system investigations. Video tapes were recorded as consumers prepared the research menu.

The 15 subjects used in this research ranged in age from 20 to 32. Subjects were graduate and undergraduate students from across the United States studying at Virginia Tech. Three of the participants were African-American and 12 were Caucasian. Three of the participants were male. One of the participants had experience cooking in a restaurant. All of the subjects knew how to complete the research menu; however, all of the 15 subjects were considered inexperienced cooks with limited experience purchasing and using innovative cooktops and cookware.

In summary, the data base contains survey items that were used to indicate users' knowledge and experience. Video tape data were used to indicate the users' interaction, practices, and appliance operating time. Each variable was quantified to facilitate analysis of Phase I and Phase II.

Phase I

Empirical Model

The empirical model (Figure 3.1) shows the independent and dependent variables under investigation in the study. The independent variables include energy sources, container materials, goodness of fit, appliance operating time, and user characteristics (i.e., knowledge, experience, practices, and interaction). Each of the independent variables may be broken into sub-variables (e.g., cooktop types and cookware types). The dependent variable is energy consumption. Each variable was operationalized by quantifying the dependent and independent variables.

The number of observations for this research was 360. Four types of electric cooktops and six types of cookware were used to form 24 cooking systems (Figure 3.2) in the research conducted at Virginia Polytechnic Institute and State University's Residential Appliance Laboratory (Appendix E). Cooking systems including gas ranges were eliminated from the data base for this study.

Existing data used for Phase I of this research included video tapes, energy consumption--watthours--for investigations using an electric heat source (Appendix D & E), and consumers' survey responses (Appendix C) regarding their knowledge and experiences.

Procedures

The following section explains the data collection procedures for this research. Data collection for this research was reviewing and quantifying the video tape data.

Video tapes. The data included appliance operating time measured for each cooking operation and total cooking time. Manipulation of food, cookware, and

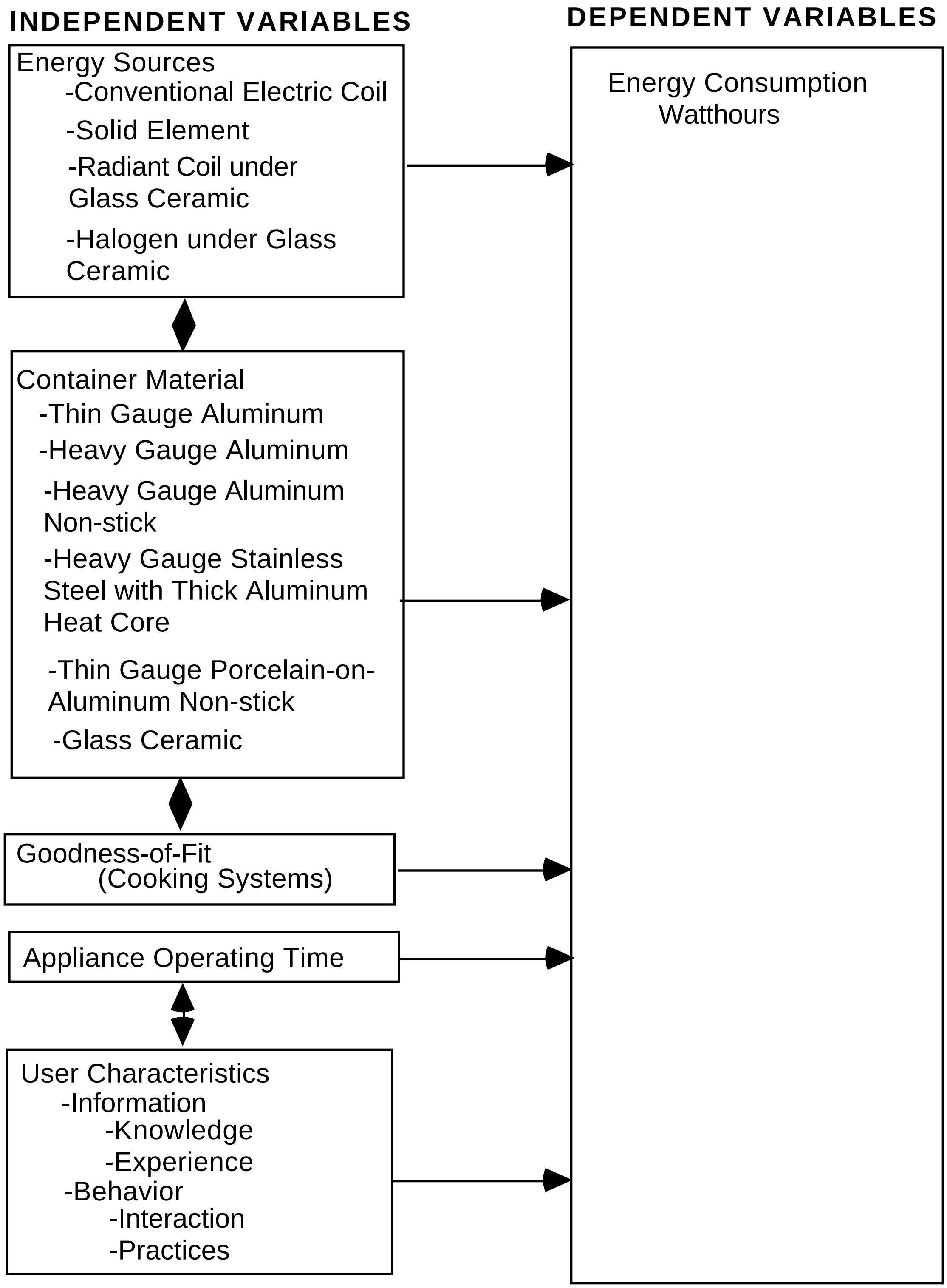


Figure 3.1. Empirical model for Phase I.

Cookware

Cooktops	Thin Alumin.	Heavy Alumin.	Heavy Alumin. N-stick	Heavy S. Steel Alum. HC	Thin porc.-on- Alum. N-stick	Glass Ceramic
Conventional Electric Coil	1	2	3	4	5	6
Solid Element	7	8	9	10	11	12
Radiant Coil u/ Glass Ceramic	13	14	15	16	17	18
Halogen u/ Glass Ceramic	19	20	21	22	23	24

Figure 3.2. Design of the study showing numerical coding for the cooking systems.

controls was quantified by counting the number of times the consumer interacted with the system. The analysis was recorded on a data collection sheet (Appendix A).

Each cooking system investigation was viewed using a tape speed of 60 frames per minute (Appendix E) and completed during one viewing when possible. Rewind and fast forwarding were used as needed. The video cassette recorder (VCR) counts in real time, and maintains the time while fast forwarding or rewinding. "Hash marks" were recorded about the observation on the data collection sheet as a method of counting (Appendix A). Questions were answered on data collection sheets directly after viewing the entire video tape (Appendix A). In addition, consumers' practices recorded throughout the observation included use of a cover on the cookware during cooking, use of retained heat, preheating the pan or the element, matching the diameter of the cooktop and cookware, and control settings used. Appliance operating time and the quantity of manipulation of food, cookware, and controls were calculated after the observation and recorded on the data sheets (Appendix A).

All video tapes were viewed by the principle researcher. However, to ensure reliability, trained assistants viewed a random sample of video tapes using a ratio of 25 observations by the principal researcher to one by an assistant. Therefore, assistants observed 15 cooking system investigations. If a discrepancy was determined between the two observers, then additional investigations were made by the principle researcher and validated by the assistant.

Video tapes--appliance operating time. Time was measured from the VCR clock that counts in real time. "On time" was the beginning of operating time or when the cooktop was turned on. "Off time" was the end of the operating time or when the cooktop was turned off. Appliance operating time was measured for each cooking operation.

If the user of the cooking system was controlled, then an assumption was drawn regarding the relationship between appliance operating time and energy consumption (i.e., increased appliance operating time yields increased energy consumption). In this research, appliance operating time served as a proxy for information that would facilitate explanation of the user's influence on energy consumption but was unavailable in the existing data base (e.g., motivation to conserve energy, user's personal time schedule, preference for degree of doneness of the food). Therefore, appliance operating time attempted to explain the "gray area" or the unexplainable variance using the existing data base.

Video tapes--user interaction. Interaction was measured for each cooking operation. In addition, the number of times food, cookware, and cooktop controls were adjusted was recorded. Cookware manipulation was further subdivided into pick up, slide, touch, and open.

Manipulation of food was quantified by counting the number of times that the participants stirred, turned, threw food into the air, shook the pan, or moved the food in any way during the cooking process. For example, stirring the boiling carrots or turning the crepe slightly were each counted as one manipulation. When a crepe was turned the action was recorded as two 'hash marks." Two hash marks were used for crepes because sometimes the participant placed the turner under the crepe and not invert the crepe. Therefore, the number (i.e., two) of different motions was counted. Each time food was placed in the cookware was recorded on the data collection sheet as "food," to indicate that all items were placed in the pan or the number of crepes fried (i.e., difference in food thickness). There was a tendency to stir the white sauce almost continuously. Therefore, each time the participant stirred the white sauce was counted; and if stirring was continuous or was almost so, then a comment was made to that respect.

Cookware manipulation was quantified by counting the number of times the consumers moved or shook the cookware in any way during the cooking process. Cookware manipulation was subdivided to indicate the number of times participants picked up or tipped the cookware, slid the cookware around on the element, touched the cookware, and lifted or removed the cover. Other examples include: moving cookware handle an inch, removing the cover from the cookware, or shaking the broccoli saucepan all counted as manipulation. In addition, whenever consumers removed the cover from the saucepan, stirred the boiling carrots, picked up the skillet to throw the crepe into the air, or shook the saucepan with the broccoli (i.e., popcorn effect), the action was counted both as cookware manipulation and food manipulation.

Cooktop control manipulation was quantified by counting the number of times that consumers adjusted the control in any way during the cooking process. For example, control turned on, off, or from one setting to another were all counted as adjusting the cooktop control.

Video tapes--practices. Practices were determined for each cooking operation. The heating element and cookware used to perform the cooking operation were recorded after noting the start of the appliance operating time and followed by recording the initial control setting. Control settings were recorded throughout the observation using categories of high, medium, and low. Appliance operating time was not recorded for each control setting due to the inability to distinguish between the actual control settings. (E.g., it was not possible to determine by watching the video if the control setting was a four or five. Sometimes the numbers could not be viewed due to glare on the control panel.) Observations regarding usage of retained heat, preheating the element or cookware, covering cookware, and leaving the heat source on after cooking were recorded on data collection sheets after or during the observation (i.e., as soon as possible).

After reviewing the video tapes, data were entered into a statistical program to perform the quantitative analysis. The data were entered following the code book (Appendix F). Video tapes were further analyzed for qualitative analysis of cooking style to explain the relationships found in the quantitative analysis. After obtaining direction from the quantitative analysis, the aim of the qualitative analysis was to develop categories of consumers' cooking style in an attempt to understand energy consumption.

Variable Description and Analysis

This research only utilized a very small fraction of the information available in the data base. These data were used to describe the user's influence on energy consumption. Specific items used and their code numbers, as indicated by the code book in Appendix F, were used to explain the analysis plan. The code book reflects the data and the recoding of the data for this investigation.

Energy consumption. Energy consumption was a continuous variable that was measured by determining the difference between the before and after watthour meter readings (Appendix F, V1).

Cooking system. Cooking system was a variable created by multiplying the energy source (V3) and container material (V4). This variable was created to account for the interaction between the cooktop and the cookware under investigation.

Energy sources. Energy source was a categorical variable that identifies the cooktop used in the investigation (Appendix F, V3). Numbers range from one through four. Conventional electric coil was an example of a cooktop used in the investigation. Justification for variable selection was based on past research in which it was found that the cooktop was an important variable when energy efficiency was the objective (DeMerchant et al., 1995).

Container materials. Container material was a categorical variable that identifies the cookware used in the investigation (Appendix F, V4). Numbers range from one through six. Heavy gauge aluminum is an example of cookware used in the investigation. Justification for variable selection was based on past research that found cookware an important variable with respect to energy consumption (DeMerchant et al, 1995; McCord, 1970; Overby, Hobocienski, & Lewis, 1978; Peters & Hunt, 1977).

Goodness-of-fit. Goodness-of-fit is a categorical variable that reflects the matching of the diameter of the contact area of the cooktop elements and the cookware (Appendix F, V64). Goodness-of-fit scores were from one through three. Justification for variable selection was based on the fact that energy consumption is most efficient when the cookware diameter matches the cooktop element diameter. Greater goodness-of-fit score indicates a better match and a more energy efficient combination.

Appliance operating time. Appliance operating time was the summation of elapsed time for each cooking operation. Timing began when an element was turned on and stopped when the element was turned off. Therefore, the number of minutes was summed for variables V22, V23, V24, V25 (Appendix F). Justification for variable selection was based on the fact that energy consumption varies for each consumer due to the pattern of interaction with the cooking system (e.g., removing cookware from the heat source) and preference for degree of doneness (e.g., degree of browning of crepes or crispness of vegetables). Summing the times for all cooking operations was selected in place of time needed to complete the menu to recognize that more than one cooktop element may be used at once or cooking activities may have been dovetailed.

User characteristics. Composite variables were established for each of the specific variables of user characteristics. User interaction was subdivided into user's information (V77) and user's behavior (V78).

Information--interaction term. Information was a variable created by multiplying knowledge (V5) and experience (V75) for each observation. This variable was created to account for the interaction between knowledge and experience.

Knowledge--composite variable. Knowledge was a percentage score of consumer's pretest knowledge (Appendix F, V5). Knowledge represents the quantity of information that each consumer had prior to investigating any cooking system

(Appendix B, Q18 - Q29). Pretest knowledge was selected in place of posttest knowledge because (a) it places more control on the variable, otherwise it would not be clear when the consumer acquired the increase in knowledge; and (b) preliminary analysis revealed that pretest knowledge and posttest knowledge explained about the same amount of variance.

Experience--composite variable. Experience was a composite variable that is a summation of variables V6, V7, V8, V9, V10, V11, V12, V13, V14, V15, V16, and V17 after recoding to make dichotomous variables (Appendix F). Examples of experience indicators are: the consumer has purchased a cooktop, has purchased cookware, or is familiar with each of the cooking operations used in the investigation. Experience was a continuous variable derived from the summation of dichotomous and categorical variables. Larger experience scores indicate greater experience.

Preliminary analysis revealed lack of variance within variable V6 and V11; therefore, both variables were removed from the composite variable and the regression analysis.

Behavior--interaction term. Behavior was a variable created by multiplying practices (V76) and user interaction (V72) for each observation. This variable was created to account for the interaction between user's practices and interaction.

Practices--composite variable. Practices was a composite variable that sums the variables V18, V19, V20, V21, V26, V27, V28, V29, V30, V31, V32, V33, V34, V35, V36, V37, V38, V39, V40, V41, V42, V43, V44, V45, V65, V66, V67, V68, and V69 after recoding (Appendix F). Use of retained heat or cooking with the cover on the cookware are examples of practices under investigation. Practice was the summation of dichotomous variables and therefore was a continuous variable. Higher practice scores indicate positive practices.

Lack of variance within variable V38 and V43 was revealed during a preliminary analysis and therefore both variables were removed from the composite variable and the regression analysis. This variable was reverse coded to have attributes going in the same direction for the analysis.

User interaction--composite variable. Interaction was a composite variable that sums the variables V46, V47, V48, V49, V50, V51, V52, V53, V54, V55, V56, V57, V58, V59, V60, V61, V62, and V63 after recoding (Appendix F). Examples of interaction are stirring of the food, picking up the cookware, and adjusting the cooktop controls. Interaction is the summation of the counts for each variable and therefore was a continuous variable. Higher interaction scores indicated greater interaction and manipulation; therefore, a relationship was anticipated between interaction and energy consumption.

Data Analysis

Data analysis for Phase I of this research was conducted in two steps to ensure the proper selection of variables for each of the composite variables used in Step II.

Step I. After reviewing the video tapes, data were entered into a statistical program to perform the quantitative analysis. The data were entered following the code book (Appendix F). Descriptive statistics were computed and correlation matrices were constructed. In the event of not finding a correlation between each of the independent variables and the dependent variable, then any uncorrelated independent variables were eliminated from the composite variable. If a correlation of 0.7 or greater was found between the independent variables then the less significant of the pair was eliminated from the equation to avoid multicollinearity. Composite variables were developed by summing each of the variables for the category that was found to have a correlation with the dependent variable.

Step II. Quantitative analysis techniques implemented in this research were correlation analysis and multiple regression. Correlation analysis was used to determine the relationships between variables. Specific correlation tests determined if significant relationships existed between the composite variables with a $p < .05$.

Multiple regression was implemented to determine the amount of explained variance when using multiple independent variables and a dependent variable. A stepwise regression was performed. A $p < .05$ was used to establish significance of the independent variables. In the event that a correlation over 0.7 was found between the independent variables then the less significant of the pair was eliminated from the final equation to avoid multicollinearity. Each independent variable was entered into the regression equation using a stepwise technique to allow comparison of results when different variables have been entered into the final equation. Therefore, variables with multicollinearity were compared to determine which variables were to be included in the final regression equation. The regression equation for hypothesis 6, user's influence, was as follows:

$$\textbf{Energy'} = \mathbf{a} + \mathbf{b_4}(\text{appliance operating time}) + \mathbf{b_5}(\text{knowledge}) + \mathbf{b_6}(\text{experience}) + \mathbf{b_7}(\text{practices}) + \mathbf{b_8}(\text{interaction}) + \mathbf{b_9}(\text{information}) + \mathbf{b_{10}}(\text{behavior}) + \mathbf{b_{11}}(\text{user}) + \mathbf{b_{12}}(\text{total model}) + \mathbf{b_{15}}(\text{composite and statistical interaction variables})$$

In addition, the regression equation for hypothesis 7, all variables that explain energy consumption with cooking systems, was as follows:

$$\textbf{Energy'} = \mathbf{a} + \mathbf{b_1}(\text{container material}) + \mathbf{b_2}(\text{energy source}) + \mathbf{b_3}(\text{goodness of fit}) + \mathbf{b_4}(\text{appliance operating time}) + \mathbf{b_5}(\text{knowledge}) + \mathbf{b_6}(\text{experience}) + \mathbf{b_7}(\text{practices}) + \mathbf{b_8}(\text{interaction}) + \mathbf{b_9}(\text{information}) + \mathbf{b_{10}}(\text{behavior}) + \mathbf{b_{11}}(\text{user}) + \mathbf{b_{12}}(\text{total model}) + \mathbf{b_{13}}(\text{cooking system}) + \mathbf{b_{14}}(\textbf{cooking } \text{system interaction and goodness-of-fit}) + \mathbf{b_{15}}(\text{composite and statistical interaction variables})$$

The analysis of Step II utilized composite and interaction variables. The composite variables were developed based on the analysis of Step I. Interaction variables were developed based on testing of the framework utilized in this investigation (Figure 2.1). All of the possible specific variables (V as shown in Appendix F) used to develop the composite variables and interaction variables are included in the description.

In summary, Phase I was conducted in two steps. Step I determined descriptive statistics and correlations between the independent and dependent variables. The results of Step I were used to develop the composite variables of Step II. The results of Phase I did not necessarily confirm the results of Phase II. However, Phase I quantitative analysis served as a starting point to describe the qualitative analysis of Phase II.

Phase II

The purpose of Phase II was to identify/ develop categories of cooking style based on energy consumption. Hence, what categories describe differences in energy consumption due to consumers' cooking style based on user characteristics and appliance operating time? The findings from Phase I provided information to facilitate the development of trends for each category.

Empirical Model

The empirical model (Figure 3.3) shows the independent and dependent variables as well as the intervening variables under investigation in the study. The

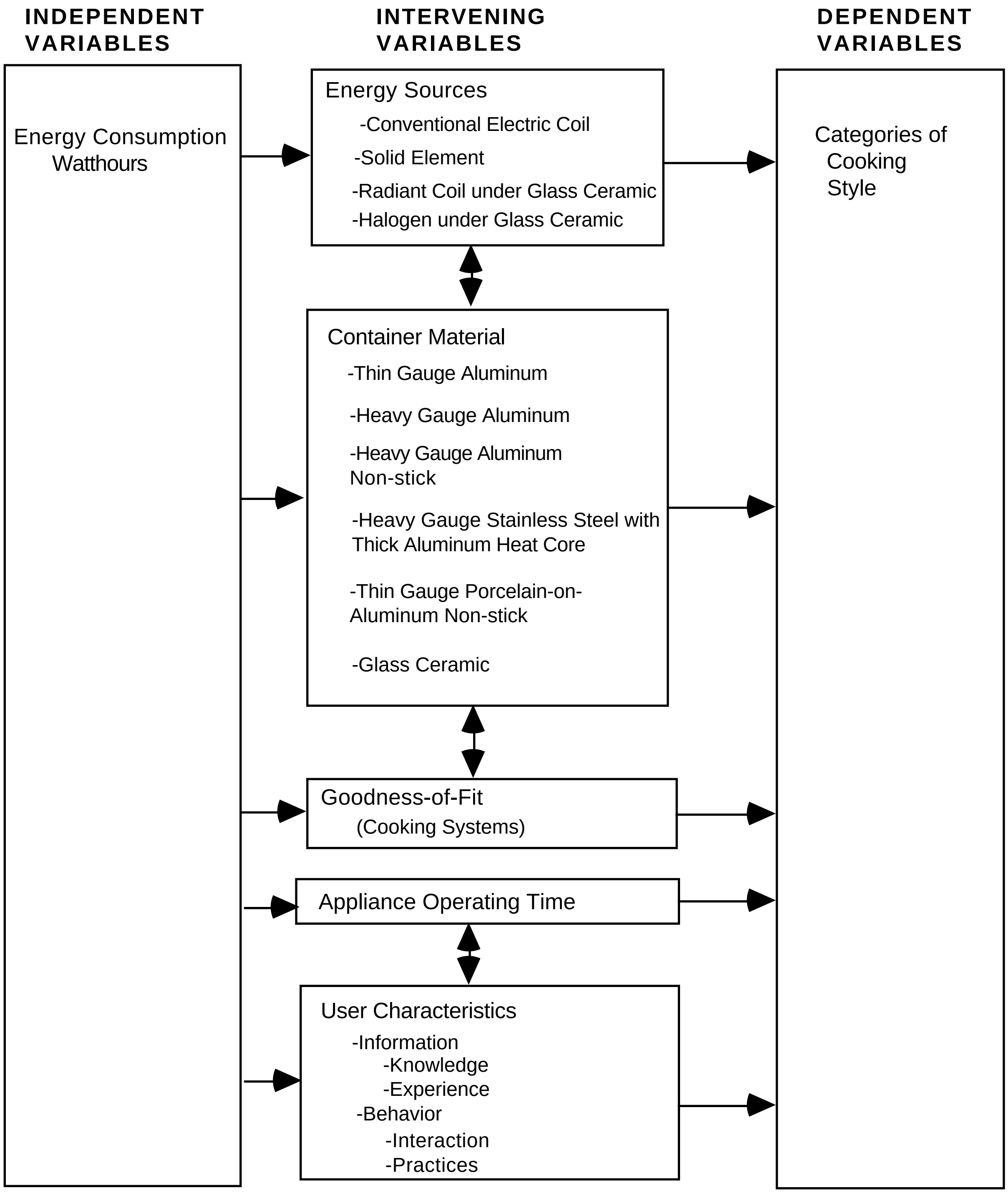


Figure 3.3. Empirical model for Phase II.

independent variable was energy consumption. The dependent variable was categories of cooking style. The intervening variables were the energy sources, container materials, goodness-of-fit, and user characteristics (i.e., knowledge, experience, practices, and user interaction and appliance operating time). The independent variables were divided into categories to ultimately establish the base for the dependent variable--categories of cooking style. The intervening variables were synthesized to describe the categories.

Procedures

The independent variable--energy consumption--was divided into five categories. A computer analysis program established a range of watthour readings for each of the categories. Each observation was manually matched to the appropriate category. Data collection sheets were divided into piles according to categories of energy consumption. The identification number was used to ensure that appropriate data collection sheets were compared. The intervening variables, data from video tapes and the existing survey, were synthesized to fully describe the trends of each category.

Data sheets were sorted according to cooking style categories, in addition to sorting the data previously entered into a statistical program. Sorting data according to categories allowed trends to be observed. The intervening variables were factors of the analysis to describe the categories. Intervening variables consisted of the types of cooktops and cookware, consumers, user characteristics, appliance operating time, highest heat setting used, and goodness-of-fit (Appendix F). Category labels were identified after establishing trends for each category and reviewing the comments about each observation.

Data Analysis

Quantitative analysis categorized the 360 cooking system observations into five categories (Table 3.1). The categories corresponded to a range of watthour readings. Composite variables of user characteristics, cooktops, cookware, consumers, appliance operating time, and goodness-of-fit that correspond to the level of energy consumption were used to qualitatively explain the cooking style categories.

Descriptive analysis was implemented after dividing the dependent variable (i.e., energy consumption) into five groups to reflect the user interaction scale (Table 3.1). Data collection sheets were divided into five piles to correspond with the five

Table 3.1

Characteristics of Users in Cooking Style Categories

Cooking Style Categories	**Observations (n/ Category)**	**Percent (%/ Category)**	**Range (Watthours)**
Patient Style	54	15.0	485 - 646
Average Style	197	54.7	647 - 806
Uninformed Style	89	24.7	807 - 966
Hurried Style	16	4.4	967 - 1127
Hurried Style with No Control	4	1.1	1128 - 1288
Total	360	100.0	485 - 1288

note. Mean energy consumption = 760.2 Wh categories. The identification number was matched to ensure that appropriate data collection sheets were matched. Each of the five piles of data collection sheets were analyzed to determine similarities or differences within each category/ pile. The qualitative data were synthesized for each category to develop a concise description of the cooking style categories. Video tapes were further analyzed, only as necessary, to identify trends that clearly describe the cooking style of each category. For example, video tapes were reviewed to facilitate explanation of outliers or for other observations when the data collection sheets did not contain adequate information.

In summary, the 360 observations were divided into five groups according to energy consumption levels (Table 3.1). A description of cooking style developed by synthesizing the variables of appliance operating time, goodness-of-fit, and user characteristics--practices, interaction, experience, and knowledge.

Categories of cooking style were established to explain the user's influence on energy consumption with cooking systems when considering just the user's characteristics and appliance operating time (i.e., the variables under the users control). Three categories of cooking style (Table 3.2) were established to summarize the data by determining the difference between the mean of the highest and lowest energy user (843.3-692.6=150.7 Wh). The difference was divided by three (150/3=50.2) and then added to the lowest energy consumer's mean watthour rating (692.6+50.2=742.8) to establish the range for the lowest energy consumption categories (692.6 to 742.8). To establish the average energy consumption category 50.2 was added to the 742.8 (category range=742.8 to 793). The highest energy consumption category was established by adding the 50.2 to 793 (category range 793 to 843.2). Participants were assigned to a category by matching their mean watthour consumption with the range of watthour consumption for each category (Table 3.2).

Table 3.2

Consumer's Energy Consumption According to Cooking Style Categories

Consumer ID Number	Watthour Consumption	Category Name
6	692.6	Low
12	703.9	Low
11	727.3	Low
4	742.9	Low
7	730.1	Average
9	734.9	Average
3	748.8	Average
2	756.7	Average
15	760.8	Average
1	774.7	Average
8	778.3	Average
13	781.2	Average
10	808.5	High
14	814.8	High
5	848.3	High

Note. Watthour consumption is the participant's mean energy consumption for 24 observations.

CHAPTER IV
Quantitative Findings and Discussion
(Phase I)

Introduction

The user's influence on energy consumption with cooking systems using electricity was investigated using existing data on video tapes and a questionnaire. Cooktops used in this investigation were conventional electric coil, solid element, radiant coil under glass ceramic, and halogen/radiant coil under glass ceramic. Cookware used in this investigation included thin aluminum, heavy aluminum, heavy aluminum with a non-stick finish, stainless steel with aluminum heat core, thin porcelain enamel on aluminum with a non-stick finish, and glass ceramic. User attributes investigated in this research were knowledge, experience, interaction, and practices. In addition, appliance operating time and goodness-of-fit of the cooking system were independent variables in the investigation.

This chapter presents the findings of the quantitative results following a two-step analysis procedure. The objective of Step I was to provide a descriptive analysis of the data including correlation among the variables. In Step II, tests of significance and the results are presented in relation to the seven hypotheses.

Step I

The purpose of this section is to describe trends and relationships in the data. Furthermore, relationships were analyzed to determine if multicollinearity exists between independent variables. The information obtained in Step I was used in Step II when determining variables for the multiple regression.

Descriptive Findings

Findings related to characteristics of the sample include data the respondents indicated on a questionnaire about themselves which the researcher observed and then quantified. Specific measures of the composite variables include experience, practices, appliance operating time, and interaction.

As seen in Table 4.1, the average amount of energy required to complete the menu was 760 watthours. The mean goodness-of-fit score was 1.5 on a 3 point scale. The mean score indicates the cooking systems used in this research were between: the categories of if neither the skillet nor the saucepan diameter corresponds less than or equal to a quarter of an inch (score of 1) and if either the skillet or saucepan

Table 4.1

Descriptive Statistics for Variables under Investigation

Variable Name	Descriptive Statistics n	Mean	SD
Energy[a]	360	760.0	118.1
Goodness-of-Fit[b]	24	1.5	0.6
Information[c]	360	356.5	165.6
Behavior[d]	360	1273.7	305.2
User[e]	360	530867.7	285419.5
Total Model[f]	360	36574990.0	27275420.0
Cooking System[g]	24	8.8	6.1
Cooking System Interaction X Goodness-of-Fit	24	19.3	15.3
Knowledge	15	44.5	18.8

Note. [a]=Energy measured in watthours
[b]=Goodness-of-fit 1 = If neither the skillet nor saucepan diameter corresponded $\leq$ 1/4" to the heat source
2 = If either the skillet or saucepan diameter corresponded $\leq$ 1/4" to the heat source
3 = If both the skillet and saucepan $\leq$ 1/4" to the heat source
[c]=Statistical Interaction, Knowledge X Experience
[d]=Statistical Interaction, Practices X Behavior
[e]=Statistical Interaction, Information X Behavior
[f]= Statistical Interaction, User X Appliance Operating Time
[g]=Statistical Interaction, Cooktop X Cookware
Obs=360

diameter corresponds less than or equal to a quarter of an inch of each other. Hence, the cooking systems used in this investigation received a mean goodness-of-fit score of 1.5 on a 3 point scale.

Experience. The participants in this research were traditional age undergraduate and graduate students studying at Virginia Tech. They were a young, well-educated sample; however, they had limited knowledge and experience with cooking, and cooking systems. Their mean pretest knowledge score was 44.5% (Table 4.1). None of the participants had purchased a cooktop (Table 4.2). The majority of the participants had not taken a: (a) food preparation and selection course, (b) household equipment course, or (c) course that covered cooktops or cookware. However, the majority of the sample had purchased cookware.

None of the participants were familiar with waterless cooking. Most of the participants were not familiar with the research procedure for frying crepes, while most were familiar with the procedure for boiling carrots or making a white sauce. When selecting participants to participate in this research, they were asked if they knew how to complete the menu. The majority of the participants had not fried crepes or used waterless cooking. However, they were further asked if they knew how to fry pancakes and steam vegetables without a steam basket and were accepted as a participant if they could perform those tasks. It was decided not to wait to find participants that prepared those items using the research procedure due to: crepes were not commonly prepared foods and were very similar in technique to pancakes, and waterless cooking is not a well known or frequently used procedure.

The majority of the participants had only used one type of cooktop (conventional electric coil) on a regular basis. Participants had regularly used only two types of cookware, i.e., aluminum and stainless steel. In addition, most of the sample used non-stick cookware on a regular basis (Table 4.2).

Practices. As seen in Table 4.3, participants typically matched the diameter of the heat source and diameter of the cookware for each cooking the white sauce (90%), while fewer matched the diameter of the heat source and diameter of the cookware for carrots (60%), broccoli (50%), and crepes (50%). Most participants did not use retained heat for any cooking operation but turned off the cooktop after cooking. They did not preheat the cookware except when frying crepes. Although participants covered the cookware when boiling carrots and cooking broccoli, they did not use the cover when cooking crepes or the white sauce. Other common practices included

Table 4.2

Consumers' Experience with Cooking Systems--Descriptive Statistics

Variable Name	Descriptive Statistics: Percentage That Said Yes
Had the participant ever purchased a cooktop?	0
Had the participant taken a food preparation and selection course?	10
Had the participant taken a household equipment course?	50
Had the participant taken a course that covered cooktops and/ or cookware?	50
Had the participant ever purchased cookware?	80
Was the participant familiar with the research procedure used to cook:	
broccoli	0
crepes	40
white sauce	50
carrots	70
Did the participant use cookware with a non-stick finish?	90

(table continues)

Table 4.2 Continued

Consumers' Experience with Cooking Systems--Descriptive Statistics

Variable Name	Descriptive Statistics	
	Mean	SD
How many electric cooktops had the participant used on a regular bases?	1.3	0.6
How many types of cookware had the participant used on a regular bases?	2.2	1.0
Total experience	7.9	1.7

Note. n=15

Table 4.3

Consumers' Practices in Preparation of the Menu--Descriptive Statistics

Variable Name	Descriptive Statistics: Percentage That Said Yes
Did the participant match the diameter of the cookware with the heat source?	
Crepes	50
Broccoli	50
Carrots	60
White sauce	90
Did the participant cook with retained heat?	
White sauce	0
Crepes	0
Carrots	0
Broccoli	0
Was food placed in the cookware at the start of heating the cookware?	
Crepes	0
White sauce	100
Carrots	100
Broccoli	100
Was the cooktop turned off after cooking?	
Carrots	100
Broccoli	100
Crepes	100
White sauce	100

(table continues)

Table 4.3 Continued

Consumer's Practices in Preparation of the Menu--Descriptive Statistics

Variable Name	Descriptive Statistics: Percentage That Said Yes
Was the cover on the cookware during cooking?	
Crepes	0
White sauce	50
Broccoli	100
Carrots	100
Was the cookware placed on the heat source before or immediately after turning on the heat source?	
Crepes	100
Carrots	100
Broccoli	100
White sauce	100
Was a low or medium heat setting selected?	
Carrots	40
Crepes	100
White sauce	100
Broccoli	100
Did the participant touch the saucepan to determine if the saucepan was warm?	
Broccoli	30
Total practices	17.1[a]

note. [a]=Mean

placing the cookware on the heat source before or immediately after turning on the heat source, and using a low or medium heat setting except to boil the carrots. In addition, consumers typically did not touch the saucepan to determine if it was warm.

Appliance operating time. The total appliance operating time ranged from 26.4 minutes to 150.3 minutes to complete the menu. Appliance operating time was greatest for frying crepes (Mean=21.4 minutes, range=5.6 - 47.2). However, the greatest range in appliance operating time was found when cooking the broccoli (range 5.3 - 55.4) (Table 4.4).

User interaction. As seen in Table 4.5, frying crepes required the greatest quantity of interaction, and boiling carrots required the least. Therefore, the order of magnitude for all categories of interaction, ranged from carrots (least) followed by broccoli, then the white sauce, and lastly crepes which required the most involvement of the user.

Correlation

Multicollinearity (r=0.7) was found between the composite variable of appliance operating time and the appliance operating time for each cooking operation: white sauce (r=0.7570), carrots (r=0.7149), broccoli (r=0.7973), and crepes (r=0.7186) (Appendix G, Table 7.1). Multicollinearity also was found between the participant's familiarity with the research procedure for cooking white sauce and crepes (r=0.764) (Appendix G, Table 7.2). However, neither of these variables significantly explained the variance in energy consumption and therefore were not added to the regression equation. Furthermore, the number of cooktops the participant had used on a regular basis was highly correlated with the composite variable for experience (r=0.699). The number of cooktops the participant had used regularly (V15) did not contribute as much to the R^2 as the composite variable of user's experience (V75). The variable that was most highly correlated with the dependent variable was selected for the final regression equation using a stepwise analysis technique.

Table 4.4

Descriptive Statistics for Variables under Investigation--Appliance Operating Time

Variable Name	Descriptive Statistics		
	Mean (Min.)	Range (Min.)	SD
White sauce	13.1	1.5 - 38.5	6.2
Carrots	15.2	3.4 - 42.5	5.7
Broccoli	16.3	5.3 - 55.4	5.9
Crepes	21.4	5.6 - 47.2	5.9
Total time	66.1	26.4 - 150.3	17.8

Note. Obs=360

Table 4.5

User Interaction with Cooking Systems to Complete the Menu--Descriptive Statistics

Variable Name	Descriptive Statistics Mean	SD
Number of times cooktop controls were manipulated		
Carrots	3.3	1.1
Broccoli	3.5	1.4
White sauce	3.7	1.5
Crepes	4.6	2.0
Number of times cookware was picked up		
Carrots	0.3	0.6
Broccoli	1.1	1.7
White sauce	2.9	2.8
Crepes	10.8	3.8
Number of times cookware was slid		
Carrots	0.5	0.8
Broccoli	0.8	1.3
White sauce	1.3	1.6
Crepes	3.4	4.0
Number of times cookware was opened		
Carrots	5.2	3.4
Broccoli	7.5	3.8
Number of times the food was manipulated		
Carrots	1.6	2.1
Broccoli	5.6	3.2
White sauce	14.3	5.6
Crepes	37.1	20.0
Composite variable for user interaction	107.3	24.2

Note. Mean = Number of times the user interacted with each variable under investigation.
Obs=360

Multicollinearity was found between the number of times the participant opened the broccoli saucepan (V55) and the composite variable for interaction (r=0.7040) (Appendix G, Table 7.3, V72). Neither of the previously mentioned variables significantly explained the variance in energy consumption; therefore, they were not added to the regression equation. Also, the number of times the user manipulated the crepes (V61) was highly correlated with the composite variable for user interaction (r=0.6871) (V72). The number of times the user manipulated the broccoli (V62) was highly correlated with the number of times the user opened the broccoli saucepan. However, none of the highly correlated user interaction variables significantly contributed to the regression equation to explain the variance in energy consumption.

There was no multicollinearity between any of the variables that measured the attributes of consumer's practices (Appendix G, Table 7.4). However, consumer's use of retained heat to cook the carrots (V27) and broccoli (V28) were highly correlated (r=0.6575). The use of retained heat to cook the broccoli contributed the most to the regression equation.

Multicollinearity was found between independent variables when all composite variables, interaction variables, and other individual variables (i.e., cooktop, cookware, knowledge, and goodness-of-fit) were analyzed (Appendix G, Table 7.5). Typically, multicollinearity was found between the original independent variable and an interaction variable that included the original variable. For example, multicollinearity was found between: knowledge (V5) and information (V106) (r=-0.8659), and knowledge (V5) and user (V107) (r=-0.7551). Furthermore, multicollinearity was found between the cooking system interaction (V81) and the cooktop (V3) (r=0.6417), and the cookware (V4) (r=0.7001). Between the cooktop (V3) and the interaction variable of cooking system interaction and goodness-of-fit (V82), multicollinearity was found (r=0.7920). In addition, multicollinearity was found between user interaction (V72): and user behavior (V104) (r=0.7018). Between the user (V107) and information (V106) (r=0.8724), and the user (V107) and the total model (V108) (r=0.8897) multicollinearity was found.

Step II

Hypotheses Related to Correlation

H_o1. There is not a significant relationship between the consumer's knowledge and energy consumption of cooking systems.

Analysis. Consumer's knowledge was a score derived from the percentage of correct responses to a pretest examination (Appendix C). Mean and standard deviation for knowledge were 44.5 and 18.8, respectively (Table 4.1). There is significant negative correlation of -0.1641 (p=0.0016) (Table 4.6) between knowledge and energy consumption. In response to H_o:1, there was a significant relationship between consumer's knowledge and energy consumption of cooking systems. Therefore, the null hypothesis was rejected, meaning that consumers with higher knowledge scores used less energy to complete the research menu.

Discussion. Consumers with more knowledge about cooking systems utilized less energy to complete the menu. Knowledge scores ranged from 20% to 84%. The consumers with the highest knowledge scores (i.e., 60% or greater, n=5) had participated in formal training and educational opportunities regarding cooking appliances and energy efficiency. For example, the participants with the greatest knowledge scores had taken a household equipment course that included study of cooktops and cookware.

Steidl and Bratton (1968) stated that information is important in skill development. From these data it appeared that using cooking energy efficiently requires skill development. However, in contrast to other forms of skill development it is not possible for consumers to visualize the energy savings in cooking. Formal training informs people how to increase energy efficiency and improves skill development of energy efficient cooking. However, it is important to recognize that a correlation is not a cause and effect relationship. The correlation simply finds support that an increase in knowledge decreases energy consumption or increases energy efficient cooking practices.

This research further found a positive relationship between knowledge and experience level regarding cooking systems (r=0.1041). Therefore, consumers with the highest knowledge scores typically had higher experience levels with cooking systems and the research procedures.

H_o2. There is not a significant relationship between the consumer's experience and the energy consumption of cooking systems.

Analysis. Twelve items used to measure consumer's experience were combined to form a composite index (Appendix C). The mean and standard deviation for experience were 7.9 and 1.7, respectively (Table 4.2). There is lack of a correlation (r=-0.0451, p=0.3925) between consumers' experience level and energy consumption

Table 4.6

Correlations Between Independent Variables and Energy Consumption

Independent Variables	Energy Consumption	
	r	*p*
Knowledge	-0.1641	0.0016*
Experience	0.0451	0.3925
Practices	-0.1580	0.0025*
User Interaction	0.1200	0.0222*
Information	-0.1289	0.0140*
Behavior	0.1754	0.0007*
User	0.1881	0.0005*
Appliance Operating Time	0.1498	0.0041*
Total Model	0.1970	0.0005*
Cooking System	-0.2188	0.0000*
Goodness-of-Fit	-0.2385	0.0000*
Cooking System and Goodness of Fit	-0.1183	0.0242*

Note. * = Significant relationship at $p \leq .05$

(Table 4.6). In response to H_o:2, there was not a significant relationship between consumer's experience level with cooking systems and energy consumption of cooking systems. Therefore, the null hypothesis is retained; there is not a relationship between experience and energy consumption.

Discussion. The lack of a significant relationship between consumer experience level and energy consumption may be explained by: consumers indicated their experiences as opposed to the researcher observing their experiences, and participants indicated having high experience level but no formal training regarding cooking systems. For example, participants indicated the types of cookware and cooktops they used regularly on a questionnaire. Participants often did not know what type of cookware they used so told the researcher the brand or description of the cookware they used, then the researcher told the participant the cookware's name. Participants were unable to discern among the types of cookware even after having completed all the investigations with the cooking systems. The researcher had to review the names of the different types of cookware after all the investigations had been completed in order that participants could select their preferred cookware type.

Several participants indicated having had a lot of experience; however, they lacked formal training regarding cooking systems. One of the participants had worked in a restaurant. She reported having used many different types of cookware and being familiar with the research procedures (Appendix F). However, she was not familiar with cooking procedures that would reduce energy consumption (Appendix F). For example, she usually used medium or high heat settings and manipulated the food and cookware considerably, e.g., lifted cookware when stirring the foods and often manipulated the food by manipulating the cookware. Usually when melting the margarine for the white sauce, she lifted and turned the saucepan to move the margarine. In addition, she transferred crepes onto a plate without using a turner and tossed the crepes into the air when inverting them.

H_o3. There is not a significant relationship between the consumer's interaction and the energy consumption of cooking systems.

Analysis. The 18 items used to measure consumers' interaction with the cooking systems were combined to form a composite index (Appendix G). Mean and standard deviation for the interaction were 107.3 and 24.2, respectively (Table 4.5). There is a positive significant correlation of 0.1200 ($p=0.0222$) between consumer's interaction and energy consumption (Table 4.6). In response to H_o:3, there is a significant relationship between consumer's interaction with cooking systems and energy consumption of cooking systems. Therefore, the null hypothesis was rejected, meaning that when consumers increased interaction with the cooking system, a greater quantity of energy was consumed.

Discussion. Consumers who interacted with the cooking system more also used more energy to complete the research menu. The composite score of users' interaction ranged from 54 to 204 (Mean=107.3, s.d.=24.2). The quantity of user interaction may serve as a proxy variable for the user's control of the cooking system or perhaps the "nervous cook syndrome." One of the participants was in continual motion during cooking. For example, he moved from turning a crepe, to stirring the carrots, then the broccoli, and then stirring the white sauce. He then immediately removed the crepe from the pan, stirred the carrots, broccoli, and white sauce, then added crepe batter to the skillet, stirred the crepes, broccoli, and white sauce. Typically, he worked around the cooktop in a clockwise motion. He perhaps would adjust the controls between stirring and often removed the cookware from the heat source while stirring.

When the user interacts with the cooking system by stirring the food, air is incorporated into the food. The air is of a lower temperature than the food; and therefore reduces the temperature of the food which extends cooking time. In addition, removing the cookware from the heat source decreases the quantity of heat available in the cookware, and therefore, the cookware must be reheated which extends cooking time. Further, the relationship between the user's interaction level and appliance operating time was positive (r=0.5554) (Table 4.7). In this study, consumers did not use retained heat frequently; therefore, appliance energy use increased in proportion to cooking time. Furthermore, energy efficient practices were significantly correlated with interaction levels (r=-0.1592) and goodness-of-fit of the cooking system (r=-0.2385). Hence, when consumers utilized energy efficient practices there was a reduction in user interaction.

H_o4. There is not a significant relationship between the consumer's practices and the energy consumption of cooking systems.

Analysis. Twenty-seven items were used to measure consumer's practices with cooking systems and were combined to form a composite index (Appendix C). Mean and standard deviation for practices were 17.1 and 1.5, respectively (Table 4.3). There is a significant negative correlation of -0.1580 (p=0.0025) between consumer's

Table 4.7

Correlations Between Selected Composite Variables

Variable Name	*r*	*p*
Experience and Knowledge	0.1041	0.0476*
Practices and Information	-0.1592	0.0023*
Appliance Operating Time and Interaction	0.5554	0.0000*
Information and Behavior	-0.2246	0.0000*

Note. *=Significant relationship at $p \leq .05$

practices and energy consumption (Table 4.6). In response to H_O:4, there is a significant relationship between consumers' practices with cooking systems and energy consumption of cooking systems. Therefore, the null hypothesis is rejected.

Discussion. Consumers with higher practice scores needed less energy to complete the research menu. Use of retained heat was limited. In addition, matching the diameter of the skillets' contact area to the diameter of the heat source was limited. A "10 inch" skillet was used in this investigation. However, the 10 inches were measured across the diameter of the top of the skillet (i.e., 10 inch opening). The range of the contact area diameter was 6.0-8.875 inches. The majority of the participants matched the skillet to the largest heat source. However, the 6" contact area of the heavy gauge aluminum with a non-stick finish most closely matched the diameter of the smaller heat source. If the participant cooked all four foods simultaneously, then one or two cooking operations would not have matched the heat source and the cookware diameter. For example, if the cooktop had two eight inch elements then at least one of the saucepans was too small for an element and the heavy gauge aluminum with a non-stick finish also was too small for the large element. Participants also chose not to dovetail all of the activities which would enabled them to reuse heated elements and match the diameter of the heat source with the cookware.

Preheating elements, preheating cookware, and failing to turn the cooktop off after cooking were not common practices. However, one participant frequently used one if not all of these practices. Typically he first turned each element on high, followed by placing the cookware on the heat source, then placing the food in each saucepan, and lastly placing the cover on the cookware. In addition, he typically left the heat source on for extended periods of time after cooking was completed. The element could be red hot with no cookware on it and he did not turn the control to off.

H_O5. There is not a significant relationship between appliance operating time and the energy consumption of cooking systems.

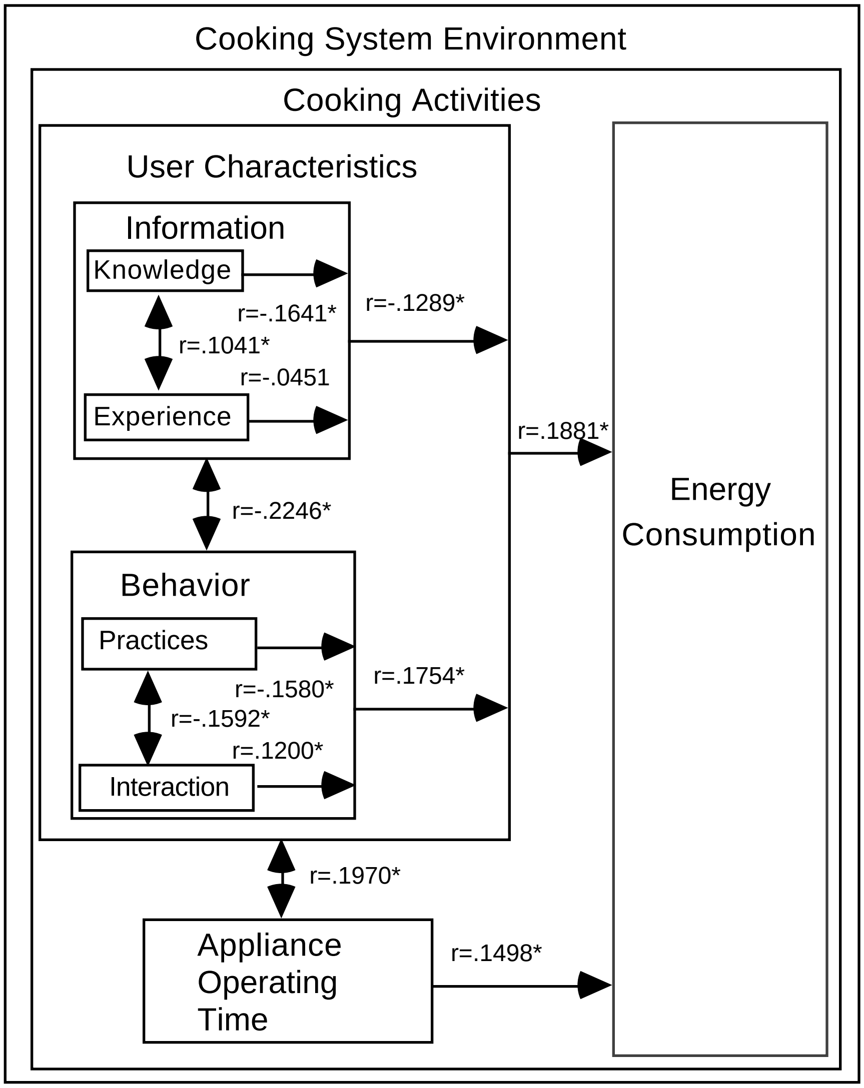
Analysis. The four appliance operating time measures were combined to form a composite index (Appendix C). Mean and standard deviation for the total appliance operating time were 66.1 minutes and 17.8, respectively (Table 4.4). Appliance operating time ranged from 26.4 to 150.3 minutes. There is a significant positive correlation of 0.1498 ($p=0.0041$) between appliance operating time and energy consumption (Table 4.6). In response to H_O:5, there is a significant relationship between appliance operating time and energy consumption of electric cooking systems. Therefore, the null hypothesis is rejected, meaning that an increase in appliance operating time yields greater energy consumption.

Discussion. The greatest variation in time required to complete the cooking operation was found with broccoli, followed by crepes. Appliance operating time may vary due to the control setting selected and preference for degree of doneness. There is an interaction between control settings used and appliance operating time. For example, if low heat settings are selected then longer appliance operating time is needed to complete the cooking. The degree of doneness is under the control of the user and has an influence on energy consumption. For example, a consumer's preference for degree of browning of crepes or crispness of vegetables influenced energy consumption.

Correlations between Statistical Interaction Terms and Energy Consumption

To empirically test the relationships expressed in the framework used for this investigation (Figure 2.1 and Figure 4.1), a correlation test of significance was conducted using Number Cruncher Statistical System (NCSS) program. Cooking system interaction was created by establishing the product (V3 X V4) of the cooktop (V3) and cookware (V4). A significant negative correlation ($r = -0.2188$, $p = 0.0000$) was found between the cooking system interaction and energy consumption (Table 4.7). In addition, the cooking system interaction (V81) was multiplied by the goodness-of-fit (V64) score to create a new interaction term (V82). A significant negative correlation ($r = -0.1183$, $p = 0.0242$) was found between the interaction of the cooking system and goodness-of-fit (Table 4.7).

An information (V77) interaction variable was created by calculating the product of consumers' knowledge (V5) and the composite index of their experience level score (V75). A significant negative relationship ($r = -0.1289$, $p = 0.0140$) was found between the user's information and energy consumption of electric cooking systems (Table 4.6). The user practices variable (V76) was reverse coded to parallel the direction of the interaction index needed to create a composite index of user's behavior. Therefore, a behavior interaction variable (V104) was created by determining the product of the composite indexes of the user's practices (V103) and interaction level (V72). In addition, a significant negative relationship ($r = -0.2246$, $p = 0.0000$) was found between the user's information and their behavior (Table 4.6).



Note. *=Significant Relationship

Figure 4.1. Application of framework of Phase I with correlation values, the user's influence on energy consumption with cooking systems as explained by user characteristics and appliance operating time.

The information composite index was reverse coded to parallel the behavior index needed to develop an index that represents the user (V107). An interaction variable that represents the user was created by multiplying the user's information index (V106) and the user's behavior (V104). A significant positive relationship was determined ($r = 0.1881$, $p = 0.0003$) between the user of the cooking system and the energy consumption of the cooking system (Table 4.7). In addition to testing the total model, a composite interaction term was created by calculating the product of appliance operating time (V74) and the user (V107). A significant positive correlation was found between the total model (i.e., V108--appliance operating time and the user), and energy consumption of the cooking system using electricity ($r = 0.1881$, $p = 0.0003$) (Table 4.7).

This research found small but significant correlations. The correlations found are considered meaningful. If a larger sample size (>15) were utilized, then larger correlation values may be anticipated. This research is only a preliminary attempt to quantify user's behavior and user's information in an attempt to explain energy consumption. Therefore, the small correlations are considered meaningful because it says we are on the right track.

Hypotheses Related to Multiple Regression

Multiple regression analysis with the computer software package Number Cruncher Statistical System (NCSS) was used to explain the variance associated with the users' influence on electric energy consumption measured in watthours. A stepwise selection procedure was used to determine the independent variables to be entered into the regression equation. Independent variables included in the full regression equation contributed significantly ($p \leq .05$) to the R^2, or significantly reduced the mean square error. Therefore, only explanatory variables with probability values that contribute significantly to the R^2 remained. However, all variables were not included in the full regression equation; see Appendix G, Table 7.6 and 7.7 for results.

When all the independent variables (79 variables) were entered into the regression equation, four variables were specified to be deleted due to lack of variance: none of the participants had purchased a cooktop (V6), none of the participants were familiar with waterless cooking (V11), none of the participants left the cooktop on after cooking the white sauce (V37), and everyone placed carrots in the cookware before or immediately after turning on the cooktop (V43).

H_o:6 . Variance in energy consumption is a function of: appliance operating time, knowledge, experience, user interaction, practices, information, behavior, user, total model and specific variables used to create statistical interaction and composite variables.

Analysis. An R^2 of 0.2535 was produced when the 11 of the available 72 independent variables, specifically the variables under the user's control, were entered into the regression equation (Table 4.8). Each of the variables added to the regression equation had a significant probability level (Table 4.8). Hence, the user explains 25.4% of the variance in energy consumption of electric cooking systems with an F ratio of 10.74. The R^2 was significant at the p=0.000 level with a root mean square error of 103.6081.

Specific measures of consumer's experience as well as the composite index of experience contributed to the relative importance when explaining user's influence on energy consumption of cooking systems. The only variable related to time that significantly explains the variance in energy consumption was the time needed to fry crepes (ß=0.2437). In addition, the only user interaction term that significantly explains variations in energy consumption due to the influence of the user was the number of times the skillet was picked up (ß=0.1582). Specific measures contribute to the explanation of variation in energy consumption. Each of the user practices that were included in the regression equation were related to the cooking of crepes or broccoli (Table 4.8).

Discussion. In this research, the user explained 25% of the variation in energy consumption. The consumer's attention to detail is an underlying trend. For example, turning off the cooktop when cooking was completed, matching the diameter of the heat source with the diameter of the cookware's contact area, using a low or medium heat setting, and preheating the element are all details that influence the quantity of energy consumed. The hurried style does not pay attention to the details and therefore, does not have as much control over the system and the outcome of the process.

Familiarity with boiling carrots had the greatest magnitude of explanation of variations in energy consumption. This variable may indicate the extent of consumers' cooking experience (and level of skill development), meaning that boiling is a very basic cooking task. If consumers had limited cooking experience with boiling, they more than likely have a limited overall cooking experience level. Frying crepes or using waterless cooking were not common experiences with this sample, therefore,

Table 4.8

Regression Coefficients for Predictors of Energy Consumption--Hypothesis 6

Variable Name	Regression Coefficient for Predictors		
	b	ß	p
Was the participant familiar with procedure used to cook carrots	-74.604	-0.2983	0.0000
Appliance operating time - Crepes	4.902	0.2437	0.0000
Had the participant taken a course that covered cooktops and/or cookware?	-45.061	-0.1907	0.0092
Was a low or medium heat setting selected - Crepes	-97.037	-0.1840	0.0001
Number of times the cookware was picked up - Crepes	4.915	0.1582	0.0014
Knowledge	-0.930	-0.1483	0.0079
Was the diameter of the heat source and cookware matched - Crepes	-33.273	-0.1411	0.0027
Was cookware placed on the element before or immediately after turning on the heat source - Broccoli	155.740	0.1385	0.0033
Was the cooktop turned off after cooking - Carrots	-73.598	-0.1247	0.0119
Number of times cooktop controls were adjusted - Crepes	-7.393	-0.1234	0.0112
Composite - Experience	-7.011	-0.0982	0.0545
Intercept	675.312	0.0000	0.0000

Note. See Appendix G (Table 7.2) for variables not included in regression model.
Listed according to order of magnitude of standardized regression coefficient
R^2 = 0.2535 Root Mean Square Error = 103.6081 0=No
F = 10.74 p = 0.000 1=Yes
b=Regression coefficient ß=Standardized regression coefficient

most of the participants were not familiar with the procedure and the variables did not explain variations in energy consumption. This research has also found that the knowledge and experience statistical interaction were significantly correlated with energy consumption. Therefore, consumers with more information used less energy to complete the research menu.

H_o:7. Variance in energy consumption is a function of: container material, energy source, goodness-of-fit, appliance operating time, knowledge, experience, user interaction, practices, information, behavior, user, total model, cooking system, cooking system and goodness-of-fit, and specific variables used to create composite and statistical interaction variables.

Analysis. An R^2 of 0.3860 was produced when the 17, of the available 75, independent variables with a significant probability were entered into the regression equation (Table 4.9). Therefore, 38.6% of the variance in energy can be explained by these combined independent variables. With an F ratio of 12.65, the R^2 was significant at the 0.000 level with a root mean square error of 94.78.

Knowledge contributed the greatest relative importance when explaining variance in energy consumption (ß=-0.3540). In addition, specific measures of experience contribute to the explanation of variance through familiarity with cooking procedure for carrots (ß=-0.3402), taking a course that included cooktops or cookware (ß=-0.2994), or an equipment course (ß=-0.1979).

Cooking system interaction and goodness-of-fit are important variables to explain variance in energy consumption. The composite variable of practices (ß=-0.2973) and other specific individual variables related to cooking crepes and broccoli contribute to the equation. Appliance operating time in cooking the crepes was the only variable related to time that significantly explained the dependent variable (ß=0.1338). Furthermore, the only interaction variable that explained the energy consumption variation was the number of times the skillet was lifted (ß=0.1048).

In summary, variables relating to cooking system, goodness-of-fit, knowledge, practices, experience (familiarity with cooking procedure for carrots, studying cooktops and cookware, and equipment course), appliance operating time to cook crepes, and the number of times the skillet was lifted explained 38.6% of the variance in energy consumption with cooking systems using electricity.

Table 4.9
Regression Coefficients for Predictors of Energy Consumption--Hypothesis 7

Variable Name	Regression Coefficient for Predictors		
	b	ß	p
Knowledge	-2.218	-0.3540	0.0001
Was the participant familiar with the procedure used to cook carrots?	-85.091	-0.3402	0.0000
Had the participant taken a course that covered cooktops and/or cookware?	-70.760	-0.2994	0.0000
Composite - Practices	-23.225	-0.2973	0.0000
Cooking System Interaction	-5.337	-0.2761	0.0000
Goodness-of-Fit	-45.973	-0.2517	0.0000
Did the participant touch the saucepan - Broccoli	52.888	0.2282	0.0000
Had the participant taken a household equipment course?	-46.779	-0.1979	0.0338
Was a low or medium heat setting selected - Crepes	-89.399	-0.1695	0.0010
Was the diameter of the cookware and the heat source matched - Crepes	-38.216	-0.1620	0.0008
Was cookware placed on the cooktop before or immediately after turning on the element - Broccoli	174.713	0.1553	0.0008
Appliance operating time - Crepes	2.693	0.1338	0.0063
Was retained heat used - Broccoli	83.545	0.1220	0.0130
Was a low or medium heat setting selected - Broccoli	116.156	0.1153	0.0150
Number of times cookware was picked up - Crepes	3.256	0.1048	0.0225
Was the cooktop turned off after cooking - Crepes	50.698	0.0985	0.0547
Was cookware placed on the cooktop before or immediately after turning on the element - Crepes	-112.961	-0.0871	0.0529
Intercept	1141.537	0.0000	0.0000

Note. See Appendix G (Table 7.1) for variables not included in regression equation.
Listed according to order of magnitude of standardized regression coefficient
R^2 = 0.3860 Root Mean Square Error = 94.78 0=No
F = 12.65 p = 0.000 1=Yes
b=Regression coefficient ß=Standardized regression coefficient

Discussion. Fechter and Porter (1978) found a variation as high 60% among homemakers using the identical ranges (cooktop and oven), utensil, and menu. In a study limited to cooking system (cooktop-cookware) use, DeMerchant, Lovingood, and Leech (1995) found a variation as high as 120% when the same menu was cooked on the same cooking system. Therefore, past research has found the user to be a significant variable when energy consumption is investigated with cooking systems. However, this research found the cooking system interaction and goodness-of-fit to contribute significantly to the explanation of variation in energy consumption. The user's knowledge, experience level, practices, and interaction level contribute the majority of the R^2. Furthermore, the cooking operations for frying crepes and using waterless cooking significantly contributed to the R^2 more frequently than did the other cooking operations. The white sauce did not contribute to the explanation of the variation in energy consumption. Participant's familiarity with boiling carrots was the only variable associated with boiling carrots that significantly explained the energy consumption variation.

Summary of Findings

The chapter began by presenting findings related to characteristics of the sample. The 15 participants were traditional age graduate and undergraduate students who had limited experience with cooking systems and cooking. The majority of them were familiar with making a white sauce and boiling carrots, but few were familiar with frying crepes or waterless cooking.

Multicollinearity was found between a few variables; therefore, only the variables that contributed the most to the R^2 were used in the regression equation (as determined by the stepwise regression). For example, appliance operating time was correlated (r=0.7) with each cooking operation's operating time (i.e., white sauce r=0.7570, carrots r=0.7119, broccoli r=0.7973, crepes r=0.7186), familiarity with cooking procedure for crepes and white sauce were highly correlated (r=0.764); and number of times the broccoli saucepan was opened and the composite variable for interaction were also highly correlated (r=0.7040).

Significant relationships were found between energy consumption and: knowledge (r=-0.1641, p = 0.0016), practices (r=-0.1580, p = 0.0025), interaction (r=0.1200, p = 0.0222), and appliance operating time (r=0.1498, p = 0.0041). However, there was not a significant relationship between experience and energy consumption (r=0.0451, p = 0.3925). Relationships between energy consumption and created interaction variables (e.g., cooking system) were found to be significant. Relationships analyzed were an empirical test of the relationships expressed in the framework used in the investigation (Figure 2.1). For example, there is a significant relationship between information and behavior.

Multiple regression was used in this analysis with variables selected using a stepwise selection procedure. An R^2 of 0.3860 was found when all possible explanatory variables related to energy consumption of cooking systems were selected for the analysis (i.e., user and cooking system). In addition, an R^2 of 0.2535 was found when only the variables under the users control (e.g., practices, experience, knowledge) were included in the regression equation. Therefore, the user explained approximately 25% of the variation in energy consumption; and when the cooking system and its goodness-of-fit were added to the equation approximately 39% of the variation in energy consumption was explained.

CHAPTER V
Descriptive Findings and Discussion
(Phase II)

Introduction

The purpose of this research was to explain the user's influence on energy consumption with cooking systems using electricity. The objective of this section is to describe two sets of cooking style categories. Cooktops used in this investigation were conventional electric coil, solid element, radiant coil under glass ceramic, and halogen under glass ceramic. Cookware used in this investigation included thin aluminum, heavy aluminum, heavy aluminum with a non-stick finish, stainless steel with aluminum heat core, thin porcelain enamel on aluminum with a non-stick finish, and glass ceramic. The attributes investigated in this research were practices and appliance operating time. The purpose of this chapter is to describe the characteristics and trends within each of the two sets of cooking style categories.

Energy consumption values (i.e., watthours used to complete each test) were divided into five categories. Computer software Number Cruncher Statistical System (NCSS) divided the data into five categories based on natural breaks in the data (Figure 3.1). Data sheets then were divided into five piles that corresponded with the computed categories. Each pile of data sheets was further divided to count the number of cooktops and cookware per category. Additional data collected from the data collection sheets: highest heat setting used, the diameter of the heat source matched with the cookware diameter when using high heat, retained heat used, hot elements reused, were pans or heating element preheated, covers used during cooking, and the heat source left on after cooking. In addition, light reflectance values of the fourth crepe were used to indicate the user's control of the cooking system. Lower light reflectance values indicate darker color or less light reflected (e.g., L-value of 1.8 is a very burned crepe or 60 is a very lightly colored crepe with little or no browning).

The range of appliance operating time was determined for each category by color coding a print-out of the data. Each category was assigned a color and energy consumption values were color coded. The range was determined by manually reviewing color categories for each cooking operation and total appliance operating time. After determining the range of appliance operating time the data sheets were reviewed for the extreme values of each range to discover the trend of each category.

Characteristics of Cooking Styles

The following discussion of cooking styles is sub-divided into five categories. A brief description of each category was developed using the characteristics and trends that bind the category together as identified by energy consumption. The five categories were: the patient style (485-646 Wh), the average style (647-806 Wh),the uninformed style (807-966 Wh), the hurried style (967-1127 Wh), and the hurried style with no control (1128-1288 Wh).

The Patient Style

Energy consumption for the first category of cooking style ranged from 485 watthours to 646 watthours (Table 5.1). Fifty-five observations that consisted of all 15 participants were included in this category. This category was called patient because of the tendency to use low to medium heat settings.

Halogen under glass ceramic was the most common type of cooktop in this category (38.2%), and the solid element was the least common (12.7%). The frequency of the conventional electric coil (27.3%) and radiant coil under glass ceramic (21.2%) were similar in occurrence. Stainless steel with aluminum heat core had the highest occurrence of the cookware (46%); thin aluminum cookware had the lowest frequency of occurrence (3.6%). In addition, the other cookware types varied little in their occurrence: heavy aluminum (7.3%), heavy aluminum non-stick (12.7%), thin porcelain-on-aluminum non-stick (12.7%), and glass ceramic (18.2)%.

Instructions for the stainless steel with aluminum heat core specify using low to medium heat setting; and therefore, may be related to the consumers' use of medium heat and using less energy. Thin aluminum cookware warped during the project. Separate cookware sets were used for heating elements with thermal limiters (i.e., solid element, radiant and halogen under glass ceramic) versus heating elements without thermal limiters (i.e., conventional electric coils). Cooktop manufacturers state that heating units containing thermal limiters will not warp cookware; however, in this research it was found that the first time a thin aluminum skillet was used on any of the cooktops it warped. Because flat-bottom cookware utilizes less energy, thin aluminum cookware was not a common occurrence in this category.

Table 5.1

Description of The Patient Style

Category Name: The Patient Style

Energy Range: 485 - 646 Watthours

Obs = 55

Number of Different Consumers (n=15)

Cooktops	Cookware
Conventional Electric Coil (27.3%)	Thin Aluminum (3.6%)
Solid Element (12.7%)	Heavy Aluminum (7.3%)
Radiant Coil u/Glass Ceramic (21.8%)	Heavy Aluminum NS (12.7%)
Halogen u/Glass Ceramic (38.2%)	Stainless Steel w/Aluminum HC (45.5%)
	Thin Porcelain-on-Aluminum NS (12.7%)
	Glass Ceramic (18.2%)

Heat Source Left on After Cooking (9.1%)

No Cover on During Cooking (1.8%)

Skillet not Preheated (5.5%)
Saucepan Preheated (1.8%)

Preheated Element (1.8%)

Used Retained Heat (9.1%)

Reused Hot Element (9.1%)

Did not Match Diameter of Heat Source and Cookware and Used High Heat (18.2%)

Appliance Operating Time

	Crepes	Carrots	White Sauce	Broccoli	Total
Range of Min:Sec	5:58-29:15	6:08-29:31	2:39-22:39	5:42-27:28	29:39-105:34
Difference	23:17	23:23	20:00	21:46	75:55

Highest Heat Setting Used

	Crepes	Carrots	White Sauce	Broccoli
	%	%	%	%
High	1.8	56.4	3.6	0.0
Med-Hi	12.7	18.2	10.9	7.3
Med	81.8	21.8	50.9	67.3
Med-low	1.8	3.6	34.5	25.5
Low	1.8	0.0	1.8	1.8
Total	99.9	100.0	99.8	100.1

Note. Percentage may not equal 100% due to rounding error.

In nine percent of the observations in this category the cooks left the heat source on after completing the cooking operation. In approximately 2% of the tests cooked without a cover on the saucepans and preheated an element before cooking. In addition, 9% of this category reused a hot element and used retained heat. However, 18.2% did not match the diameter of the heat source with the diameter of the cookware when using high heat. A medium heat setting was selected by the majority of the participants for frying crepes (81.8%), waterless cooking (67.3%), and thermalization (50.9%). However, 56.4% of the observations selected high when boiling carrots. Also, medium-low was used by 26% of the category to cook the broccoli and 36% for boiling.

The observations with the shortest total appliance operating time (29 min. 39 sec.) cooked with medium heat when using the conventional electric coil and heavy aluminum non-stick cookware. However, she started the carrots on high heat and turned the setting down to medium. She also had the shortest appliance operating time to fry crepes (5 min. 58 sec.). The six crepes fried were dark but even (L-value 15.2 - 18.8). This participant did not measure the crepe batter. She used minimum user interaction: picked up skillet (n=7), slid skillet (n=5), manipulated crepes (n=28). She adjusted the controls five times in the short time the crepes cooked.

The observation with the longest total appliance operating time (150 min. 34 sec.) used low heat when cooking white sauce and broccoli when using the halogen under glass ceramic and heavy aluminum non-stick cookware. In addition, the same observation was the longest operating time for: carrots (29 min. 31 sec.) using medium to low heat, white sauce using low heat (22 min. 29 sec.), and crepes using medium heat (29 min. 31 sec.; L-value, 10.7 - 28.6). She used minimum user interaction: manipulated carrots (n=0), opened carrots (n=1), picked up skillet (n=8 to fry 6 crepes), slid skillet (n=4), opened broccoli (n=4), manipulated broccoli (n=3), picked up and slid white sauce (n=0), stirred white sauce (n=14).

The observation with the shortest time needed to cook the white sauce (2 min. 39 sec.) used retained heat (9 min. 19 sec.) to complete the cooking when using the halogen under glass ceramic and stainless steel with aluminum heat core cookware. This observation never picked up the white sauce pan and only stirred it 10 times and slid the pan four times (i.e., she did not hold the handle when stirring, so the pan would slide around). Retained heat (18 min. 15 sec.) was used by the observation who only operated the conventional electric coil and heavy aluminum non-stick cookware to cook carrots 6 minutes and 9 seconds. This observation initially started the carrots on high and then turned the heat setting to low. During the entire cooking process, the saucepan was opened eight times but never manipulated the carrots. When cooking broccoli with the radiant coil under glass ceramic cooktop and stainless steel with aluminum heat core cookware the appliance operating time was 5 minutes and 42 seconds. Furthermore, a medium heat setting was used and the user only interacted with the cookware three times. The longest appliance operating time (27 min. 34 sec.) to cook broccoli occurred with the solid element and glass ceramic cookware using medium to medium-low heat settings; and the participant opened the saucepan 13 times and manipulated the broccoli 12 times.

In summary, the cooks in this category were more patient with the cooking without using more appliance operating time. They used medium heat settings, reused hot elements, and used retained heat. Stainless steel with aluminum heat core was used in 46% of the observations in this category. However, 9% did leave the heat source on after cooking and 18% did not match the diameter of the heat source and diameter of the cookware when using high heat.

The Average Style

Energy consumption for the second category of cooking style ranged from 647 watthours to 806 watthours (Table 5.2). This range of watthours contained the largest number of observations (n=191) and all 15 participants were included in this category. Solid element cooktop was the least common type of cooktop observed in this category. Other cooktops varied little in their frequency: conventional electric coil (29.3%), radiant coil under glass ceramic (31.4%), and halogen under glass ceramic (26.2%). In addition, the frequency of cookware was similar across types: thin aluminum (15.7%), heavy aluminum (17.3%), heavy aluminum non-stick (17.8%), stainless steel with aluminum heat core (16.2%), thin porcelain-on-aluminum non-stick (14.7%), and glass ceramic (18.3%).

Approximately 10% of the observations in this category left the heat source on after completing the cooking operation. Less than one percent of the observations cooked without a cover on the saucepans, and less than one percent preheated an element before cooking. However, 2.6% of this category reused a hot element and 10% used retained heat. In addition, 18.3% did not match the diameter of the heat source with the diameter of the cookware when using high heat. A medium heat setting was selected by the majority of the observations for frying crepes (75.9%),

Table 5.2

Description of The Average Style

Category Name: The Average Style

Energy Range: 647 - 806 Watthours

Obs= 191

Number of Different Consumers (n=15)

Cooktops	Cookware
Conventional Electric Coil (29.3%)	Thin Aluminum (15.7%)
Solid Element (13.1%)	Heavy Aluminum (17.3%)
Radiant Coil u/Glass Ceramic (31.4%)	Heavy Aluminum NS (17.8%)
Halogen u/Glass Ceramic (26.2%)	Stainless Steel w/Aluminum HC (16.2%)
	Thin Porcelain-on-Alum NS (14.7%)
	Glass Ceramic (18.3%)

Heat Source Left on After Cooking (9.9%)

No Cover on During Cooking (0.005%)

Skillet not Preheated (2.6%)
Saucepan Preheated (2.6%)

Preheated Element (0.005%)

Used Retained Heat (9.4%)

Reused Hot Element (2.6%)

Did not Match Diameter of Heat Source and Cookware and Used High Heat (18.3%)

Appliance Operating Time

	Crepes	Carrots	White Sauce	Broccoli	Total
Range of Min:Sec	10:26-45:36	3:41-27:25	2:07-38:06	6:38-55:36	37:58-127:39
Difference	35:10	24:24	36:36	49:38	89:41

Highest Heat Setting Used

	Crepes	Carrots	White Sauce	Broccoli
	%	%	%	%
High	5.2	62.3	5.2	1.1
Med-Hi	15.2	15.7	7.8	3.7
Med	75.9	21.5	70.2	77.0
Med-low	1.6	0.0	9.9	14.1
Low	2.1	0.0	6.8	4.2
Total	100.0	99.5	99.9	100.1

Note. Percentage may not equal 100% due to rounding error.

waterless cooking (70.2%), and thermalization (77%). However, 62% of the observation selected high when boiling carrots.

The observation with the shortest total appliance operating time (37 min. 55 sec.) cooked with medium heat and did not turn the setting up or down during the cooking process except high heat was used to boil the carrots. He never checked the carrots for doneness and crepes were dark and uneven (L-value, 10.2 - 26.5).

The observation with the longest cooking time started cooking the white sauce and broccoli and turned the heat up to medium and back to low. In addition, the initial heat setting for carrots was high until the boiling point was reached, medium was used until the carrots were cooked, and low was selected to keep them warm; medium and medium-low heat settings were selected to fry crepes (L-value 32.6 - 37.9). She removed all food from the cooktop approximately at the same time. However, the person who used the shortest span of appliance operating time removed foods immediately after cooking was complete; hence, all the foods were removed at a different time.

Both of the total appliance operating time observations described occurred with the same cooking system (i.e., conventional electric coil and stainless steel with aluminum heat core). In addition, both observations selected the same elements to perform each cooking operation. The observation with the shortest appliance operating time (Participant #5) used 715 watthours; the observation with the greatest appliance operating time (Participant # 3) used 752 watthours (only 5% variation in energy consumption).

The quantity of user interaction for cooking was greatest for the observation with the longest cooking time: he (#5) never checked the carrots and she (#3) checked them six times for doneness; he (#5) manipulated the crepes 25 times compared to her 71 times (#3); he (#5) opened the broccoli three times and manipulated it twice while she (#3) opened the broccoli 18 times and manipulated it 16 times and touched the saucepan twice to determine if it was warm; he stirred the white sauce six times and she stirred it 15 times. He conducted all four cooking operations at the same time (#5). She started the white sauce after the carrots and broccoli were nearly done, and completed the crepes and white sauce at the same time (#3). However, the biggest difference in users' control and appliance operating time may be attributed to the heat setting selected.

Conventional electric coil and heavy aluminum were used when the greatest amount of time (55 min. 36 sec.) was needed to cook the broccoli, compared to 6 minutes 38 seconds (i.e., shortest appliance operating time) used with the solid element and stainless steel with aluminum heat core. The difference between the two observations is due to the shortness of the appliance operating time needed when a medium heat setting was selected as compared to a medium and then low heat selection used in the observation with the longest appliance operation time.

When cooking the white sauce, the same cooking system (i.e., solid element and stainless steel with aluminum heat core) was used by the observation with the longest (38 min. 6 sec., 782 watthours) and the shortest appliance operating time (2 min. 7 sec., 738 watthours). The shortest appliance operating time occurred when only a medium heat setting was selected and then the heat source was turned off after cooking was completed. The longest appliance operating time occurred when a medium-low heat setting was selected initially, then turned to medium, and later back to medium-low to keep the white sauce warm. The observation who used the shortest time stirred continuously compared to the person who used the greatest amount of time, stirring 25 times.

Appliance operating time for crepes varied from 10 minutes 26 seconds (i.e., radiant coil under glass ceramic and glass ceramic cookware) to 45 minutes and 36 seconds (i.e., solid element and stainless steel with aluminum heat core). The crepes cooked with the shortest appliance operating time were cooked on medium-high and were unevenly browned (L-value, 7.9 - 23.9) as were the crepes cooked with the longest appliance operating time (L-value, 22.3 - 44.4). The observation that used the shortest time had to lift the skillet to cool and make small adjustments in control settings (n=9). The uneven browning of the crepes when using the solid element and stainless steel with aluminum heat core may be attributed to the user greasing the skillet between crepes. The hot oil causes crepes to brown unevenly; however, the instructions said to grease the skillet when preheating the skillet and to throw away the first crepe.

Appliance operating time for carrots varied from 3 minutes and 41 seconds (i.e., conventional electric coil with heavy aluminum non-stick) to 27 minutes and 25 seconds (i.e., solid element and heavy aluminum). The observation that used the least time used high heat to boil the carrots and never checked the carrots for doneness, but did remove the cover twice. However, the observation that used the most time used med-high and medium heat settings to boil the carrots and opened the cover seven times and manipulated them four times.

In summary, the use of medium heat was typical in the average style category. The majority of the cooks did not leave the heat source on after cooking. Furthermore, the average style did not preheat the saucepans or elements. In addition, did not use retained heat or reuse a hot element in most of the observations. Only 18.3% of the observations did not match the diameter of the heat source and diameter of the cookware when using high heat.

The Uninformed Style

Energy consumption for the third category of cooking style ranged from 807 watthours to 966 watthours (Table 5.3). The number of observations in this category was 88 with all 15 of the cooks included. The solid element cooktop was the most common type found in this category (48.8%). All the other cooktop types varied little in their percentage of occurrence: conventional coil (14.8%), radiant coil under glass ceramic (17.2%), halogen under glass ceramic (19.3%). Cookware found in this category varied little, except for stainless steel with aluminum heat core which occurred only 3.4%: thin aluminum (22.7%), heavy aluminum (22.7%), heavy aluminum with non-stick (19.3%), thin porcelain-on-aluminum non-stick (20.5%), and glass ceramic (11.4%).

In approximately 21% of the observations in this category the cook left the heat source on after cooking was completed. All observations cooked with a cover on the saucepans, and only one percent preheated an element before cooking or reused a hot element. In addition, only 4.6% used retained heat. However, 36.8% did not match the diameter of the heat source with the diameter of the cookware when using high heat. A medium heat setting was selected the majority of the time by this category of cooks for frying crepes (65.6%), waterless cooking (78.2%), and thermalization (60.9%). However, in 69% of the observations selected high when boiling carrots. The majority of the cooking systems included in this category were heavy--a lot of mass. However, the observations in this project were not familiar with working with heavy cooking systems. Therefore, very few used retained heat to complete the menu.

The observation with the shortest total appliance operating time (39 min. 18 sec.) made the comment that the halogen under glass ceramic and thin porcelain-on-aluminum non-stick cooking system was "slow to heat-up, but once it gets hot the cooking was fast." She only fried eight crepes (L-value, 14.6 - 27.8) and slid the

Table 5.3

Description of The Uninformed Style

Category Name: The Uninformed Style

Energy Range: 807 - 966 Watthours

Obs = 88

Number of Different Consumers (n=15)

Cooktops (n=88)	Cookware (n=88)
Conventional Electric Coil (14.8%)	Thin Aluminum (22.7%)
Solid Element (48.8%)	Heavy Aluminum (22.7%)
Radiant Coil u/Glass Ceramic (17.2%)	Heavy Aluminum NS (19.3%)
Halogen u/Glass Ceramic (19.3%)	Stainless Steel w/Aluminum HC (3.4%)
	Thin Porcelain-on-Alum NS (20.5%)
	Glass Ceramic (11.4%)

Heat Source Left on After Cooking (20.7%)

No Cover on During Cooking (0%)

Skillet not Preheated (3.4%)
Saucepan Preheated (4.6%)

Preheated Element (1.1%)

Used Retained Heat (4.6%)

Reused Hot Element (1.1%)

Did not Match Diameter of Heat Source and Cookware and Used High Heat (36.8%)

Appliance Operating Time (n=87)

	Crepes	Carrots	White Sauce	Broccoli	Total
Range of Min:Sec	9:33-47:19	4:48-42:47	1:53-28:54	6:45-46:42	39:18-150:32
Difference	38:16	38:39	27:01	40:37	111:14

Highest Heat Setting Used

	Crepes %	Carrots %	White Sauce %	Broccoli %
High	10.3	69.0	3.4	1.1
Med-Hi	20.7	13.8	11.5	6.9
Med	65.5	13.8	60.9	78.2
Med-low	1.1	3.4	13.8	11.5
Low	2.3	0.0	10.3	2.3
Total	99.9	100.0	99.9	100.0

Note. Percentage may not equal 100% due to rounding error.
Differences in sample size are due to missing data.

cookware around to cover up the light as it cycled on and off. The observation with the longest total appliance operating time (150 min. 32 sec.) also used the most time to fry crepes (47 min. 19 sec.) and broccoli (46 min. 42 sec.) when using the solid element cooktop and heavy aluminum cookware. She was very particular about the crepes browning; hence, she moved them around to get even browning and cooked them until they were light brown (L-value, 38.9 - 41.4). In addition, she cooked the broccoli with a low heat setting and crepes on medium-low, and left the largest element on medium-low after completing the frying operation. Furthermore, she opened the cookware 27 times--hardly allowing the cookware time to heat up--when cooking the broccoli.

The observation with the shortest length of appliance operating time (9 min. 33 sec.) used a medium-high heat setting on the solid element with heavy aluminum non-stick cooking system. The observation with the shortest time (6 min. 45 sec.) to cook the broccoli was familiar with waterless cooking and only opened the cookware three times. In addition, she used a medium to medium-low heat setting in the test with the solid element and thin aluminum cooking system.

When preparing the white sauce, one observation only required 1 minute and 53 seconds using solid element and glass ceramic cookware compared to another participant who required 28 minutes and 54 seconds to perform the same task but using the solid element and thin porcelain-on-aluminum non-stick cookware. In both situations, low heat was selected. However, the participant who required longer to cook the white sauce lifted the saucepan seven times as compared to the saucepan which was not picked up during the shorter appliance operating time. In addition, the observation who cooked the white sauce using the shorter time was afraid of sticking when using glass ceramic cookware. In this project, food quality was not controlled, degree of doneness was the consumer's choice. Therefore, the appliance operating time was under the user's control and this user chose to limit appliance operating time to avoid scorching.

The observation with the shortest appliance operating time (4 min. 48 sec.) needed to boil carrots used medium-high and never checked to determine if they were actually done; however, the observation with the longest appliance operating time (42. min. 47 sec.) cooked the carrots on medium heat and checked the carrots three times to determine doneness. Furthermore, the observation with the longest time needed to boil the carrots changed elements after 31 minutes and 45 seconds of cooking. This participant was right handed and preferred to work on the right side of the cooktop. After a cooking operation was nearly complete, she transferred the operation to the left side of the cooktop to allow her to start another activity on the right side.

In summary, in 21% of the observations in this category the heat source was left on after cooking and in only 4.6% was retained heat used. However, in 36.8% of the observations did not match the diameter of the heat source with the diameter of the cookware when using high heat. A medium heat setting was selected most of the time except high was selected to boil. In addition, none of the participants cooked without a cover on the saucepans, and in only 1% of the test an element preheated before cooking or a hot element reused.

The solid element cooktop was the most common type found in this category (48.8%). The majority of the cooking systems included in this category were heavy with a lot of mass. However, the observations in this project were not familiar with working on heavy cooking systems and therefore, very few used retained heat to complete the menu. Hence the name, the uninformed cook.

The Hurried Style

Energy consumption for the fourth category of cooking style ranged from 967 watthours to 1127 watthours (Table 5.4). The number of observations in this category was 16 with only seven of the 15 participants included. The majority of the observations in this category were conducted on the conventional electric coil. Approximately 19% of the observations in this category included the halogen under glass ceramic cooktop, while the solid element and radiant coil under glass ceramic were used the least (6.3%). Thin aluminum cookware was the most commonly occurring type in this cooking style category (43.8%). The other types of cookware were not included as frequently in this category: heavy aluminum (12.5%), heavy aluminum non-stick (0%), stainless steel with aluminum heat core (6.3%), thin porcelain-on-aluminum non-stick (25%), and glass ceramic (12.5).

In 31% of the observations in this category participants left the heat source on after cooking. The majority of the participants preheated the skillet to fry crepes (87.5%). Only one observation (6.3%) preheated a saucepan in this category. None of the observations cooked without a cover on the saucepans; in addition, observations did not preheat the element or used retained heat, and only one observation reused a hot element (6.3%). Many of the observations did not match the diameter of the heat source and cookware when using high heat (i.e., 43.7% boiled

Table 5.4

Description of The Hurried Style

Category Name: The Hurried Style

Energy Range: 967 - 1127 Watthours

Obs = 16

Number of Different Consumers (n=7)

Cooktops	Cookware
Conventional Electric Coil (68.8%)	Thin Aluminum (43.8%)
Solid Element (6.3%)	Heavy Aluminum (12.5%)
Radiant Coil u/Glass Ceramic (6.3%)	Heavy Aluminum NS (0%)
Halogen u/Glass Ceramic (18.8%)	Stainless Steel w/Aluminum HC (6.3%)
	Thin Porcelain-on-Aluminum NS (25%)
	Glass Ceramic (12.5%)

Heat Source Left on After Cooking (31.3%)

No Cover on During Cooking (0%)

Skillet not Preheated (12.5%)
Saucepan Preheated (6.3%)

Preheated Element (0%)

Used Retained Heat (0%)

Reused Hot Element (6.3%)

Did not Match Diameter of Heat Source and Cookware and Used High Heat (43.7%)

Appliance Operating Time

	Crepes	Carrots	White Sauce	Broccoli	Total
Range of Min:Sec	15:03-35:28	7:22-25:30	6:24-37:15	7:13-37:36	52:17-106:36
Difference	20:25	18:08	29:36	30:23	54:19

Highest Heat Setting Used

	Crepes %	Carrots %	White Sauce %	Broccoli %
High	31.3	50.0	0.0	0.0
Med-Hi	12.5	18.7	12.5	0.0
Med	56.0	37.5	56.0	81.2
Med-low	0.0	0.0	25.0	12.5
Low	0.0	0.0	6.3	6.3
Total	99.8	100.0	99.8	100.0

Note. Percentage may not equal 100% due to rounding error.

carrots on using a large element on high heat). In addition, 31.3% of the participants left the heat source on after the cooking operation was completed.

The majority of the observations used medium heat when completing the menu: crepes (31.1%), white sauce (56%) and broccoli (81.2%) and half boiled carrots using high heat. Also, most of the observations were conducted with a conventional electric coil and thin aluminum cookware; hence, the speed of heating was rapid and therefore participants did not need to turn up the heat setting to accelerate heating.

The observation with the shortest total appliance operating time (52 min. 17 sec.) only fried eight crepes and did not cook them long enough to allow the crepes to brown (L-value, 48.4 - 52.8), when using conventional electric coil and thin porcelain-on-aluminum with non-stick. The lack of browning is an indication that this participant was afraid of burning the foods and lacked control of the heating of the system. The participant with the longest appliance operating time (106 min. 36 sec.) cooked the broccoli on low and therefore extended the time to 37 minutes and 36 seconds. When frying crepes, the participant with the shortest appliance operating time (15 min. 3 sec.) only fried seven crepes with uneven but medium browning (L-value 20.4 - 43.3) when using the solid element and thin porcelain-on-aluminum non-stick cookware. The greatest amount of appliance operating time (35 min. 28 sec.) was needed to fry 13 crepes on the solid element and thin aluminum cookware (L-value, 14.7 - 22.6). Observations all had the same amount of crepe batter; observations varied in their measuring as well as the degree of browning.

When cooking carrots the observation with the shortest appliance operating time (7 min. 22 sec). used medium-high heat and never checked to determine if the carrots were actually done. However, the observation with the longest appliance operating time (25 min. 3 sec.) cooked the carrots on medium heat and checked the carrots three times to determine doneness. The shortest operating time to cook broccoli occurred when a participant who was familiar with the procedure cooked with medium and low heat settings (6 min. 45 sec.). She opened the saucepan six times compared to the participant with the longest appliance operating time (37 min. 36 sec.) who opened the saucepan 12 times and used low heat the majority of the time. The observation with the longest time was using the conventional electric coil range and heavy gauge aluminum cookware. He typically burned the broccoli and said he used low heat to avoid burning the broccoli, but it was too low for this system.

The observation with the shortest appliance operating time (6 min. 24 sec.) to cook the white sauce used medium heat and removed the white sauce after cooking was completed. However, the observation that needed the longest time cooked the white sauce on low to medium heat for 37 minutes and 15 seconds. He made the white sauce in 8 min. 12 sec.; then turned off the element for one minute exactly, followed by turning the element back on medium-low for 28 minutes and 3 seconds to keep the white sauce warm. He removed the white sauce and crepes at the same time as if he were going to serve them.

In summary, many of the observations in this category used medium heat settings. High heat was used 50% of the time to boil and 43.7% did not match the diameter of the heat source and the diameter of the cookware. In addition, 31.3% left the heat source on after cooking was completed. These cooks appeared to be in a hurry, but were in control of the heat generated by the system under investigation (i.e., they didn't burn the crepes).

The Hurried Style with No Control

The category with the greatest energy consumption (i.e., 1128 - 1288 watthours) included only four observations, with only three of the 15 participants (Figure 5.5). The solid element cooktop was used in 75% of the observations, leaving the conventional electric coil in only 25% of the observations. Glass ceramic cookware was used in 50% of the observations. Thin aluminum and heavy aluminum with a non-stick finish cookware comprised 25% of the observations in this category.

Observations left the heat source on after cooking 50% of the time. When frying crepes, all observations preheated the skillet and at least one saucepan per observation. The observations were usually talking or reading when the pans were preheated. None of the observations used retained heat or reused a hot element. None of the observations matched the diameter of the heat source and cookware when using high heat.

When frying crepes, all participants used high heat at some time during the cooking operation. Typically, medium or medium-high was selected initially; and when the cooking was too slow for the participant's preference, then high heat was selected. The participant with the shortest time to fry the crepes (14 min. 41 sec., 9 crepes) burned them when using the conventional electric coil cooktop and glass ceramic cookware (L-value, 1.8 - 46.7). The same observation had similar results, and the shortest total appliance operating time (45 min. 5 sec.), using the solid element

Table 5.5

Description of The Hurried Style with No Control

Category Name: The Hurried Style with No Control

Energy Range: 1128 - 1288 Watthours

Obs = 4

Number of Different Consumers (n=3)

Cooktops	Cookware
Conventional Electric Coil (25%)	Thin Aluminum (25%)
Solid Element (75%)	Heavy Aluminum (0%)
Radiant Coil u/Glass Ceramic (0%)	Heavy Aluminum NS (25%)
Halogen u/Glass Ceramic (0%)	Stainless Steel w/Aluminum HC (0%)
	Thin Porcelain-on-Aluminum NS (0%)
	Glass Ceramic (50%)

Heat Source Left on After Cooking (50%)

No Cover on During Cooking (0%)

Skillet not Preheated (0%)
Saucepan Preheated (100%)

Preheated Element (0%)

Used Retained Heat (0%)

Reused Hot Element (0%)

Did not Match Diameter of Heat Source and Cookware and Used High Heat (100%)

Appliance Operating Time

	Crepes	Carrots	White Sauce	Broccoli	Total
Range of Min:Sec	14:41-32:57	7:21-26:32	7:28-17:20	7:49-20:20	45:05-89:08
Difference	18:16	19:11	9:52	12:31	44:03

Highest Heat Setting Used

	Crepes %	Carrots %	White Sauce %	Broccoli %
High	100.0	100.0	25.0	25.0
Med-Hi	0.0	0.0	25.0	50.0
Med	0.0	0.0	25.0	25.0
Med-low	0.0	0.0	0.0	0.0
Low	0.0	0.0	25.0	0.0
Total	100.0	100.0	100.0	100.0

and heavy aluminum non-stick cookware (L-value, 7.2-11.2). However, the observation with the greatest length of time (89 min. 9 sec., 10 crepes) cooked most of the time on medium or medium-low using the solid element and glass ceramic cookware; and furthermore, she did not allow the crepes to brown (L-value, 45.06-60.2). The participant with the shortest appliance operating time picked up the skillet excessively and the red hot element could be viewed each time the skillet was picked up. However, the participant with the longest appliance operating time slid the skillet around on the element to even out the heating.

The observation with the highest energy consumption had the shortest appliance operating time for each cooking operation. Furthermore, each cooking operation with the shortest appliance operating time cooked on high heat the majority of the time. For example the shortest appliance operating time for carrots (7 min. 28 sec.), white sauce (6 min. 32 sec.), and crepes (14 min. 41 sec.) were all found on the conventional electric coil with glass ceramic cookware. The same participant cooked the broccoli (7 min. 49 sec.) on the solid element with heavy aluminum non-stick with the shortest time due to use of high heat most of the time. The participant with the greatest amount of appliance operating time cooked the carrots (26 min. 32 sec.) and crepes (35 min. 57 sec.) on high heat for a short time and never turned the white sauce (17 min. 20 sec.) or broccoli (20 min. 20 sec.) on high heat.

In summary, the observations in the highest energy consumption category (i.e., hurried cook with no control) cooked crepes and carrots on high heat without matching the diameter of the heat source and cookware diameter. Furthermore, none of the observations used retained heat or reused a hot element. They also preheated a saucepan and 50% left the heat source on after cooking. None of the observations in this group were able to control the quantity of heat. Hence, crepes were either burned or left unbrowned.

Categories of Consumers

Three categories were established by determining the difference between the mean of the highest and lowest energy consumer (Table 5.6). The difference was divided by three and then added to the lowest energy consumers mean watthour rating to establish the range for the lowest energy consumption categories (Table 5.6). This procedure was followed to establish the three categories of consumers. As seen in Table 3.4, the data were sorted according to categories and the percentage of occurrence was recorded for the following: heat source left on, no cover on during

Table 5.6

Categories of Cooking Style When Considering Only the User's Influence

	Cooking Style Categories		
	Low Energy Consumer	**Average Energy Consumer**	**High Energy Consumer**
Number of Cooks	4	8	3
Energy Consumption Range (Wh)	692.6 - 744.5	744.6 - 796.4	764.5 - 848.3
Heat Source Left On After Cooking (%)	5.2	23	45.8
No Cover on During Cooking (%)	0	0	0
Skillet Not Preheated (%)	21	10	0
Saucepan Preheated (%)	0	3	12.5
Preheat Element (%)	0	2	9.7
Used Retained Heat (%)	7.3	17	9.7
Reused Hot Element (%)	4.2	12	0
Did Not Match Diameter of Heat Source and Cookware when Using High Heat (%)	14.6	28	16.7
Appliance Operating Time - White Sauce (Min:Sec)	12:07	13:06	13:50
Carrots (Min:Sec)	15:40	15.15	15:07
Broccoli (Min:Sec)	15:48	16:07	16:19
Crepes (Min:Sec)	20:14	22:40	21:20
Total (Min:Sec)	63:50	67:52	66:04
Knowledge (%)	58	44	28

cooking, skillet not preheated, saucepan preheated, preheated element, used retained heat, reused a hot element, did match the diameter of the heat source and cookware when using high heat, appliance operating time, and knowledge. Appliance operating time and use of a cover on saucepans did not differ across the categories of cooking style when analyzing the level of energy consumption.

Low Energy Consumption. Low energy consumers had the highest knowledge level. Energy efficient practices implemented by the low energy consumers were: most likely to turn the heat source on after cooking, and match the diameter of heat source and cookware when using high heat. Furthermore, they never preheated a saucepan or heating element. However, they also seldom used retained heat or reused a hot element. As seen in Table 5.7, the low energy consumers usually selected medium heat when frying crepes, cooking white sauce, and broccoli; and high heat when boiling carrots.

Average Energy Consumption. Average consumers of energy had the median knowledge level. This category most frequently used retained heat and reused a hot element. Also, often the same person who used an energy efficient practice also preheated an element, preheated a saucepan, or left the heat source on after cooking. Therefore, often average cooks counteracted their energy efficient practices with inefficient practices.

High Energy Consumption. Highest energy consumption cooks had the lowest knowledge level, and in nearly half of the observations had at least one heat source on after cooking was completed. One of the cooks frequently left one heating element and sometimes left all the heat sources on after cooking operations were completed. Highest energy consumers most frequently preheated the cookware. Furthermore, the highest energy consumers used high heat more frequently than the other categories (Table 5.7). The highest energy cooks frequently did not pay attention to the cooking because they read, talked, sat, danced, and sang.

In summary, consumers' use of high heat, leaving the heat source on after cooking, and their knowledge were the most distinguishing characteristics among the groups. In addition, only the highest energy consumers read or sat while cooking.

Summary of Findings

This chapter presents the findings regarding cooking style as a dependent variable. Five categories of cooking style were established by allowing a computer software program to sort the energy consumption values from each observation based

Table 5.7

Highest Heat Setting Selected By Cooking Style Categories

	Crepes	Carrots	White Sauce	Broccoli
Low Energy Consumption (n=96)				
	%	%	%	%
High	6	64	1	1
Medium-High	13	18	14	6
Medium	74	20	64	73
Medium-Low	3	0	19	18
Low	4	0	3	2
Average Energy Consumption (n=188)				
	%	%	%	%
High	6	63	4	1
Medium-High	21	14	6	4
Medium	70	20	73	78
Medium-Low	1	3	11	13
Low	2	0	6	5
High Energy Consumption (n=72)				
	%	%	%	%
High	21	68	10	1
Medium-High	11	11	11	7
Medium	68	21	61	79
Medium-Low	0	0	8	8
Low	0	0	10	3

note. n does not equal 360 due to missing data.
Column total percentages may not total 100% due to rounding error.

on natural breaks in the data. Data sheets were reviewed to develop a description of each category.

Characteristics of Cooking Style

The three most important factors that distinguish the categories were: percentage of the sample that left the heat source on after cooking (Figure 5.1), percentage of the sample that did not match the diameter of the heat source and the diameter when using high heat (Figure 5.2), and percentage of the sample that fried using high heat (Figure 5.3). As each figure illustrates, there is a natural positive relationship between energy consumption and using high heat, not matching the diameter of the heat source and cookware diameter when using high heat, or leaving the heat source on after cooking. Additional factors, included reusing hot elements, use of retained heat, and use of medium heat settings. The participants in the patient style category used retained heat, reused hot elements, and used medium heat settings. The hurried style seldom used retained heat, reused hot elements, or used high heat for frying and boiling. Participants in the hurried style with no control category did the same things as the hurried style, only they could not control the quantity of heat and tended to burn the food.

Categories of Consumers

Consumers' use of high heat, leaving the heat source on after cooking, and their knowledge were the most distinguishing characteristics among the groups. Highest energy consumers had the lowest knowledge, used high heat, and left the heat source on after cooking the most frequently. Low energy consumers had the highest knowledge level and most typically used medium heat and turned the heat source off after cooking. Average cooks had the median value of knowledge and left the heat source on after cooking. In addition, average cooks most frequently used retained heat or reused a hot element. Also, average cooks often counteracted their energy efficient practices with inefficient practices such as preheating a pan or element or leaving the heat source on after cooking.

Discussion

This research found the 15 participants asserted the same cooking style with the different cooking systems and therefore did not change their behavior when using innovative cooking systems. Changes in user behavior with different cooking systems may explain why consumers may be in both the patient style and average style. For example they may have used low heat because the instructions said to, but their

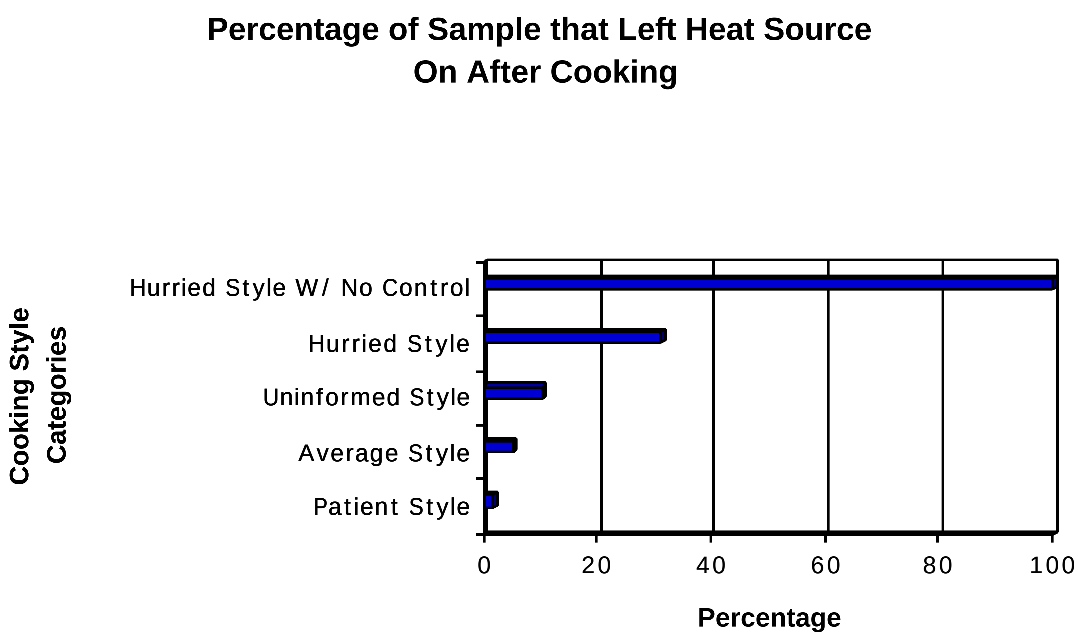


Figure 5.1. Percentage of the sample that left the heat source on after cooking per cooking style category.

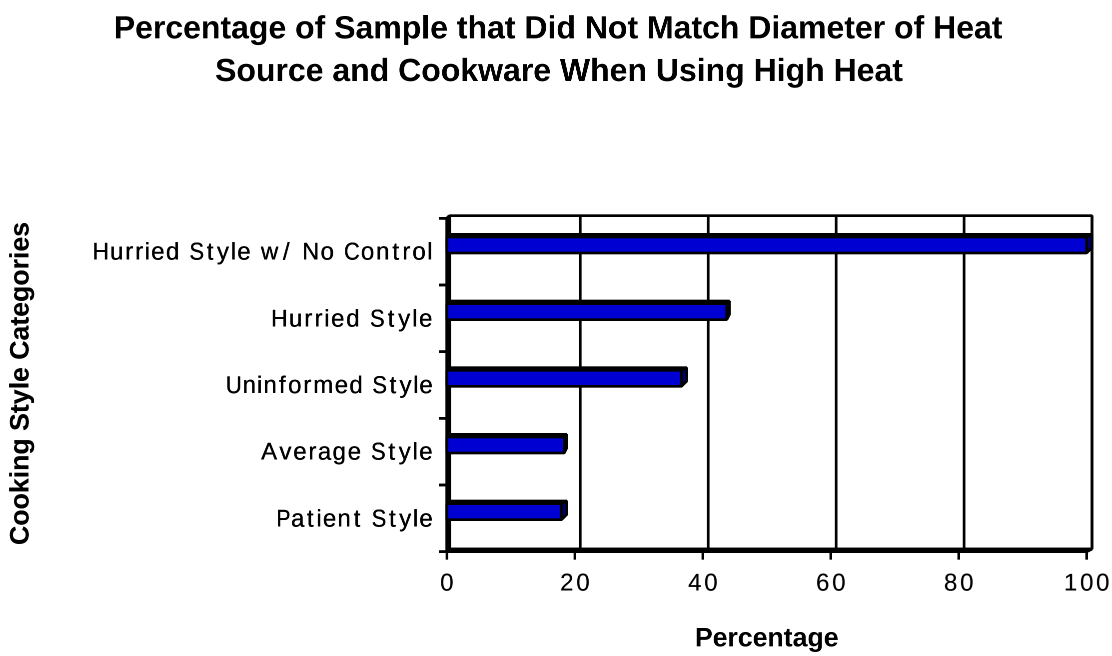


Figure 5.2. Percentage of sample that did not match the diameter of the heat source and contact area of the cookware when using high heat.

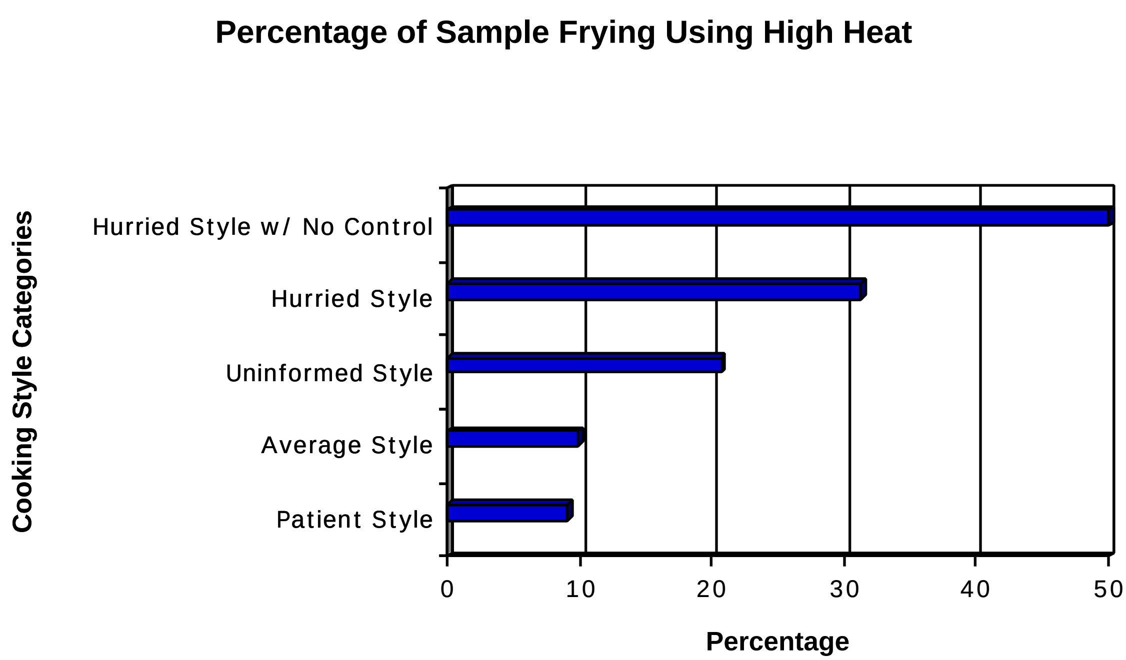


Figure 5.3. Percentage of the sample that fried crepes with high heat per cooking style category.

typical behavior may have been to use higher heat settings. Participants did not change their behavior when using the various cooking systems until the found they found they had to change. For example, the same heat setting was selected for each cooking system and then later adjusted when needed during cooking. Therefore, how the user utilizes the cooktops and cookware influences energy consumption.

Participants in the low energy category were typically observed in the patient and average cooking style categories. The high energy participants were observed in the uninformed style, the hurried style, and the hurried style with no control categories. Participants most often did the same thing on all cooking systems. Therefore, participants may be observed in multiple categories. Periodically, participants lacked experience in controlling the heat of cooking systems with much mass. Therefore, the low energy consumers could be part of the uninformed style category when using the solid element cooktop.

High energy consumers were usually always in the high energy consumption category for all 24 cooking systems. However, participants in the high energy category may have been observed in the patient category. For example, the highest energy consumer (Participant 5) has one observation in the patient category. Participant 5 almost always left the heat source on after cooking and used high heat. However, when he used a familiar cooking system (i.e., conventional electric coil and thin porcelain-on-aluminum with a non-stick finish) he was in control of the system. He used medium heat and turned the heat source off after cooking. This participant commented that he usually leaves the heat source on after cooking, and therefore, his lack of energy efficient behavior was not just something he did during this project. Familiarity with the system is not anticipated to be the reason for lower energy consumption. The participant's paying attention to what he was doing was the distinguishing factor.

Using a rate of 8.3 cents per KWH (EnergyGuide Label, 1996), it would cost the highest energy consumer (0.848 KWH) on average of 1.3 cents more to prepare the same meal as the lowest energy consumer (0.692 KWH). This is a small amount of energy but on an annual basis the cost of high energy cooking behavior is greater. In a Good Housekeeping Institute (1989) survey of 200 women, an average of 3.7 meals were prepared fresh per week in addition to the number of meals eaten outside the home, served as leftovers, convenience foods, take out foods, and delivered foods. In this research, participants prepared a fresh start meal and therefore, it would cost the highest energy consumer 4.81 cents more than the lowest energy consumer per week or $2.50 more per year.

The U.S. Census (1992) reported 95,669,000 households in the United States. However, according to Appliance Magazine (1995) only 58.5% of the households own an electric range. Therefore, the difference in cost of operation between the highest and lowest energy consumers when applied to the total number of U.S. households with an electric range would be approximately $1,404,000.

The purpose of this section is simply for discussion and to provide a sense of how much energy could be conserved due to the users influence. Energy consumption was converted to dollars to provide an information base that is readily comprehensible. It is also recognized that the total dollar amount reported for households is inflated compared to the actual amount due to data used to compute the difference between the mean of the lowest and highest energy consumers in this study.

CHAPTER VI
Summary, Conclusions, Recommendations, and Implications

Summary

The purpose of this research was to explain the user's influence on energy consumption of cooking systems using electricity. To accomplish this purpose two separate investigations were conducted and have been organized in two phases. During Phase I the user's influence was quantified to determine relationships that explain variations in the energy consumption with cooking systems using electricity. In Phase II, two sets of cooking system categories were developed to describe (a) the user characteristics and cooking systems that explain variations in energy consumption, and (b) what users typically do that influences where their average energy consumption level falls on a continuum of energy.

Existing data used to answer the research question consisted of: video tape data (Appendix A) of consumers preparing the research menu (Appendix B), a survey (Appendix C), and data recorded on a data collection sheet by the researcher (i.e., watthour consumption, Appendix D). Data collection for this research was comprised of reviewing and quantifying the video tape data.

Simultaneous triangulation was used to answer the research questions. Phase I determined that energy consumption was correlated with knowledge, interaction, practices, appliance operating time, cooking system interaction, goodness-of-fit, information, behavior, user, and interaction between the cooking system and goodness-of-fit. Independent variables explained 38.6% of the variation in energy consumption. However, when only the variables under the user's control were included, just 25% of the variation in energy consumption was explained. Phase II determined that the three most important factors that distinguish the five cooking style categories were: (a) percentage of the sample that left the heat source on after cooking, (b) percentage of the sample that did not match the diameter of the heat source and the diameter of the heat source when using high heat, and (c) percentage of the sample that fried using high heat. Additional variables that differed among categories were: reusing hot elements, use of retained heat, and use of medium heat settings.

In summary, important factors in explaining variations in energy consumption include inherent characteristics of the cooking system, consumer's knowledge, highest heat setting selected and matching the diameter of the heat source with the cookware diameter, leaving the heat source on after cooking, and highest heat setting selected when frying.

Conclusions

Quantitative Conclusions

The following were derived from the quantitative results of this study. There is a significant correlation between energy consumption and:

1) knowledge. The participants in this project with the greatest knowledge used the least amount of energy to complete the research menu.
2) practices. Consumers in this sample with higher practice scores (e.g., used retained heat) utilized less energy to complete the research menu.
3) user interaction. Energy consumption increases as user's interaction with the cooking system increases.
4) behavior. Consumers with higher behavior scores (i.e., statistical interaction term of composite variables practices, e.g., use of retained heat) and user interaction, e.g., pick up skillet) used more energy to complete the research menu.
5) information. Participants with higher information scores (i.e., interaction term created from knowledge and experience scores) utilized less energy to complete the research menu.
6) appliance operating time. As consumers used longer periods of appliance operating time, energy consumption increased.
7) the user. As users interacted with the cooking system more, they used increasing amounts of energy.
8) cooking system. Some cooking systems naturally consume more energy due to inherent characteristics.
9) goodness-of-fit. Cooking systems with greater compatibility utilize less energy.

In addition, this research found significant relationships between:

1) goodness-of-fit and cooking system interaction. The cooking system and its compatibility (i.e., interaction term created from cooking system and

goodness-of-fit scores) influence the quantity of energy necessary to complete the research menu.

2) knowledge and experience. Consumers with greater knowledge scores tended to have more experience with cooking systems and cooking the menu.
3) information level and practices. Consumers with more information utilize more energy efficient practices.
4) appliance operating time and user's interaction level. Appliance operating time influences the quantity of user interaction.
5) information level and behavior. Participants with greater amounts of information regarding cooking systems interacted with the cooking system less.

This research found lack of a significant relationship between energy consumption and experience. Consumers' experience level does not influence energy consumption.

User's influence. Regression analysis identified the following variables that explain 25.4% of the variation in energy consumption: familiarity with boiling carrots, appliance operating time to fry crepes, participant taken cooktop/cookware course, use of low or medium heat when frying, number of times the skillet was picked up, knowledge, matching the diameter of the heat source and cookware when frying, preheating the element when cooking broccoli, turning off the cooktop after boiling, number of times cooktop controls were adjusted when frying, and experience.

Cooking system and user's influence. Based on regression analysis, the variables that explain 38.6% of the variation in energy consumption were identified as knowledge, participant's familiarity with boiling carrots, participant taken a course that included cooktop and cookware, practices, cooking system interaction, goodness-of-fit, participant touching broccoli saucepan, taking a household equipment course, use of low or medium heat when frying and cooking broccoli, preheating the element when frying crepes and cooking broccoli, appliance operating time to cook crepes, use of retained heat when cooking broccoli, number of times skillet was picked up, and turning off the heat source after frying crepes.

Descriptive Conclusions

The following results were derived from the descriptive results of the five cooking style categories developed in this research:

The patient style (55 observations) used the least energy (485-646 Wh) to complete the research menu. Typically, they used medium heat as the highest heat setting selected, reused hot elements, and used retained heat. Furthermore, stainless steel with an aluminum heat core was used in 46% of the observations in this category. However, only nine percent of the patient style left the heat source on after cooking and 18% did not match the diameter of the heat source and the diameter of the cooking when using high heat.

The average style category (191 observations, 647-806 Wh) contained the largest number of observations (n=191). Average style mostly used medium heat and did not leave the cooktop on after cooking was completed. Furthermore, they did not preheat the saucepans or elements. Retained heat or reusing hot elements was not a characteristic of this category. In only 18.3% of the observations in this category did the participants not match the diameter of the heat source and diameter of the cookware when using high heat.

The range of watthour consumption for the category of uninformed style was 807 to 966. Participants in this category (88 observations) lacked the information needed to efficiently utilize the solid element cooktop. Solid element was the most common type of cooktop in this category (48.8%). The consumers in this research were not familiar with heavy cooking systems; and therefore, very few used retained heat to complete the menu. Twenty-one percent of the uninformed style left the heat source on after cooking. Furthermore, 36.8% did not match the diameter of the heat source with the diameter of the cookware when using high heat. High heat was used for boiling and medium heat was selected for the other cooking operations. However, only 4.6% of the uninformed style used retained heat.

The hurried style (16 observations) used high heat for boiling 50% of the time and 43.7% did not match the diameter of the heat source and the diameter of the cookware when using high heat. Also, 31.3% of the category left the heat source on after cooking was completed. Medium heat was selected for frying, waterless cooking, and thermalization. Energy consumption ranged from 967 to 1127 watthours for cooks in a hurry to complete the cooking operation.

Cooks with the highest energy consumption style (1128-1288 Wh) were in a hurry and exhibited lack of control over the cooking system. This category contained the fewest observations (n=4) Crepes and carrots were cooked on high heat without matching the diameter of the heat source and cookware. None of sample used retained heat or reused a hot element. Furthermore, participants preheated a saucepan and 50% left the heat source on after cooking.

Summary. Consumers use of high heat, leaving the heat source on after cooking, and their knowledge were the most distinguishing characteristics among the three cooking style categories based on energy consumption:

1) Highest energy consumers had the lowest knowledge, used high heat and left the heat source on after cooking the most frequently.
2) Average cooks had the median value of knowledge and leaving the heat source on after cooking. In addition, average cooks most frequently used retained heat or reused a hot element. Also, average cooks often counteract their energy efficient practices with inefficient practices by preheating a pan or element or leaving the heat source on after cooking.
3) Low energy consumers had the highest knowledge level and most typically used medium heat and turned the heat source after cooking.

Recommendations

The following recommendations are made for further research on determining the factors which affect consumer's influence on the energy consumption of cooking systems as well as performance evaluation research.

1) Conduct further research with other brands and types of cooktops to validate the cooktops used in this research as representative samples of the United States market. The different types of cooktops should include differences in rated wattages of the heating elements. For example, six inch elements can range in wattage from 1200 Wh to 1500 Wh and eight inch elements range between 2200 Wh and 2400 Wh.
2) Conduct additional studies with other brands and types of cookware to validate the cookware in this research as representative samples of the United States market. The different types of cookware include metal alloys, copper heat core, differences in construction of heat core, and finishes.

3) Replication of this study with a larger group of participants. Replication of this study with other segments of the population (i.e., limited income cooks and experienced cooks).

4) Include foods in the research that allow for differences in user behavior that influence outcome for all cooking operations. For example, including macaroni and cheese would allow participant variations that might include not using a cover or tipping the cover when boiling pasta. Heating cheese in a white sauce too rapidly would cause the oil to separate from the curd. Another example is pudding that can easily scorch or has an uneven consistency if not stirred.

5) Objectively measure food quality after foods were cooked by the user to determine the user's control of the cooking systems by the degree of doneness (e.g., viscosity of the white sauce, shear test of carrots and broccoli). In this study light reflectance values of the crepes was used as an indication of the user's control of the heat in the cooking system . An objective indication of degree of doneness would provide a clearer picture regarding appliance operating time and heat settings selected.

6) Conduct further research to determine the user's influence on baking systems. Fechter and Porter (1978) investigated the entire range when studying homemakers' influence on energy consumption. This would facilitate explaining why Fechter and Porter found a 58% variation and DeMerchant, Lovingood, and Leech (1995) found 120% variation in energy consumption. The majority of the energy consumed when using an oven is for heating the "block" or the mass of the oven. In addition, cooks do not interact (e.g., open, adjust heat settings, or time) with the oven as often as they do a cooktop. Therefore, Fechter and Porter (1978) might be expected to have found a smaller variation when studying range energy consumption than DeMerchant, Lovingood, and Leech (1995).

7) Measure energy consumed for each specific cooking operation used in the investigation (i.e., boiling, waterless, frying, thermalization). This research measured energy consumption needed to complete the entire research menu. However, a study of variation in energy consumption via cooking operations is needed to determine if differences exist between consumers and cooking operations.

8) Replicate this study to include consumer's influence on energy consumption with gas ranges which was not possible due to the lack of gas meters

9) Record data using VHS video tapes. This research transferred data from 6mm tapes to VHS tapes. Only 6mm video cameras were available for recording; and therefore, all observations of this were copied from 6mm to VHS tapes using the slowest tape speed. A weakness of this study was the missing data. Observations were lost in the copying of the tapes and video tapes broke causing data to be lost. In addition, data were missing when the tape ran out before the participant completed the research menu; and therefore, recording each observation on a separate video tape would enable less data to be lost.

10) Have the researcher or a trained assistant record information about what the participant was doing during the observation. Because glare was a problem in this research it was difficult to always determine small changes in control settings. Therefore, high, medium-high, medium, medium-low, and low were recorded on the data collection sheet in place of the actual cooktop "number" setting (e.g., 1=High).

11) Have all three parts of the questionnaire completed for each observation. In this research, knowledge was measured only before and after the investigation of the 30 cooking systems. Therefore, it is not clear when consumers' knowledge increased.

12) Replicate this study utilizing a temperament scale. It was observed that when consumers were stressed, they tended to hurry and were not as careful with the cooking system under investigation. For example, one participant waited to finish the 30 investigations after the academic semester ended. His stress level decreased; he no longer left the cooktop on after cooking, and he exhibited more control over the system by not always utilizing high heat. Further research is needed to determine if temperament influences behavior using cooking systems.

13) Further research should include additional variables to improve the percentage of explained variance when using multiple regression analysis. The additional variables would include: highest heat setting, matching diameter of heat source and cookware diameter when using high heat, rated wattage, length of time skillet was picked up, statistical interaction of rated wattage and

matching diameter of the heat source and cookware diameter, statistical interaction of heat setting and length of time setting was used, and statistical interaction of heat setting and matching diameter of the heat source and diameter of the cookware.

Due to the difficulty of collecting this type of data, an in-depth analysis of the cooking system (i.e., conventional electric coil with glass ceramic cookware) with the greatest percentage of variation (120%) between consumers is a possible area for exploratory research. The difficulty of this data collection is due to the intensity of time needed to record the appliance operating time for as many of the independent variables as possible. It may be necessary to review the video tape observations using a screen-by-screen technique.

Implications

The following implications for consumer education and public policy are based on the findings of this research. Cooking performance has been included in this discussion due to similarity in concept--outcome of user interaction with cooking system.

Education

1) Manufacturers of appliances and cookware need to supply an educational medium with each product. Knowledge explained more about variations in energy consumption than any other single variable in this research. EnergyGuide labels have not been mandated on cooking appliances because the greatest variation in energy consumption is found with the user. In 1994, 80% of the population owned a VCR (Appliance Magazine, 1995). In order to improve users' cooking behavior regarding energy efficiency, a VCR tape is one way to deliver mass education to consumers. A video tape that describes the product purchased and its features is currently available when purchasing many high end cooking appliances. However, if all appliances came with a video tape that explained how to utilize the system safely and efficiently, then energy efficient usage procedures could be taught to consumers in addition to use and care of the products. Therefore, a separate video tape that only addressed energy efficient product usage would not be necessary.

2) In the future, virtual reality may be used to teach energy efficient cooking in classrooms and even to consumers owning video games. For example, a cooktop-cookware combination or system could be selected by the user who

could then could boil water or perform other cooking operations using different techniques to see the influence of different techniques on energy consumption or even performance. Research data could be used to determine appliance operating time and performance outcomes of the users influence. Data would need to be collected to represent differences in user's behavior. How much time is needed to boil water with the cover on the saucepan, removed, and tipped; to determine the outcome when the diameter of the saucepan is correctly matched with the diameter of the heat source and when it's not matched. The analysis of this study is a good start to predict differences in outcome due to the user's influence. In the future, through the use of virtual reality an introductory household equipment course could be taught without a laboratory, equipment, or supplies.

Public Policy

The Department of Energy (DOE) currently establishes only performance standards for specific products. However, due to the diversity of products available in the marketplace, performance standards are not always the best solution because the entire system must be considered. A cooking system consists of the cooktop, cookware, and control device (Schott Glaswerke, 1984). Therefore, if the DOE mandated the standardization of diameters of heat source and cookware contact area, then more energy efficient cooking systems could be manufactured.

In addition, the need to educate consumers regarding matching the diameter of the heat source and cookware would be reduced. However, this would not entirely eliminate the issue of educating consumers about the importance of matching diameters of heat source and cookware because two different diameters would be necessary to accommodate differences in food load. Specifically, from a public policy perspective, the results of this research imply it would be beneficial to:

1) Standardize the diameter of the cookware contact area. If the diameter of the cookware contact area were standardized then cooktop manufacturers could design heating units with increased compatibility (DeMerchant, 1993). The goodness-of-fit was a significant variable in this study. Given the large number of lines of cookware with each having its own contact area diameter, appliance manufacturers vary the size of each element on innovative cooktops to try to accommodate differences in cookware.

2) Standardize the diameter of the heat source. Heating elements used in cooktops are made by a small number of manufacturers. Furthermore, major appliance manufacturers only select a few of the available sizes of heating elements. However, innovative cooktops may contain four or more different size elements. Cookware is primarily sold in "sets" that contain only a few different sizes, but even so, goodness-of-fit is not assured.

3) Cooktops should contain a variable size heating element. Participants in this research typically performed all four cooking operations at the same time. Two of the four cooktops had two eight inch elements. Therefore, participants did not match one of the saucepans with the diameter of the heat source. This research found the heat setting selected when not matching the diameter of the heat source with the diameter of the cookware as an important factor, i.e., visual positive relationship between participants using high heat when not matching the diameter of heat source and cookware diameter and quantity of energy consumed (Figure 5.2). However, if the research menu had required a skillet and a Dutch oven (e.g., spaghetti dinner) then two eight inch elements would be necessary. Hence, if a variable size heating element were included on each cooktop, consumers would be able to match the diameter of the heat source with the cookware for different menus.

4) Provide heating elements that automatically turn off after the cookware has been removed. A time of 30 seconds could be used as a time setting for the heat source to be turned off, automatically, after the cookware has been removed. This concept is similar to the auto shut-off irons currently on the market. This would facilitate safety as well as energy efficiency. Participants in this research frequently left the heat source on after cooking was completed. Eighteen percent of the lowest energy consumers left the heat source on after cooking compared to 50% of the highest energy consumers. Furthermore, participants commented that leaving the heat source on after cooking was a common habit when cooking every day in their homes.

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APPENDIX A

Data Collection Sheet

DATA COLLECTION SHEET
For User Interaction and Energy Consumption

Start Time: ____________________ End Time: ____________________

Food:	Carrots	Crepes	Broccoli	White Sauce
Time:	Food ________ On ________ Off ________ Removed ______	Food ________ On ________ Off ________ Removed ______	Food ________ On ________ Off ________ Removed ______	Food ________ On ________ Off ________ Removed ______

Manipulation:				
Controls				
Greased Skillet				
Cookware Pick-up				
Slide				
Touch				
Open				
Food Count				
Manipulation				

note. Hash marks were made to count observations.
Food count indicates each time food was placed in the pan.

DATA COLLECTION SHEET
For User Interaction and Energy Consumption

ID Number ________________ Date______________________

Cooktop __________________ Cookware _________________

1. Cooktop Design. Label each element with foods cooked on it.

2. Identify each food cooked with the pan used.

Representative Foods	Cookware	Order Prepared
White Sauce/ Chicken	__________	_______________
Carrots	__________	_______________
Broccoli	__________	_______________
Crepes	__________	_______________

3. Length of cooking time for each food cooked.

Representative Foods	Time	Comments
White Sauce/ Chicken	__________	________________
Carrots	__________	_______________
Broccoli	__________	_______________
Crepes	__________	_______________
Total	__________	_______________

4. Identify settings used for each heat source.

Food	Setting	Comments
Crepe	_____	______________________________
_____	_____	______________________________
_____	_____	______________________________
Carrots	_____	______________________________
_____	_____	______________________________
_____	_____	______________________________
White Sauce	_____	______________________________
_____	_____	______________________________
_____	_____	______________________________
Broccoli	_____	______________________________
_____	_____	______________________________
_____	_____	______________________________

DATA COLLECTION SHEET
For User Interaction and Energy Consumption

ID Number ___________________ Date_________________________
Cooktop _____________________ Cookware ___________________

General

Remove pan from element during cooking ______ Heat source left on after cooking (Y/N) ______

Use retained heat ______ Cookware in way of other cookware during cooking ______

Reach across hot surface ______ Cover on pan during cooking (Y/N) ______

Preheat pan (Y/N) ______ Preheat element (Y/N) _______

Clean-up	**Time**	**Comments**
Cooktop	______	____________________________________
		____________________________________
Cookware-Total	______	____________________________________
Crepes		____________________________________
White Sauce		____________________________________
Broccoli		____________________________________
Carrots		____________________________________

User Interaction

Manipulation	Carrots	Crepes	Broccoli	White Sauce
Controls				
Greased Skillet				
Cookware				
Food				

Comments:____
____

note. Notes were made under "general" for each cooking operation.

APPENDIX B

Research Menu

Research Menu

Crepes with Chicken in a White Sauce
Broccoli
Carrots

APPENDIX C

Survey: Part 1

Respondent No.___________

Part 1
Cooking Systems Satisfaction Survey

The first section of the questionnaire includes general questions about you, your household and your knowledge and practices regarding the cooking system.

Q-1 Your sex. (Circle number of your answer)

1 MALE
2 FEMALE

Q-2 What is the highest level of education that you have completed? (Circle number)

1 SOME COLLEGE
2 COMPLETED COLLEGE
3 SOME GRADUATE WORK
4 A GRADUATE DEGREE

Q-3 Have you ever purchased a cooktop? (Circle number)

1 NO
2 YES

Q-4 Have you ever purchased cookware? (Circle number)

1 NO
2 YES

Q-5 How would you rate your cooking experience? (Circle number)

1 GOURMET
2 BASIC COOK: INVOLVED
3 BASIC COOK: UNINVOLVED
4 RELUCTANT COOK
5 NON-COOK

Q-6 Have you taken a household equipment course? (Circle number)

1 NO
2 YES

Q-7 Have you taken a food preparation and selection course? (Circle number)

1 NO
2 YES

Q-8 Have you taken a course that covered cooktops and/ or cookware? (Circle number)

1 NO
2 YES

Q-9 What type of cooking procedure do you use when cooking broccoli? (Circle number)

1 COOKTOP AND COOKWARE - STEAM
2 COOKTOP AND COOKWARE - WATERLESS
3 MICROWAVE OVEN
4 RARELY

Q-10 What type of cooking procedure do you use when cooking carrots? (Circle number)

1 COOKTOP AND COOKWARE - STEAM
2 COOKTOP AND COOKWARE - WATERLESS
3 COOKTOP AND COOKWARE - BOIL
4 MICROWAVE OVEN
5 RARELY

Q-11 What type of cooking procedure do you use when cooking a white sauce? (Circle number)

1 COOKTOP AND COOKWARE
2 MICROWAVE OVEN
3 RARELY

Q-12 What type of cooking procedure do you use when cooking crepes? (Circle number)

1 COOKTOP AND COOKWARE
2 PORTABLE CREPE BAKER
3 RARELY

Q-13 What type of cooktop have you used on a regular basis? (Circle as many as apply)

1 CONVENTIONAL ELECTRIC COIL
2 SOLID ELEMENT
3 ELECTRIC RESISTANCE COIL UNDER GLASS CERAMIC
4 HALOGEN UNDER GLASS CERAMIC
5 GAS FLAME
6 SEALED GAS

Q-14 What type of material is the cookware constructed of that you presently use? (Circle as many as apply)

1 ALUMINUM
2 STAINLESS STEEL
3 PORCELAIN -ON- STEEL
4. PORCELAIN-ON-ALUMINUM
5 GLASS CERAMIC
6 COPPER
7 CAST IRON
8 DO NOT KNOW

Q-15 Do you presently use cookware with a non-stick finish? (Circle number)

1 NO
2 YES

Q-16 What gauge (thickness) of cookware do you presently use? (Circle as many as apply)

1 HEAVY
2 MEDIUM
3 THIN
4 DON'T KNOW

Q-17 Rank the cooking system qualities in order of importance.

_____ RETAINED HEAT
_____ SPEED OF HEATING
_____ EVEN HEAT DISTRIBUTION
_____ CLEAN ABILITY

Q-18 The gauge of the cookware affects the speed of heating, retained heat and evenness of heat distribution. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-19 A flat bottom pan, _____ than a pan that does not have a flat bottom. (Circle number)

1 CONDUCTS HEAT MORE EVENLY
2 HEATS UP SLOWER
3 BOTH
4 NEITHER

Q-20 Stainless steel is a good conductor of heat. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-21 Only heavy gauge flat bottom pans can be used on glass ceramic cooktops. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-22 Glass ceramic pans produce even heat distribution and with stand extreme temperature change. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-23 A conventional electric coil element has an even heat distribution and quick speed of heat due to direct conduction of heat. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-24 Aluminum or copper is often applied to stainless steel to reduce conductivity and produce a more even heat. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-25 The gauge of the cookware does not affect the required manipulation of food during cooking. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-26 An advantage of a sealed gas burner is ease of cleaning. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-27 The solid element is very fast to heat up and produces even heat distribution. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-28 Only magnetic cookware can be used on a "smooth-top" range. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

Q-29 Glass ceramic cooktops with electric coil or halogen elements do not retain heat. (Circle number)

1 TRUE
2 FALSE
3 DO NOT KNOW

APPENDIX D

Specific Procedures

Specific Procedures

for Consumers' Knowledge, Practices, and Satisfaction

Day 1

On the first trip to the Residential Appliance Laboratory each consumer will:

1) Be given a tour of the laboratory and an explanation about the roles of the laboratory.

2) Be given an overview of the project.

3) Complete part 1 of the questionnaire.

4) Complete a consent form.

5) Set up a schedule of the times to participate in the investigation.

Day 2

The following procedures will be performed prior to the consumer entering the Residential Appliance Laboratory at Virginia Polytechnic Institute and State University.

Step 1

Crepe

1) In a blender combine the following ingredients:
   - 1 C All-Purpose Flour
   - 1 1/2 C Milk
   - 2 Eggs
   - 2 T Sugar
   - 1 T Vegetable Oil
   - 1/8 t Salt

2) Blend batter for one minute in an electric blender.

3. Place batter in the refrigerator.

Carrots

1) Peel and wash carrots.

2) Slice carrots in half inch slices.

3) Weigh and package 0.75 lb. of carrots.

4) Place carrots in the refrigerator.

5) Measure 2 cups of water. Do not place in the refrigerator.

Broccoli

1) Weigh and repackage 0.60 lb.. of frozen broccoli cuts.

2) Place broccoli in the freezer.

White Sauce

1) Measure and package 3 tablespoons of margarine.

2) Measure and package the following ingredients:
   3 T Flour
   1/4 t Salt
   1/8 t Pepper

3) Measure and package 1 cup of milk in a liquid measuring cup covered with plastic wrap.

4) Open one 5 oz. can of chunk chicken.

5) Drain liquid from the can of chicken.

Step 2

1) The following ingredients are to be collected and placed on a tray:
   Crepe batter
   Non-stick cooking spray
   Carrots
   Water
   Frozen broccoli
   Margarine
   Flour Mixture
   Milk
   Canned Chicken

2) The following equipment is to be collected and placed on a tray:
  - Cooktop and Cookware Manuals
  - Rubber Scraper
  - 1/3 C Dry Measuring Cup
  - 2 Spatulas
  - Damp Dish Cloth
  - 3 Wooden Spoons
  - Dinner Plate
  - Pot Holders
  - Kitchen Timers

3) Place one set of cookware on the cooktop to be investigated.

   One set of cookware includes:
  - One brand/ type of cookware
  - 3 2 qt. Saucepans
  - 1 10 in. Skillet

4) Arrange cabinets in Residential Appliance Laboratory to allow landing space on each side of the cooktop to be investigated.

5) Arrange trays with ingredients and equipment on a cabinet near the cooktop under investigation.

6) Set up video camera.

7) Complete data sheet.

8) Place the following items near the sink for consumers to wash the cooktop and cookware:
  - Dishwashing detergent
  - Dish towel
  - Dish cloth
  - Steel wool scrub pad -- when cookware without a non-stick finish was investigated.
  - Plastic scrub pad -- when cookware with a non-stick finish is investigated.

Day 2 -- Consumer

Step 1

The following procedures are to used when preparing the menu, to evaluate the performance of each cooktop/ cookware combination:

Research Menu

Crepes with Chicken in a White Sauce
Broccoli
Carrots

Step 2

After cooking the menu, consumers are to clean the cooktop and cookware used in the investigation, following manufacturers recommended instructions.

Step 3

The consumers are to complete the questionnaire.

Step 4

Repeat steps 1 - 3 until each consumer has investigated all 30 cooking systems.

Crepes

1) The following ingredients have been mixed in a blender:
   - 1 C All-Purpose Flour
   - 1 1/2 C Milk
   - 2 Eggs
   - 2 T Sugar
   - 1 T Vegetable Oil
   - 1/8 t salt
2) Lightly grease a skillet with cooking spray.
3) Heat pan till 2 or 3 drops of water on surface sizzles.
4) Pour 1/3 C batter into the skillet.
5. Lift and tilt skillet to spread out the batter.
6) Return to heat source.
7) Cook 2 minutes or until top is set.
8) With spatula, lift edge of crepe all around edges.
9) Invert crepe; cook other side 30 seconds.
10) Stack crepes one on top of another.
11) Repeat (steps 2-10) with remaining batter, grease as necessary.

White Sauce

1) In a saucepan melt margarine over low heat.
2) Blend in flour mixture over medium heat.
3) Stir until bubbly.
4) Add 1 C Milk.
5) Cook quickly, stirring constantly until mixture thickens and bubbles.
6) Remove from heat; turn range unit off.
7) Pour one can of chicken into white sauce.
8) Place the pan on the range unit.
9) Cook the chicken and white sauce until warm, stirring as necessary.

Carrots

1) Place carrots in a saucepan.
2) Cover carrots with water (2 C Water).
3) Place cover on the saucepan.
4) Place the pan on the range.
5) Turn on the cooktop unit needed.
6) Adjust the cooktop controls as needed.
7) Cooking time may range from 5 to 25 minutes depending upon maturity and size pieces.
8) Cook carrots until tender.
9) Drain the remaining water.

Broccoli

1) Place frozen broccoli in a saucepan.
2) Make sure the pan is more than 1/2 full of broccoli.
3) Do not add any liquid.
4) Place the cover on the saucepan.
5) Place the pan on a range unit.
6) Set the heat on the medium setting.
7) When the cover of the pan is hot to the touch turn the heat to the lowest setting.
8) Cook the broccoli until tender.

DATA COLLECTION SHEET
for Consumers' Knowledge, Practices, and Satisfaction

Cooktop ___________________________

Cookware _________________________

Date ______________________________

Investigator _______________________

Ambient Conditions:

Room Temperature

Wet Bulb ___________________

Dry Bulb ____________________

Relative Humidity (Percent) ___________

Barometric Pressure ________________

Required Manipulation:

White Sauce ________________

White Sauce w/ Chicken ______

Broccoli ____________________

Crepes _____________________

Required User Interaction - -Clean-up:

Cooktop-
Units ________________

Surface ______________

Cookware-
White Sauce _________

Broccoli ______________

Carrots ______________

Crepes _______________

Energy Consumption:

WH After ___________________

WH Before _________________

Cooking Time Required ______________

User Interaction Scale:

1 = None

2 = Slight -- Stir/ Turning

3 = Moderate -- Stir/ Turning

4 = Frequent -- Adjust Controls

5 = Continual

User Interaction Scale: Clean-up

1 = Wiped out/ off

2 = Wiped out/ off with increased pressure

3 = Wiped out/ off and additional tools

4 = Additional tools and increased pressure

5 = Extended time, tools, and pressure

Comments: ____

____

____

APPENDIX E

Equipment

Cooktop

Conventional Electric Coil	Brand Maytag Model CRE355 6 inch, 1500 Watts 8 inch, 2600 Watts
Solid Element	Brand Thermador Model E36 6 inch, Thermal Limiter, 1500 Watts 6 inch, Thermal Sensor, 1500 Watts 8 inch, Thermal Sensor, 2000 Watts 9 inch, Thermal Limiter, 2600 Watts
Radiant Coil under Glass Ceramic	Brand Maytag Model BCRE955 6 inch, 1200 Watts 8 inch, 2100 Watts Black Glass Panel
Halogen under Glass Ceramic	Brand Amana Model AK2H30HR 1. a. 9 inch, Radiant Coil, 2400 Watts b. 6 inch, Radiant Coil, 1400 Watts 2. 6 inch, Radiant Coil, 1400 Watts 3. 7 inch, Halogen Tube, 1800 Watts 4. 6 inch, Halogen Tube, 1200 Watts White Glass Ceramic Panel

Figure 7.1. Cooktops used in the investigation.

Saucepans

Thin Aluminum	Brand Mirro/ Foley Model C6372 Gauge .03 Size 2 qt. Top Diameter 6 inches Contact Area 5.125 inches
Heavy Aluminum	Brand Magnalite Model Classic 4862 Gauge .125 Size 2 qt. Top Diameter 6.563 inches Contact Area 5.625 inches
Heavy Aluminum Non-stick	Brand Circulon Model 88220 Gauge .125 Size 2 qt. Top Diameter 6.938 inches Contact Area 5.625 inches
Stainless Steel with Aluminum Heat Core	Brand RevereWare Model 3520020 Gauge .25 Size 2 qt. Top Diameter 7.0 inches Contact Area 5.438 inches
Thin Porc-on-Aluminum Non-stick	Brand T-Fal Ultrabase Model Versailles - 62023 Gauge .25 Size 2 qt. Top Diameter 7.0 inches Contact Area 5.188 inches
Glass Ceramic	Brand Visions Model V-20-N 6001889 Gauge .125 Size 2 qt. Top Diameter 6.813 inches Contact Area 4.875 inches

Figure 7.2. Saucepans used in the investigation.

Skillet

Thin Aluminum	Brand Mirro Company Model Classic - 5000001 Gauge .0625 Top Diameter 9.5 inches Contact Area 8.375 inches Non-stick Finish
Heavy Aluminum	Brand Magnalite Model Classic - 4508-B Gauge .125 Top Diameter 9.75 inches Contact Area 8.875 inches
Heavy Aluminum Non-stick	Brand Circulon Model 88220 Gauge .125 Top Diameter 9.875 inches Contact Area 6.0 inches
Stainless Steel with Aluminum Heat Core	Brand RevereWare Model 3520020 Gauge .25 Top Diameter 10.0 inches Contact Area 7.25 inches
Thin Porc-on-Aluminum Non-stick	Brand T-Fal Ultrabase Model Versailles - 982100 Gauge .25 Top Diameter 10.0 inches Contact Area 7.25 inches
Glass Ceramic	Brand Visions Model 6015076 Gauge .375 Top Diameter 10.125 inches Contact Area 7.625 inches Non-stick Finish

Figure 7.3. Skillets used in the investigation.

Instruments

Watthour Meter	Brand Duncan Electric Co. Single Station Watthour Meter 2-3 Wire CL100 MQ-A Form 20A
VCR	Kenmore LXI Series Model 934.55134490
Light Reflectance Meter	Photovolt Reflection Meter Model 577 Green Filter

Figure 7.4. Instruments used in cooking system research.

APPENDIX F

Code Book

Number	Variable	Location	Description
1	Energy	Datasheet	Energy consumption Watthours
2	Consumer	Datasheet	Consumer identification number
3	Energy Sources	Datasheet	Cooktop 1 = Conventional electric coil 2 = Solid element 3 = Electric resistance coil under glass ceramic 4 = Halogen under glass ceramic
4	Container Materials	Datasheet	Cookware 1 = Thin aluminum 2 = Heavy aluminum 3 = Heavy aluminum non-stick 4 = Stainless steel with alum. HC 5 = Thin porc-on-alum NS 6 = Glass ceramic
5	Knowledge	Survey	Pretest Knowledge Percent correct
6	Experience	Survey	Have you ever purchased a cooktop? 1 = No = 0 2 = Yes = 1
7	Experience	Survey	Have you ever purchased cookware? 1 = No = 0 2 = Yes = 1
8	Experience	Survey	Have you taken a household equipment course? 1 = No = 0 2 = Yes = 1
9	Experience	Survey	Have you taken a food preparation and selection course? 1 = No = 0 2 = Yes = 1
10	Experience	Survey	Have you taken a course that covered cooktops and/ or cookware? 1 = No = 0 2 = Yes = 1

11 Experience Survey What type of cooking procedure do you use when cooking broccoli?
1 = Cooktop and cookware - steam
2 = Cooktop and cookware - waterless
3 = Microwave oven
4 = Rarely

Question: Was the participant familiar with the research procedure used to cook broccoli? (i.e., Did the consumer circle number two?)
No = 0
Yes = 1

12 Experience Survey What type of cooking procedure do you use when cooking carrots?
1 = Cooktop and cookware - steam
2 = Cooktop and cookware - waterless
3 = Cooktop and cookware - boil
4 = Microwave oven
5 = Rarely

Question: Was the participant familiar with the research procedure used to cook carrots? (i.e., Did the consumer circle number three?)
No = 0
Yes = 1

13 Experience Survey What type of cooking procedure do you use when cooking a white sauce?
1 = Cooktop and cookware
2 = Microwave oven
3 = Rarely

Question: Was the participant familiar with the research procedure used to cook a white sauce? (i.e., Did the consumer circle number one?)
No = 0
Yes = 1

14	Experience	Survey	What type of cooking procedure do you use when cooking crepes? 1 = Cooktop and cookware 2 = Portable crepe baker 3 = Rarely

Question: Was the participant familiar with the research procedure used to cook crepes? (i.e., Did the consumer circle number one?)

No = 0
Yes = 1

15	Experience	Survey	What type of cooktop have you used on a regular basis? 1 = Conventional electric coil 2 = Solid element 3 = Electric resistance coil under glass ceramic 4 = Halogen under glass ceramic 5 = Gas flame 6 = Sealed gas

Question: How many electric cooktops had the participant used on a regular bases? (i.e., count the number of electric cooktops the participant circled. The number will range from one to four?)

1 = Conventional electric coil
2 = Solid element
3 = Electric resistance coil under glass ceramic
4 = Halogen under glass ceramic

16	Experience	Survey	What type of material is the cookware constructed of that you presently use? 1 = ALUMINUM 2 = STAINLESS STEEL 3 = PORCELAIN -ON- STEEL 4. = PORCELAIN-ON-ALUMINUM 5 = GLASS CERAMIC 6 = COPPER 7 = CAST IRON 8 = DO NOT KNOW

Question: How many types of cookware had the participant used on a regular bases? (i.e., count the number of cookware types the participant circled. The number will range from zero to seven?)

17	Experience	Survey	Do you presently use cookware with a non-stick finish? 1 = No = 0 2 = Yes = 1
18	Practices	Datasheet	Element crepes were cooked on 1 = Front left 2 = Back left 3 = Front right 4 = Back right

Question: Did the participant match the diameter of the cookware with the diameter of the heat source to cook crepes?
No = 0
Yes = 1

19	Practices	Datasheet	Element broccoli was cooked on 1 = Front left 2 = Back left 3 = Front right 4 = Back right

Question: Did the participant match the diameter of the cookware with the diameter of the heat source to cook broccoli?
No = 0
Yes = 1

20	Practices	Datasheet	Element carrots were cooked on 1 = Front left 2 = Back left 3 = Front right 4 = Back right

Question: Did the participant match the diameter of the cookware with the diameter of the heat source to cook carrots?
No = 0
Yes = 1

21	Practices	Datasheet	Element white sauce was cooked on 1 = Front left 2 = Back left 3 = Front right 4 = Back right
			Question: Did the participant match the diameter of the cookware with the diameter of the heat source to cook white sauce? No = 0 Yes = 1
22	Appliance Operating Time	Datasheet	Cooking time - White sauce/ chicken Minutes
23	Appliance Operating Time	Datasheet	Cooking time - Carrots Minutes
24	Appliance Operating Time	Datasheet	Cooking time - Broccoli Minutes
25	Appliance Operating Time	Datasheet	Cooking time - Crepes Minutes
26	Practices	Datasheet	Use retained heat - Crepes
			Question: Did the participant cook crepes with retained heat? No = 0 Yes = 1
27	Practices	Datasheet	Use retained heat - Carrots
			Question: Did the participant cook carrots with retained heat? No = 0 Yes = 1
28	Practices	Datasheet	Use retained heat - Broccoli
			Question: Did the participant cook broccoli with retained heat? No = 0 Yes = 1

29 Practices Datasheet Use retained heat - White Sauce

Question: Did the participant cook a white sauce with retained heat?

No = 0
Yes = 1

30 Practices Datasheet Preheat pan - Crepes

Question: Was food placed in the cookware at the start of heating the cookware?

No = 0
Yes = 1

31 Practices Datasheet Preheat pan - White sauce

Question: Was food placed in the cookware at the start of heating the cookware?

No = 0
Yes = 1

32 Practices Datasheet Preheat pan - Carrots

Question: Was food placed in the cookware at the start of heating the cookware?

No = 0
Yes = 1

33 Practices Datasheet Preheat pan - Broccoli

Question: Was food placed in the cookware at the start of heating the cookware?

No = 0
Yes = 1

34 Practices Datasheet Heat source left on after cooking - Carrots

Question: Was the cooktop turned off after cooking?

No = 0
Yes = 1

35	Practices	Datasheet	Heat source left on after cooking - Broccoli

Question: Was the cooktop turned off after cooking?
No = 0
Yes = 1

36	Practices	Datasheet	Heat source left on after cooking - Crepes

Question: Was the cooktop turned off after cooking?
No = 0
Yes = 1

37	Practices	Datasheet	Heat source left on after cooking - White Sauce

Question: Was the cooktop turned off after cooking?
No = 0
Yes = 1

38	Practices	Datasheet	Cover on pan during cooking - Broccoli

Question: Was the cover on the cookware during cooking?
No = 0
Yes = 1

39	Practices	Datasheet	Cover on pan during cooking - Carrot

Question: Was the cover on the cookware during cooking?
No = 0
Yes = 1

40	Practices	Datasheet	Cover on pan during cooking - Crepes

Question: Was the cover on the cookware during cooking?
No = 0
Yes = 1

41	Practices	Datasheet	Cover on pan during cooking - White sauce

Question: Was the cover on the cookware during cooking?
No = 0
Yes = 1

42	Practices	Datasheet	Preheat element - Crepes

Questions: Was the cookware placed on the heat source before or immediately after turning on the element?
No = 0
Yes = 1

43	Practices	Datasheet	Preheat element - Carrots

Questions: Was the cookware placed on the heat source before or immediately after turning on the element?
No = 0
Yes = 1

44	Practices	Datasheet	Preheat element - Broccoli

Questions: Was the cookware placed on the heat source before or immediately after turning on the element?
No = 0
Yes = 1

45	Practices	Datasheet	Preheat element - White Sauce

Questions: Was the cookware placed on the heat source before or immediately after turning on the element?
No = 0
Yes = 1

46	Interaction	Datasheet	Cooktop controls - Carrots Count
47	Interaction	Datasheet	Cooktop controls - Crepes Count
48	Interaction	Datasheet	Cooktop controls - Broccoli Count
49	Interaction	Datasheet	Cooktop controls - White sauce Count
50	Interaction	Datasheet	Cookware - pick up - Carrots Count
51	Interaction	Datasheet	Cookware - slide - Carrots Count

52	Interaction	Datasheet	Cookware - open - Carrots Count
53	Interaction	Datasheet	Cookware - pick up - Crepes Count
54	Interaction	Datasheet	Cookware - slide - Crepes Count
55	Interaction	Datasheet	Cookware - open - Broccoli Count
56	Interaction	Datasheet	Cookware - pick up - Broccoli Count
57	Interaction	Datasheet	Cookware - slide - Broccoli Count
58	Interaction	Datasheet	Cookware - pick up - White sauce Count
59	Interaction	Datasheet	Cookware - slide - White sauce Count
60	Interaction	Datasheet	Food - manipulation - Carrots Count
61	Interaction	Datasheet	Food - manipulation - Crepes Count
62	Interaction	Datasheet	Food - manipulation - Broccoli Count
63	Interaction	Datasheet	Food - manipulation - White sauce Count
64	Goodness-of-Fit	Datasheet 1 = If neither the skillet nor saucepan diameter corresponded $\leq$ 1/4" to the heat source 2 = If either the skillet or saucepan diameter corresponded $\leq$ 1/4" to the heat source 3 = If both the skillet and saucepan corresponded $\leq$ 1/4" to the heat source	

65 Practices Datasheet Initial cooktop control setting - Carrots
High = 1
Medium = 2
Low = 3

Questions: Was a low or medium heat setting selected?
No = 0
Yes = 1

66 Practices Datasheet Initial cooktop control setting - Crepes
High = 1
Medium = 2
Low = 3

Questions: Was a low or medium heat setting selected?
No = 0
Yes = 1

67 Practices Datasheet Initial cooktop control setting - White sauce
High = 1
Medium = 2
Low = 3

Question: Was a low heat setting used? (Did the user follow the instruction?)
No = 0
Yes = 1

68 Practices Datasheet Initial cooktop control setting - Broccoli
High = 1
Medium = 2
Low = 3

Question: Was a medium heat setting used? (Did the user follow the instruction?)
No = 0
Yes = 1

69 Practices Datasheet Touch saucepan - Broccoli
Number of times touched

Question: Did the participant touch the saucepan to determine if the saucepan was warm? (i.e., Did the user follow the instruction?)
No = 0
Yes = 1

70	Experience	Composite Variable b_2(V6+V7+V8+V9+V10+V11+V12+V13+V14+V15+V16+V17)
71	Practices	Composite Variable b_6(V18+V19+V20+V21+V26+V27+V28+V29+V30+V31+ V32+V33+V34+V35+V36+V37+V38+V39+V40+V41+V42 +V43+V44+V45+V65+V66+V67+V68+V69)
72	Interaction	Composite Variable b_7(V46+V47+V48+V49+V50+V51+V52+V53+ V54+V55+V56+V57+V58+V59+V60+V61+V62+V63)
73	Appliance Operation Time	Composite Variable b_8(V22+V23+V24+V25)
74	Appliance Operation Time	Composite Variable 73 converted to real time
75	Experience	Composite Variable b_2(V7+V8+V9+V10+V12+V13+V14+V15+V16+V17) Removed V6 & V11 due to no variance found
76	Practices	Composite Variable b_6(V18+V19+V20+V21+V26+V27+V28+V29+V30+V31+ V32+V33+V34+V35+V36+V37+V39+V40+V41+V42 +V44+V45+V65+V66+V67+V68+V69) Removed V38 & V43 due to no variance found
77	Information	Interaction Term Knowledge X Experience (V5 X V75)
78	Behavior	Interaction Term Practices X Interaction (V76 X V72)
79	User	Interaction Term Information X Behavior (V77 X V78)
80	Total Model	Interaction Model User X Appliance Operating Time (V79 X V74) Removed last ten decimal places

81	Cooking System Interaction	Interaction Term Cooktops X Cookware (V3 X V4)
82		Interaction Term Cooking System Interaction X Goodness of Fit (V81 X V64)
83	Cooking System	Cooking System Number (Number 1 - 24)
84	Total Model	Interaction Term User X Appliance Operating Time (V79 X V74) Formula and all decimal places
85		Copy of variable V5
86		Copy of variable V8
87		Copy of variable V10
88		Copy of variable V12
89		Copy of variable V18
90		Copy of variable V25
91		Copy of variable V28
92		Copy of variable V36
93		Copy of variable V42
94		Copy of variable V44
95		Copy of variable V47
96		Copy of variable V53
97		Copy of variable V64
98		Copy of variable 66
99		Copy of variable V68
100		Copy of variable V69
101		Copy of variable V76

102		Copy of variable V81
103	Practices	Reverse code V76 29 (Total points available) - V76
104	Behavior	V103 X V72
105	User	V77 X V104
106	Information	V77 Reverse coded
107	User	V106 X V104
108	Total Model	V74 X V107

109 Categories of Cooking Style

1=Low Energy Consumers	692.6 - 744.5 Wh
2=Average Energy Consumers	744.5 - 796.4 Wh
3=High Energy Consumers	764.4 - 848.3 Wh

Appendix G

Tables

Table 7.1

Correlation Matrix for Appliance Operating Time Among Cooking Operations as Represented by Menu Items

	White Sauce	Carrots	Broccoli	Crepes	Composite
White Sauce	1.0000				
Carrots	0.3457	1.0000			
Broccoli	0.4987	0.4853	1.0000		
Crepes	0.4032	0.3387	0.4131	1.0000	
Composite	0.7570[a]	0.7149[a]	0.7973[a]	0.7186[a]	1.0000

Note. [a]=Multicollinearity level $\geq$ 0.70

Table 7.2

Correlation Matrix of Experience Variables

	V7	V8	V9	V10	V12	V13
V7	1.000					
V8	0.468	1.000				
V9	-0.294	0.026	1.000			
V10	-0.200	0.464	0.026	1.000		
V12	-0.354	0.378	0.277	0.661	1.000	
V13	-0.134	0.071	0.367	0.071	-0.095	1.000
V14	-0.272	0.055	0.080	0.327	-0.000	**a** 0.764
V15	-0.000	0.149	0.439	-0.075	0.158	0.299
V16	-0.223	-0.435	-0.075	-0.435	-0.406	-0.205
V17	-0.134	-0.286	0.105	-0.286	-0.189	0.286
V75	-0.121	0.442	0.491	0.361	0.313	0.609

(table continues)

	V14	V15	V16	V17	V75
V7					
V8					
V9					
V10					
V12					
V13					
V14	1.000				
V15	-0.228	1.000			
V16	-0.417	0.214	1.000		
V17	0.218	0.149	0.051	1.000	
V75	0.280	0.699	0.085	0.151	1.000

Note.
[a]=Multicollinearity level $\geq$ 0.70
V7=Have you purchased a cookware?
V8=Have you taken a household equipment course?
V9=Have you taken a food preparation and selection?
V10=Have you taken a course that covered cooktops and/or cookware?
V12=Was the participant familiar with the research procedure used to cook carrots?
V13=Was the participant familiar with the research procedure used to cook white sauce?
V14=Was the participant familiar with the research procedure used to cook crepes?
V15=How many electric cooktops had the participant used on a regular bases?
V16=How many types of cookware had the participant used on a regular bases?
V17=Do you use cookware with a non-stick finish?
V75=Composite variable of experience.

Table 7.3

Correlation Matrix of User Interaction Variables

	V46	V47	V48	V49	V50	V51	V52	V53
V46	1.0000							
V47	0.1888	1.0000						
V48	0.3630	0.2268	1.0000					
V49	0.2882	0.1991	0.2684	1.0000				
V50	0.0677	-0.0162	0.0663	0.0518	1.0000			
V51	0.0732	0.0982	0.0400	0.1352	0.0165	1.0000		
V52	0.3544	0.1225	0.3499	0.1964	0.0943	0.0589	1.0000	
V53	0.0405	0.0877	-0.0073	0.0602	0.0175	-0.0328	0.1069	1.0000
V54	0.0060	0.0899	0.0101	0.0899	-0.1038	0.0404	0.0114	0.1936
V55	0.1647	0.0831	0.3196	0.2124	0.0377	0.0005	0.5302	0.1466
V56	-0.0642	0.0944	0.0568	-0.1070	0.2352	-0.1236	0.0218	0.1508
V57	0.0907	0.0293	0.2199	0.1333	0.0199	0.3244	0.1200	-0.0327
V58	-0.1276	0.0600	-0.0132	0.0827	0.0320	-0.0651	0.0661	0.1322
V59	0.0163	0.0906	-0.0348	0.0840	0.0469	0.1512	0.1099	0.0096
V60	0.2495	0.1460	0.2780	0.2788	0.0013	0.1290	0.6137	0.1153
V61	0.1055	0.2819	0.1147	0.1823	0.0824	-0.0231	0.1389	0.2889
V62	0.0802	0.0432	0.2501	0.2094	-0.0272	0.0335	0.2375	0.0737
V63	0.1548	0.0421	0.1816	0.2997	-0.0619	-0.0094	0.3156	0.0714
V72	0.2783	0.3221	0.3621	0.3559	0.0980	0.0797	0.5308	0.4025

(table continues)

	V54	V55	V56	V57	V58	V59	V60	V61
V46								
V47								
V48								
V49								
V50								
V51								
V52								
V53								
V54	1.0000							
V55	0.1498	1.0000						
V56	[a] -0.7060	0.1097	1.0000					
V57	0.1716	0.2467	-0.0912	1.0000				
V58	0.1740	0.2161	0.2760	0.0101	1.0000			
V59	0.1408	0.1303	0.0246	0.2781	0.2033	1.0000		
V60	0.2258	0.2518	-0.1026	0.1972	0.0295	0.1500	1.0000	
V61	0.1581	0.3239	0.1499	0.1979	0.2183	0.1257	0.1216	1.0000
V62	0.2572	0.6871	0.0739	0.2681	0.1797	0.1770	0.2759	0.2896
V63	0.2172	0.4411	-0.1829	0.1456	0.3310	0.0990	0.2209	0.2391
V72	0.4226	[a] 0.7040	0.1452	0.3369	0.4217	0.2839	0.4723	0.6871

(table continues)

Table 7.3 Continued

Correlation Matrix of User Interaction Variables

	V62	V63	V72
V46			
V47			
V48			
V49			
V50			
V51			
V52			
V53			
V54			
V55			
V56			
V57			
V58			
V59			
V60			
V61			
V62	1.0000		
V63	0.3378	1.0000	
V72	0.6144	0.6124	1.0000

Note.
V46=Number of times cooktop controls adjusted - Carrots
V47=Number of times cooktop controls adjusted - Crepes
V48=Number of times cooktop controls adjusted - Broccoli
V49=Number of times cooktop controls adjusted - White sauce
V50=Number of times cookware was picked up - Carrots
V51=Number of times cookware was slid - Carrots
V52=Number of times cookware was opened - Carrots
V53=Number of times cookware was picked-up - Crepes
V54=Number of times cookware was slid - Crepes
V55=Number of times cookware was opened - Broccoli
V56=Number of times cookware was picked up - Broccoli
V57=Number of times cookware was slid - Broccoli
V58=Number of times cookware was picked up - White sauce
V59=Number of times cookware was slid - White sauce
V60=Number of times food was manipulated - Carrots
V61=Number of times food was manipulated - Crepes
V62=Number of times food was manipulated - Broccoli
V63=Number of times food was manipulated - White sauce
V72=Composite variable of interaction

Table 7.4

Correlation Matrix of Practice Variables

	V18	V19	V20	V21	V26	V27	V28	V29
V18	1.0000							
V19	0.1559	1.0000						
V20	-0.2591	[a] -0.7251	1.0000					
V21	0.1224	-0.2937	-0.2005	1.0000				
V26	0.0181	0.0117	-0.0629	0.0713	1.0000			
V27	0.0028	0.0986	-0.1460	0.0101	0.4203	1.0000		
V28	0.0837	0.0777	-0.0935	-0.0341	0.4847	0.6575	1.0000	
V29	0.0160	0.0788	-0.0002	0.0186	0.2059	0.3907	0.3690	1.0000
V30	0.0267	-0.1158	0.0948	-0.0046	-0.0517	-0.0452	0.0173	-0.0665
V31	0.0310	0.0028	-0.0280	0.0420	0.0327	0.0286	0.0300	0.0421
V32	0.0519	-0.0519	0.0673	-0.0194	0.0102	0.0089	0.0094	0.0131
V33	0.0519	-0.0519	0.0673	-0.0194	0.0102	0.0089	0.0094	0.0131
V34	-0.0730	-0.0382	0.0656	-0.0339	0.0404	0.0352	0.0370	0.0519
V35	-0.0463	-0.1196	0.1569	-0.0750	0.0006	-0.0140	0.0516	0.0723
V36	-0.0283	-0.0445	0.0846	-0.0519	0.0469	0.0410	0.0431	0.0604
V37	-0.0274	-0.0885	0.1344	-0.0224	-0.0128	0.0431	0.0453	0.0635
V39	0.0512	-0.0512	0.0261	0.0427	0.0205	0.0179	0.0188	-0.0867
V40	-0.0519	-0.0537	0.0414	0.0194	-0.0102	-0.0089	-0.0094	-0.0131
V41	0.0040	0.0445	-0.0597	-0.0602	0.0181	0.0328	0.0274	-0.0086
V42	-0.0321	0.0321	-0.0089	0.0605	0.0177	0.0155	0.0163	-0.1076
V44	0.0512	-0.0512	0.0261	-0.0390	0.0205	0.0179	0.0188	-0.0867
V45	-0.0932	-0.0290	-0.0719	-0.0338	0.0177	0.0155	0.0163	-0.1076
V65	-0.1393	-0.0194	0.0138	-0.0293	-0.0679	-0.1043	-0.1129	0.0131
V66	0.0085	0.0164	-0.0059	-0.0486	-0.0209	-0.0357	-0.0303	0.0057
V67	-0.0730	-0.0104	0.0370	0.0089	-0.1087	-0.1339	-0.1245	-0.0667
V68	-0.0732	0.0257	0.0048	-0.0437	0.0230	0.0201	0.0211	0.0295
V69	0.0539	0.0335	0.0182	0.0064	0.0865	0.1292	0.2087	0.1274
V76	0.2807	0.0581	0.0101	0.0530	0.2663	0.2937	0.3759	0.3484

(table continues)

Table 7.4 Continued

Correlation Matrix of Practice Variables

	V30	V31	V32	V33	V34	V35	V36	V37
V18								
V19								
V20								
V21								
V26								
V27								
V28								
V29								
V30	1.0000							
V31	0.0452	1.0000						
V32	0.0141	0.3122	1.0000					
V33	0.0141	0.3122	[a]1.0000	1.0000				
V34	0.0000	0.0493	0.2531	0.2531	1.0000			
V35	0.0776	0.0771	0.1817	0.1817	0.4585	1.0000		
V36	0.0648	0.1066	0.2176	0.2176	0.2529	0.2918	1.0000	
V37	0.0217	0.0980	-0.0135	-0.0135	0.4111	0.3589	0.1913	1.0000
V39	-0.0779	-0.0179	-0.0056	-0.0056	-0.0221	-0.0308	-0.0257	-0.0270
V40	-0.0141	0.0089	0.0028	0.0028	0.0110	0.0153	0.0128	0.0135
V41	-0.0648	0.0410	0.0128	0.0128	0.0506	-0.0201	0.0588	0.0619
V42	0.0245	-0.0155	-0.0048	-0.0048	-0.0191	-0.0266	-0.0222	-0.0234
V44	0.0283	0.1433	-0.0056	-0.0056	0.1105	0.0682	-0.0257	0.0836
V45	0.0245	0.1704	-0.0048	-0.0048	-0.0191	-0.0266	-0.0222	-0.0234
V65	0.0984	0.0335	0.0433	0.0433	0.0295	-0.0364	0.0014	0.0440
V66	0.0133	0.0357	-0.0125	-0.0125	0.0751	0.1634	0.2682	0.0435
V67	0.0557	-0.0352	-0.0110	-0.0110	0.0957	0.0952	0.1315	0.1209
V68	0.0317	-0.0201	-0.0063	-0.0063	-0.0247	-0.0345	0.1785	-0.0303
V69	0.0555	-0.0295	-0.0715	-0.0715	0.0455	0.0961	-0.0185	0.1104
V76	0.2297	0.2215	0.2126	0.2126	0.3976	0.4205	0.3902	0.4204

(table continues)

Table 7.4 Continued

Correlation Matrix of Practice Variables

	V39	V40	V41	V42	V44	V45	V65	V66
V18								
V19								
V20								
V21								
V26								
V27								
V28								
V29								
V30								
V31								
V32								
V33								
V34								
V35								
V36								
V37								
V39	1.0000							
V40	0.0056	1.0000						
V41	0.0257	-0.0128	1.0000					
V42	-0.0097	-0.5757	-0.1112	1.0000				
V44	-0.0112	0.0056	0.0257	0.2818	1.0000			
V45	-0.0097	0.0048	0.0222	0.3277	0.2818	1.0000		
V65	-0.0750	0.0643	0.0728	-0.0493	-0.0210	0.0130	1.0000	
V66	-0.0250	0.0125	0.0572	-0.0216	-0.0250	-0.0216	0.0672	1.0000
V67	-0.0221	0.0110	0.0506	-0.0191	0.1105	-0.0191	0.0862	0.3860
V68	-0.0126	0.0063	-0.0748	-0.0109	-0.0126	-0.0109	0.0975	0.3966
V69	0.0127	-0.0323	0.0185	0.0561	0.0127	-0.0040	-0.1348	-0.0754
V76	0.0230	-0.0027	0.1964	0.0452	0.1635	0.0250	0.2467	0.3085

(table continues)

Table 7.4 Continued

Correlation Matrix of Practice Variables

	V67	V68	V69	V76
V18				
V19				
V20				
V21				
V26				
V27				
V28				
V29				
V30				
V31				
V32				
V33				
V34				
V35				
V36				
V37				
V39				
V40				
V41				
V42				
V44				
V45				
V65				
V66				
V67	1.0000			
V68	0.4504	1.0000		
V69	0.0729	0.0259	1.0000	
V76	0.2963	0.2263	0.4461	1.0000

Note. 0=No 1=Yes
V18=Did the participant match the diameter of the cookware and heat source-Crepes
V19=Did the participant match the diameter of the cookware and heat source-Broccoli
V20=Did the participant match the diameter of the cookware and heat source-Carrots
V21=Did the participant match the diameter of the cookware and heat source-White sauce
V26=Did the participant use retained heat - Crepes
V27=Did the participant use retained heat - Carrots
V28=Did the participant use retained heat - Broccoli
V29=Did the participant use retained heat - White sauce
V30=Was food placed in the cookware at the start of heating the cookware - Crepes
V31=Was food placed in the cookware at the start of heating the cookware - White sauce
V32=Was food placed in the cookware at the start of heating the cookware - Carrots
V33=Was food placed in the cookware at the start of heating the cookware - Broccoli
V34=Was the cooktop turned off after cooking - Carrots
V35=Was the cooktop turned off after cooking - Broccoli
V36=Was the cooktop turned off after cooking - Crepes
V37=Was the cooktop turned off after cooking - White sauce
V38=Was the cover on the pan during cooking - Broccoli
V39=Was the cover on the pan during cooking - Carrots
V40=Was the cover on the pan during cooking - Crepes
V41=Was the cover on the pan during cooking - White sauce
V42=Was cookware placed on the heat source before ... turning on the element - Crepes
V44=Was cookware placed on the heat source before ... turning on the element - Broccoli
V45=Was cookware placed on the heat source before ... turning on the element - White sauce
V65=Was a low or medium heat setting selected - Carrots
V66=Was a low or medium heat setting selected - Crepes
V67=Was a low or medium heat setting selected - White sauce
V68=Was a low or medium heat setting selected - Broccoli
V69=Did the participant touch the saucepan - Broccoli
V76=Composite - practices

Table 7.5

Correlation Matrix of All Variables Under Investigation

	V3	V4	V5	V64	V72	V74	V75	V81
V3	1.0000							
V4	0.0000	1.0000						
V5	-0.0000	0.0000	1.0000					
V64	0.1212	-0.0063	0.0035	1.0000				
V72	0.0246	-0.0053	-0.1796	-0.0337	1.0000			
V74	-0.0910	-0.0646	-0.0958	-0.0429	0.5554	1.0000		
V75	0.0000	-0.0000	0.1041	0.0002	-0.4275	-0.2226	1.0000	
V81	0.6417	[a] 0.7001	-0.0000	-0.0139	0.0056	-0.1062	0.0000	1.0000
V82	[a] 0.7920	0.0699	0.0028	0.6148	-0.0033	-0.0953	0.0001	0.5387
V103	0.1054	-0.0032	-0.1105	-0.0026	-0.1592	-0.0904	-0.1425	0.0688
V104	0.0691	-0.0020	-0.2004	-0.0500	[a] 0.8631	0.4902	-0.4813	0.0389
V106	0.0018	0.0064	[a] -0.8659	-0.0058	0.2459	0.0705	-0.4649	0.0067
V107	0.0260	0.0062	[a] -0.7551	-0.0298	0.6063	0.2982	-0.5701	0.0225
V108	-0.0238	-0.0224	-0.6079	-0.0331	[a] 0.7018	0.6407	-0.5178	-0.0311

(table continues)

	V82	V103	V104	V106	V107	V108
V3						
V4						
V5						
V64						
V72						
V74						
V75						
V81						
V82	1.0000					
V103	0.1031	1.0000				
V104	0.0353	0.3408	1.0000			
V106	-0.0023	0.1818	0.3060	1.0000		
V107	0.0059	0.2641	[a] 0.7002	[a] 0.8724	1.0000	
V108	-0.0422	0.1356	[a] 0.7344	0.6810	[a] 0.8897	1.0000

Note.
V3=Cooktop
V4=Cookware
V5=Knowledge
V64=Goodness-of-Fit
V72=Interaction
V74=Appliance Operating Time
V75=Experience
V81=Cooking System Interaction
V82=Cooking System Interaction X Goodness-of-Fit (V81 X V64)
V103=Practices
V104=Behavior (V103 X V72)
V106=Information
V107=User (V106 X V104)
V108=Total model (V74 X V107)
a=Multicollinearity level $\geq$ 0.70

Table 7.6

Variables Not Included in Regression Model--Hypothesis 6

Variable Number	Regression Coefficient for Predictors		
	R^2-Add	p[a]	%RMSE[b]
V7	0.006	0.0940	-0.3
V8	0.006	0.1066	-0.2
V9	0.000	0.8141	0.1
V13	0.001	0.6036	0.1
V14	0.000	0.9821	0.1
V15	0.003	0.2294	-0.1
V16	0.003	0.2606	-0.0
V17	0.001	0.4212	0.1
V19	0.000	0.7671	0.1
V20	0.002	0.3894	0.0
V21	0.002	0.3705	0.0
V22	0.001	0.5747	0.1
V23	0.000	0.9109	0.1
V24	0.000	0.8633	0.1
V26	0.001	0.6242	0.1
V27	0.001	0.6052	0.1
V29	0.003	0.2670	-0.0
V30	0.003	0.2368	-0.1
V31	0.001	0.4903	0.1
V32	0.004	0.1956	-0.1
V33	0.004	0.1956	-0.1
V35	0.001	0.4652	0.1
V36	0.003	0.2700	-0.0
V37	0.000	0.9747	0.1
V39	0.006	0.0885	-0.3
V40	0.002	0.3390	0.0
V41	0.002	0.3561	0.0
V42	0.006	0.1001	-0.2
V45	0.007	0.0697	-0.3
V46	0.000	0.7578	0.1
V48	0.002	0.3635	0.0
V49	0.000	0.7246	0.1
V50	0.005	0.1238	-0.2
V51	0.003	0.2167	-0.1
V52	0.007	0.0628	-0.4

(table continues)

Table 7.6 Continued

Variables Not Included in Regression Model--Hypothesis 6

Variable Number	Regression Coefficient for Predictors		
	R^2-Add	p^a	%RMSE[b]
V54	0.000	0.6695	0.1
V55	0.005	0.1347	-0.2
V56	0.001	0.6165	0.1
V57	0.003	0.2436	-0.1
V58	0.001	0.6283	0.1
V59	0.002	0.3571	0.0
V60	0.000	0.7524	0.1
V61	0.000	0.7965	0.1
V62	0.007	0.0773	-0.3
V63	0.001	0.5160	0.1
V65	0.002	0.3038	-0.0
V67	0.001	0.5412	0.1
V68	0.004	0.1588	-0.1
V69	0.006	0.0892	-0.3
V71	0.000	0.9532	0.1
V72	0.003	0.2115	-0.1
V73	0.001	0.5847	0.1
V74	0.000	0.6554	0.1
V75	0.000	1.0000	0.1
V76	0.000	0.9532	0.1
V77	0.003	0.2722	-0.0
V78	0.003	0.2455	-0.1
V79	0.000	0.9893	0.1
V80	0.000	0.8681	0.1
V103	0.002	0.3153	-0.0
V104	0.003	0.2279	-0.1
V105	0.000	0.7063	0.1
V106	0.001	0.4851	0.1
V107	0.007	0.0728	-0.3
V108	0.003	0.2487	-0.0

Note. [a]=$p \leq .05$
[b]=Percent Root Mean Square Error

Table 7.7

Variables Not Included in Regression Model--Hypothesis 7

Variable Number	Regression Coefficient for Predictors		
	R^2-Add	p[a]	%RMSE[b]
V3	0.000	0.9756	0.1
V4	0.000	0.9264	0.1
V7	0.001	0.5174	0.1
V9	0.000	0.7892	0.1
V13	0.000	0.8477	0.1
V14	0.001	0.9245	0.1
V15	0.004	0.1282	-0.2
V16	0.000	0.6582	0.1
V17	0.000	0.8989	0.1
V19	0.000	0.6541	0.1
V20	0.003	0.1814	-0.1
V21	0.000	0.6443	0.1
V22	0.003	0.2039	-0.1
V23	0.005	0.0938	-0.3
V24	0.000	0.6437	0.1
V26	0.000	0.9387	0.1
V27	0.000	0.9084	0.1
V29	0.000	0.9037	0.1
V30	0.001	0.4619	0.1
V31	0.002	0.2840	-0.0
V32	0.005	0.1096	-0.2
V33	0.005	0.1096	-0.2
V34	0.002	0.2804	-0.0
V35	0.001	0.5381	0.1
V37	0.000	0.9328	0.1
V39	0.004	0.1599	-0.1
V40	0.001	0.5558	0.1
V41	0.002	0.3385	0.0
V45	0.003	0.2367	-0.1
V46	0.000	0.7477	0.1
V47	0.006	0.0623	-0.4
V48	0.000	0.9740	0.1
V49	0.001	0.5678	0.1
V50	0.001	0.4012	0.0
V51	0.000	0.9427	0.1

(table continues)

Table 7.7 Continued

Variables Not Included in Regression Model--Hypothesis 7

Variable Number	Regression Coefficient for Predictors		
	R^2-Add	p[a]	%RMSE[b]
V52	0.000	0.7714	0.1
V54	0.000	0.9375	0.1
V55	0.000	0.6299	0.1
V56	0.000	0.8264	0.1
V57	0.000	0.9524	0.1
V58	0.000	0.8075	0.1
V59	0.002	0.3129	-0.0
V60	0.001	0.5805	0.1
V61	0.000	0.9663	0.1
V62	0.001	0.3628	0.0
V63	0.000	0.6483	0.1
V65	0.000	0.6743	0.1
V67	0.000	0.8606	0.1
V70	0.001	0.4126	0.0
V71	0.000	1.0000	0.1
V72	0.000	0.9032	0.1
V73	0.005	0.0985	-0.3
V74	0.005	0.0957	-0.3
V75	0.001	0.4126	0.0
V77	0.002	0.2978	-0.0
V78	0.000	0.9826	0.1
V79	0.000	0.8385	0.1
V80	0.000	0.9431	0.1
V82	0.000	0.7641	0.1

Note. [a]=$p \leq .05$
[b]=Percent Root Mean Square Error

VITA

Elizabeth Ann DeMerchant was born in Easton, Maine, on September 19, 1965. She graduated from Easton High School in 1984, and then the University of Maine at Farmington (UMF) in 1988 with a Bachelor of Science in Home Economics. Upon graduating from college, she accepted a position in August 1988, to teach home economics grades 7-12, at School Administrative District #13, Valley Jr./Sr. High School, in Bingham, Maine.

In September 1991, she entered Virginia Polytechnic Institute and State University as a full-time master's degree student. She received a Master of Science degree in Housing, Interior Design, and Resource Management in December of 1993. In January 1994, she entered the Ph.D. program in the same department. As a graduate student, she was employed as a graduate teaching assistant in household equipment. In addition, she has participated in several department research projects. Requirements for the doctorate were completed in April, 1997.

Professional memberships include: American Association of Family and Consumer Sciences (AAFCS), Virginia Association of Family and Consumer Sciences (VAFCS), Maine Home Economics Teachers Association, Home Economics Educators Association, Association of Home Equipment Educators (AHEE), American Association of Housing Educators, Electrical Women's Round Table, American Council on Consumer Interest, Eastern Regional Family Economics and Home Management Association. Membership in honor organizations include: Omicron Delta Kappa (ODK), Kappa Omicron Nu (KON), and Phi Upsilon Omicron.

While in the doctoral program, she served as president of the O Beta Zeta Chapter of KON, member of the Graduate Honor Court, member of the History and Archives Committee of AAFCS, and member of the Consumer Interest Organization. She became certified in family and consumer sciences (CFCS) in 1995. Currently, Elizabeth is a member-at-large on the national board of AHEE and student representative on the national board of KON, Scholarship Chair for VAFCS, and treasurer for the Alpha Circle of ODK. She has co-authored 14 conference papers and four journal articles in professional journals.

As a Ph.D. student, she has received the Elizabeth S. Gorvine Scholarship from UMF, VAFCS Graduate Student Scholarship and Mary Margaret Barry Scholarship, AHEE's International Appliance Technical Conference Scholarship, Graduate Student Assembly Travel Grant, and AAFCS College and University Section Travel Funds.