11-15-1989

Designing to increase user acceptance of respiratory protection

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"Designing To Increase User Acceptance Of Respiratory Protection."

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MFA Thesis Paper

November 15, 1989

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I would like to thank the many people who helped make this a rewarding and successfull project. Especially Mr.Steve Fess at Xerox Corporation, Mr.Jeff Sweedler at North Safety Equipment, Mr.Earl Ganzenmueller at Scott Safety Equipment, my thesis committee: Prof.J Sias, Prof.P Hoogesteger, Prof.T Tompson, and my tireless grammatical expert Ms.R Abkowitz.

Introduction: Problem Identification.

As unfortunate as it may be, we live in a time when the need for repiratory protection equipment is rising. Air pollution is increasingly responsible for illness and lost work days. In a recent unprecedented move Mexico was forced to alter the school schedule in Mexico City so that school children would not be as exposed to the smog created by early morning traffic. In addition to the decrease in air quality we are also learning that many substances previously thought safe are in fact toxic. For these reasons as well as those discussed in the following chapters it is imperative that respirators be designed to increase user acceptance.

This project was initiated during a visit to Smith Corona's manufacturing facility in Cortland, N.Y. There I visited a small enclosed room where engineering controls of air quality appeared to be ineffective. I asked if in fact they were effective, and was told that air quality standards met OSHA (Occupational Safety and Health Administration) requirements.

During the summer and fall of 1988 there was a great deal of media attention given to the drought, global warming, and air pollution. At about this time OSHA released new guidelines tightening controls on many substances and regulating a large group of previously unregulated substances, many of which are commonly found in the home. These regulations, which took affect in March 1989, were the most sweeping ones OSHA had enacted since its inception in 1970. They suggest that in the future there will be a demand for respiratory protection in the typical American household.

For example, by a model airplane builder, someone cleaning a fiberglass boat hull or just cleaning the oven.

Designing personal respiratory protection for the consumer market raises a number of previously unaddressed issues such as: How does one instruct people in their proper use with out the safety framework typical of corporations? How do you account for the variation in size and facial structure between family members? How do you convince people of the imporatance of utilizing air purifying respirators?

PHASE 1: Problem Restatement and Initial Research.

In restating the project directive I wanted to address issues pertinent to both workers and consumers. I therefore defined the design problem as "how can user acceptance of air purifying respirators be increased?" To begin with I did three things:

(1) developed a user survey (Table 1) to help define the issues;
(2) developed a manufacturers survey (Table 2) and evaluated the respirators currently on the market;
(3) worked out a project schedule (Table 3).

(Table 1) User Survey: Personal Respiratory Protection.

(This survey was given verbally on a one to one basis. Those questioned were educated individuals primarily students, professors, and industrial chemists.)

-Are there toxic or potentially toxic materials in your work environment?

-Do you wear an air purifying respirator ?

-Does your employer require or recommend that you wear a respirator?

-Is wearing a respirator important to you ?

-What do you dislike about air purifying (cartridge type) respirators?

-What is a typical period of use between breaks ?

-Does it make you feel secure ?

-Does it cause sores or bruises on your face or neck ?

-Does it make you feel confined or trapped ?

-Do you ever share your respirator ?

-How often do you clean it ?

-Do you take it apart for cleaning ?

-Does it get hot and moist underneath the face piece?

-Are straps and buckles a problem ?

-Does it become entangled with other equipment ?

-Do you use other safety equipment with your respirator ?

-Do you put your respirator on the same way every time?

-Would a more stylish air purifying respirator appeal to you ?

-Would a more light weight air purifying respirator appeal to you ?

-Do present respirators upset your hair or makeup ?

-Cartridges are now replaced when breathing becomes difficult (particulate) or a smell becomes evident (fume). Are you ever unsure about when your cartridges need replacement ?

(Table 2) Questions for Manufacturers: Personal Respiratory Protection.

-Who buys Personal Protection Equipment (PPE).

-Are they usually bought by a client establishing a comprehensive safety program ?

-Are PPE being used in place of engineering solutions in work environments ?

-What is your marketing basis ?

-How do you decide where the market is going ?

-Are there identifiable trends ?

-Are regular users moving toward belt mounted cartridges ?

-What percentage of the time are respirators used in a daily work situation ?

-Are most used for eight hour periods ?

-What is a typical period between breaks ?

-What equipment is used with a respirator - hardhat, earmuffs, goggles, coveralls ?

-What percentage of the time are air respirators used with and without other equipment ?

-What are the hazards ?

-Are the hazards immediate or long term in danger ?

-What is the proof of their danger ?

-Do people understand the hazards ?

-Do you use "maximum allowable concentration" or "minimum concentration of known effect".

-How do you utilize anthropometric data ?

-What affects your costs ?

-How many are made ? Yearly volume sold? units per manufacture run?

-What is being done to address the difficulties of fitting orientals with air respirators ?

-How are decisions made about breathing resistance ?

-Does the placement of the cartridge on a belt require a positive pressure to overcome air hose resistance?

-Is air quality better at the face, back, or waist ?

-Is there an IDSA member in your organization you can put me in contact with ?

During the first phase of the project I met with Steve Fess, head of safety at the Xerox Webster Research Center. Steve works to ensure the safety of about 12000 employees through the distribution of safety instruction, equipment, and emergency services. I then met with Earl Ganzenmueller, product planner at Scott Safety Equipment in Buffalo, N.Y. and Jeff Sweedler of North Safety Equipment in Cranston, R.I.

From these interviews I learned that: Respirators were initially developed by industry and the military independent of federal regulation. The regulation of manufacture and use came into effect with the Occupational Health and Safety Act of 1970 which created OSHA. In the design of respirators, human factors data is for the most part derived from the military. As a result there is a gap in the proper fit for Orientals, some women, and others with facial structure different from the Caucasian male.

There are a number of different types of air purifying respirators categorized by the way they supply air, (supplied air, pressure demand, continuous flow) and the way that they cover the nose and mouth, (full face half mask, and hood or body suit).

The requirements and procedures for NIOSH (National Institute for Occupational Safety and Health) approval, required for sale in the U.S., are all contained in the Code of Federal Regulations #30 Part 11. There is an interest, evidenced by recently released products, in moving cartridges off the face. However, moving the cartridges to the back or waist requires positive air pressure to overcome breathing hose resistance.

User feedback indicated that prolonged use caused a pressure point on the nose bridge, heat causes discomfort, and moisture build up under the face piece, with no means for its expulsion, causes the facepiece to slip on the face. In general, prolonged use caused fatigue.

At the end of Phase 1 I developed a number of possible directions for this project: (1) Design and build three respirators showing the effect of cost on a concept; (2) design a Respiratory Protection Series: full facepiece, half mask, dust mask; (3) design a "kit of parts" which allows a light weight respirator to be worn in a number of configurations.

I also made up a second generation schedule (Table 3) and began thinking about how to most effectively exhibit the project: rendered control drawings developed on the Intergraph, finished models exhibited on a mannequin, illustrated instructions, and renderings exhibiting the designs in use.

PHASE 2: Research and Report on Issues Related to Increasing User Acceptance of PPE.

During the second phase four issues were researched: (1) What are the requirements and procedures for getting NIOSH approval? (2) Why are some people more likely to use respirators than others? (3) How does one account for ethnic variation in size and structure? (4) What is fatigue and can good design reduce it in air purifying respirators.

(1) The government, under the auspices of The National Institute for Occupational Safety and Health (NIOSH), defines the usability criteria and carries out usability tests on all respiratory protection equipment. All such equipment sold in the U.S must be approved and properly labeled with a registration number from NIOSH. Each filter cartridge must display a description and color code based on the American National Standard for Identification of Gas Mask Canisters, K13.1.

All of the criteria for approval are contained in the Code of Federal Regulations #30 Part 11. These regulations define such things as construction and performance requirements, various type classifications, and fit and testing procedures at the time the equipment is distributed.

A registration fee of $3500 dollars is required for each piece of equipment each time an application for approval is made. The testing constraints for both half and full face (piece) respirators are essentially the same. They are that "Each wearer will enter a chamber containing 100 p.p.m. isoamyl acetate vapor for half mask facepieces, and 1,000 p.p.m. for full facepieces, mouthpieces, hoods, and helmets. Each wearer will remain in the chamber for eight minutes while performing the following activities: nodding and turning head, calisthenic arm movements, running in place, and pumping with a tire pump into a 28 liter container. Each wearer shall not detect the odor of isoamyl acetate vapor during the test." (30 CFR Part 11 pg. 73.)

NIOSH divides classification into areas: respirators, hazards, and service time. Respirators are classified in two ways: (1) respirators designed for use during entry into and escape from a hazardous atmosphere, and (2) respirators designed for use only during escape from a hazardous atmosphere. The hazards are divided into: (1) oxygen deficiency, (2) gases and vapors, (3) particles including dusts, fumes and mists, (4) pesticides. Service time is indicated in intervals from three minutes to four hours.

Fit and testing practices are also regulated, and for a number of reasons this poses a serious issue for the consumer marketing of respirators. Regulations maintain that the face piece must be capable of a facial seal check and subsequent usage without removal from the face. Choosing the correct filter canister can be confusing and is of the utmost importance. Confounding this is the issue that in a consumer application the hazards being faced are not likely to remain constant. For example, a consumer might use a respirator for pesticide application and painting. For these reasons packaging, instruction, and labeling become critical elements in the overall design. Materials science may provide part of the answer to this problem by providing a litmus test of some sort, enabling the consumer to positively identify a contaminant.

(2) Whether or not someone will choose to use an air purifying respirator may reflect ones perception of risk. A number of things affect risk taking behavior, decision time, experience, need for achievement, and the locus of control. Accounting for these factors in the design of PPE may prove pivotal to increasing user acceptance.

The length of time for making a decision under conditions of risk is important to the design of respirators as they typically involve an immediate danger without immediate consequences, and their proper use on a regular basis is imperative to their effectiveness. "In general as time for a decision decreases, the choice tends to be more conservative." Typically the amount of time available for deciding whether or not to wear a respirator is generous. One exception is in an emergency situation such as a chemical spill.

The emergency evacuation style respirator attaches to the mouth\face like a snorkel, one size fits all. These are handed out to persons entering areas which contain dangerous substances. In the event of an emergency the respirator is inserted into the mouth allowing the user to safely evacuate.

The length of time involved in normal respirator application would suggest that a user might act carelessly about the use of respiratory protection. The design of a respirator should account for this and imply the immediacy of danger. This might be accomplished through the use of emergency colors presently used in the design of many pieces of other safety equipment.

Key ideas have been expressed by Shealy 1974.

> "The level of experience and ability are significant and confusing factors of risk taking behavior. As a person becomes more experienced and skilled, s/he takes on greater levels of objective risk. This happens because the experienced individuals' subjective evaluation of the risk inherent in the situation goes down. In fact the skilled person maintains the same objective risk and probability of success."

Need for achievement affects risk in the following ways.

> "People with a high need for achievement will generally pick moderate levels of subjective risk and people with a low need will chose either high or low subjective levels of risk. They chose high because they do not care about failing or low because they do not feel driven to take any risk."(Shealy 1974)

The users' perception of control is another area which has immediate implication for the design of respirators.

> "The more external the locus of control the higher the level of subjective risk taking. That is to say that if a person feels they cannot control their own fate they will take on more risk. The more internal the locus of control the lower the level of subjective risk taking. That is to say that if a person feels able to affect his/her life he/she will take a more conservative stance toward risk. The findings that an internal locus of

control is associated with low risk taking appears contrary to the finding that as skill, ability, and experience increase, so does risk taking. This apparent contradiction is the result of confusion between subjective and objective risk taking. In fact the more skilled person does not take more risk, he/she is simply capable of more."(Shealy 1974)

Understanding how and why people take risk affects the design of consumer respiratory protection in a number of ways: marketing strategy, the design of packaging and instructions, as well as the products form and colors. Forms should be psychologically reassuring and aid in proper use, such as buckles which release in front of and not behind the head.

(3) How does one account for ethnic variation in facial size and structure? The design criteria of a half mask cartridge type respirator, aimed at the consumer market, differs significantly from the design criteria based on light industrial application. The environment and application of use might vary a great deal from one user to the next, and different sized family members might want to share a single respirator. Complicating these issues is the fact that the U.S. population may be the least physiologically homogenous populous in the world. All of these things make it appealing to explore how a face piece might be designed to accomodate a great variation in facial structure and size. To do this I began by looking at how the worlds' populations differ and how these differences are presently accounted for.

When one examines the data on a world scale, a clear pattern emerges between population differences and climate. Peoples living in warmer climates tend to have longer arms and legs in proportion to overall size. Peoples living in colder climates tend to have shorter limbs and more round forms. These variations serve the function of dissipating or maintaining body heat in different climates (Roberts 1952,1972). It seems reasonable to assume that these physical characteristics are the result of natural selection. Studies comparing immigrants with their offspring born in the U.S. demonstrate a tendency for the stature and other longitudinal body dimensions of the migrants to be greater in the new environment as compared with those of their kin remaining at home. This may be evidence of genetic plasticity or a better diet. Another explanation is that those with a particular growth tendency might naturally choose the habitat to which they are best suited.

It is not possible to quantify the genetic contribution to any dimensional difference between populations. We can say that the probability is very high that there is an appreciable genetic contribution to the dramatic differences between peoples. Although a relationship between size and genetics is difficult to show, the relationship between body porportions and genetics is quite well documented. Shapiro's (1939) analysis of Japanese migrants in Hawaii demonstrated "that although the Hawaiian born are taller and have larger sitting heights than the immigrants, nevertheless the proportion remains unaltered."

One rather perplexing fact shown by both Roberts (1956) and Tildesley (1950) is that variability within populations is typically greater than that between populations. Tildesley examined a number of anthropometric dimensions for indigenous populations all over the world. Table 5 summarizes her findings. In almost every dimension the variability within populations was greater than that between populations.

Physical dimensions are not the only differences between populations. Other differences include practices, customs and methods of accomplishing tasks. Although it is impossible to quantify cultural differences, it is possible to qualify them and indeed they must be accounted for in the design of products in our multinational trading community. Although customs may be difficult to account for, anthropometry can surely be quantified. This raises the issue of international standardization. It is important that ergonomic and anthropometric surveys are planned and coordinated so that the real differences between populations are not concealed by technical and observational differences. Assuring that we are all using the same point of reference is crucial, and optical technology will assure this in the future.

In most countries it is the military which produces the most comprehensive anthropometric data. The military has long had an interest in standardization. The military also has tremendous funding, and a large number of people at its disposal. Because of the time intensive measuring techniques of the past there is an abundance of data for military personnel but far less for the civilian population, i.e. women and children. However helpful, there are a number of problems with relying on military data for the design of consumer products. "Military data are frequently truncated, leading to distortions both of mean and variability," (Roberts 1975) and military data does not represent the whole population. Great advances are being made in the accuracy, completeness, and speed of taking measurments through the use of computers and optical scanning systems. Until now measuring a face and skull was limited by the fact that a head is made up of numerous compound curves, while rulers remain straight, thus making its measure a somewhat imprecise undertaking as well as time intensive. A revolutionary system being developed by Gregory F. Zehner at Wright Patterson AFB, uses a Silicon Graphics computer and a laser scanner. He gets 170,000 points as 3-D coordinates in a single head/face scan (McConville, 1/26/89). This can then be displayed as three dimensional information. As the efficiency of data collection techniques inproves it will cost far less to get anthropometric data for the civilian population.

Design applications which involve different populations require special research of and fitting trials for the end users. "Even quite intricate problems, for which interpopulation variation seems at first insurpassable, may be capable of relatively simple solutions"(Roberts 1975). He gives the example of a keyboard design problem whose goal was to find the relationship of the fingers to one another in a relaxed position. All the hand studies done to this point had been static measurements giving no real insight into the placement of fingers which would minimize fatigue. He set out to find whether there is a position of functional rest of the hand and if so, to identify it. He defined this position as the position in which there was the most complete relaxation of the muscles and ligaments. Utilizing electromyography they then set about finding the resting positions for a test group of 30 males and 30 females. Despite some significant differences between male and female averages for certain positions, they found that a keyboard based on these resting fingertip positions would be equally usable by both sexes if the keyboard were correctly positioned for the hand and if the thumb key were designed as a bar instead of a round button. Roberts suggests that interpopulation differences could be accounted for in as simple a way as just changing the position of the hand relative to the keyboard.

However simple or complex the solution, research, standardized means of observation, and international cooperation are increasingly imperative in the design of products aimed at an international market.

(4) What is fatigue and can good design reduce it? In the use of respirators a number of factors contribute to fatigue including breathing resistance, weight, pressure, heat, moisture, and movement. To best limit fatigue in my designs I first set out to define and understand it. Even if it can not be eliminated it should be minimized and the design should not increase it.

The definition of fatigue is somewhat obtuse. A number of attempts have been made to qualify the term fatigue and quantify its measure. These attempts typically represent the field of study from which they come and tend to be somewhat inconsistant with each other. The studies essentially fall under two categories: psychological and physiological.

Pyschologists tend not to define fatigue but to say that certain symptoms arise from it, represent it, or are due to it. (Viteles 1940) states that "fatigue is characterized by (1) a decreased capacity for work, known as work decrement; (2) modifications in the physiological state of the individual; and (3) a feeling of weariness. (Guilford, J.P.,and others 1940)" The first of these is referred to as objective fatigue because it can be measured by means of work output. The second is integral with the first but cannot be measured on its own. The third is a subjective experience which makes a person feel s/he must slow down or stop work. The muscular fatigue resulting from physical exertion is easily measured. However the tired feeling which results from mental exertion is difficult to demonstrate and measure.

The psychologists hold that mental fatigue reduces to physical or physiological fatigue. They believe that the so called subjective fatigue of the mind is only physical fatigue which occurs during mental work. They point out the discrepency between objective symptoms and subjective sensations. "In many activities objective collapse comes long after the feeling of weariness has reached a maximum, passed off and been succeeded by a feeling of well being." (Cattell,R.B.)

Physiologists define fatigue as something which happens during activity in muscle and nerve tissue to diminish activity. Fatigue is categorized by the physical system involved: fatigue of the central nervous system results in "general fatigue;" "perceptual fatigue" is due to the overuse of neurological pathways; "transmission fatigue" takes place at a neuromuscular junction; "contractile fatigue" takes place within muscle itself. The physiologists maintain that fatigue occuring during muscular activity is essentially the same as fatigue occuring in the course of mental activity. However, this may be the result of the ways in which fatigue is measured. The physiological performance requirements used to measure fatigue affect the outcome. The tests used typically involve strength, endurance and work output. "We can measure muscular fatigue as exhaustion of the glycogen, hexone phosphate or creatin phosphate, or the accumulation of acids." (Schneider,E.C.)

It is difficult to isolate the causes and measure the responses of mental fatigue. Two immeasurable effects on neurological fatigue are adaptation and emotional duress. An example of adaptation is the brains' ability to shut out surrounding noises when going to sleep. Evidence of the physical effects of emotional duress are commonplace. Mental exertion can cause physical exhaustion, however this can be accounted for by emotional responses such as teeth clenching. In and of itself mental work has a small cost in terms of calories burned. When an individual is highly motivated and experiencing little conflict, the mental capacity to continue will far exceed the physical ability.

In the main the literature on fatigue defines the term as Bartley & Chute do. "Fatigue is an experience of the whole person." They draw a distinction between impairment of the inability of the muscles to function, and fatigue, a mental and physical expression. The interrelationship between body and mind inherent in this definition has far reaching implications for the design of respirators and protection equipment in general.

User acceptance is affected both physiologically and psychologically by perception. For example, the weight of most respirators is on the face, not distributed over the entire head. Although this imbalance may not cause muscular impairment it may cause fatigue which is, as we have seen, both a physiological and psychological reaction. Other questions this raises include: Does retention strap pressure cause nonadaptable pressure points? Does the appearance of the unit interfere with the task being performed (i.e. line of sight)? Seeing that we know endurance decreases as temperature increases, can temperature control and increased perspiration be accounted for in the design of respiratory protection equipment?

PHASE 3: Develop Design Criteria and Design Alternatives:

Based on the preceding research I derived a set of eight design criteria: communication, perception, balance, movement, restraint, pressure, size, and structure. The solutions proposed emphasize addressing user needs which have not been previously attended to.

A key feature of the proposed alternatives is the distribution of 50% of the device weight off the face, thus reducing pressure on the nose bridge. The latter is accomplished by enabling the user to place the filter on top of or behind the head. This novel configuration of components reduces the number of retention straps and retention strap pressure needed to maintain a proper seal. The designs incorporate transparent rigid members in the face pieces which act as speaking diaphrams and enable the users lips to be seen, thus aiding in communication.

The purple respirator (Table 4) utilizes a large gel-filled seal which can accomodate a greater variation in nose bridge structure. This seal also allows the face piece to rest farther down the nose enabling the user to wear safety goggles, which is not presently possible.

The close proximity of filter element and face piece reduces breathing hose length and therefore resistance. Breathing hose resistance is a problem in those respirators presently on the market which have belt mounted filters. They require a battery pack and fan to create positive air pressure.

These novel designs require fewer injection molded parts by molding the intake and exhaust valve seats as integral parts of the face pieces. No seals are required between the filter or the face piece and the hoses, because the hoses themselves are sealed against the valve seats and filter elements. The purple filter (Table 4) is composed of two identical pieces ultrasonically welded together. This reduces the number of molded parts in the filters' manufacture by one. Living hinges and snap locks are incorporated where the hoses attach to the filters and face pieces, reducing the tooling costs for a thread or bayonet mount. As part of the design development a hole pattern optimization study would need to be conducted to assure that air was drawn over the filter bed evenly. Vanes to direct the air flow would be molded into the filter casing.

The elastic retention straps allow the respirators to be put on and removed without releasing the latch. When the restraint latch is utilized, its location in front of the head makes it easier for inexperienced users to mount.

Positioning the filter element off the face improves the wearers' line of sight. The uniform distribution of weight makes the respirators less fatiguing to wear by eliminating pressure points on the nose and face. The design which incorporates a gel-filled seal conforms to fit a greater variation in facial size and structure.

Areas where action is required, such as in the removal of the filter, are indicated by texture which is molded into the piece. The yellow face piece is an injection molded clear ABS piece.

The valve seats are molded as part of this piece. It is then placed as an insert into a mold where the yellow silicon is molded onto it.

In working to develop designs which are more aesthetically appealing I used visual metaphors such as "a smile, and a barrette." I tried to create harmonies between the various pieces of each design as well as between the wearer and the respirator. For example, with the yellow respirator (Table 4), the exhaust valve cover/retention strap visually wraps around the face piece and appears to continue in the form of the release button. This creates a harmony between the retention strap and the breathing hose/retention strap. The fact that clear sections were incorporated is a metaphorical expression of the respirators function namely to clean.

My Thesis exhibition was set up in a way which indicated both alternative respirator designs and the process by which they were arrived at. The exhibit consists of a map which compares and contrasts a standard half mask type respirator with the alternative designs. The exhibit demonstrates how the solutions respond to the established criteria, and how existing designs fall short.

IN CONCLUSION:

Advanced development of this project would include creating a wearable prototype. This could then be used to get user feedback on the design alternatives. Although the filters are intended to be mounted on top of or behind the head, user feedback is needed to judge feasibility and comfort.

Other ideas to be developed in the future coming out of this project include a body suit filter, integral respirator helmet, and a full-face respirator. The ideas which I believe have the most value are the criteria I developed talking to users and through research. Future respirator design should account for balance and the distribution of pressure points reducing fatigue and increasing comfort.

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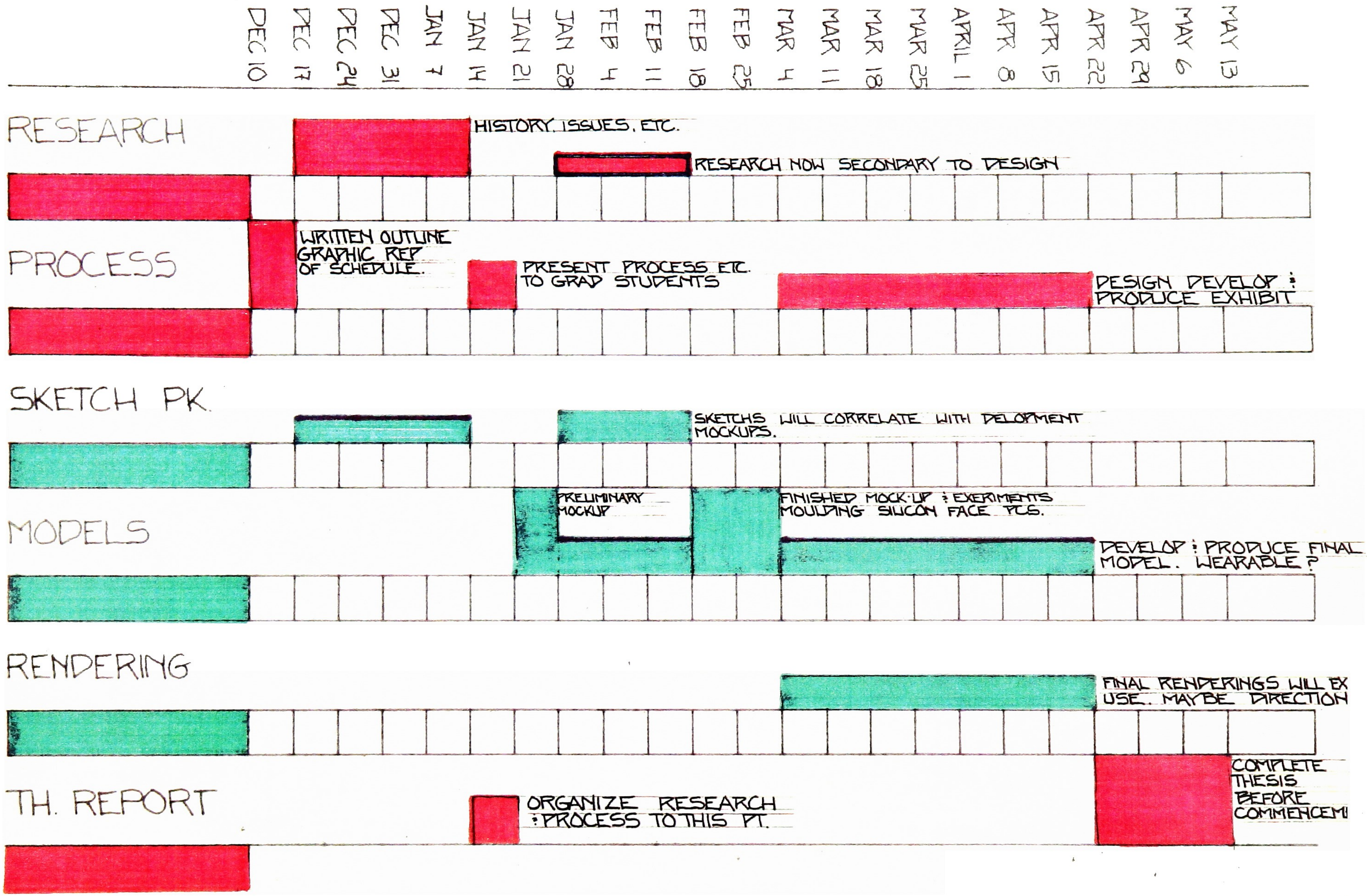
TABLE 3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MAR 4
MAR 11
MAR 18
MAR 25
APRIL 1
APR 8
APR 15
APR 22
APR 29
MAY 6
MAY 13
RESEARCH
HISTORY, ISSUES, ETC.
RESEARCH NOW SECONDARY TO DESIGN
PROCESS
WRITTEN OUTLINE GRAPHIC REP OF SCHEDULE.
PRESENT PROCESS ETC. TO GRAD STUDENTS
DESIGN DEVELOP : PRODUCE EXHIBIT
SKETCH PK.
SKETCHS WILL CORRELATE WITH DELOPMENT MOCKUPS.
MODELS
PRELIMINARY MOCKUP
FINISHED MOCK-UP : EXERIMENTS MOULDING SILICON FACE PCS.
DEVELOP : PRODUCE FINAL MODEL. WEARABLE ?
RENDERING
FINAL RENDERINGS WILL EX USE. MAYBE DIRECTION
TH. REPORT
ORGANIZE RESEARCH : PROCESS TO THIS PT.
COMPLETE THESIS BEFORE COMMENCEM

TABLE 4.

Table 5 Dimensional variation among and within populations (all measurements in mm)

Dimension	Population means: Number of populations	Population means: Mean of population means	Population means: Standard deviation of population means, i.e., interpopulation standard deviation σ_r	Population standard deviations: Number of populations	Population standard deviations: Mean standard deviation of populations, i.e., intra-population standard deviation $\bar{\sigma}_w$	$\frac{\bar{\sigma}_w}{\sigma_r}$
Nose-breadth	370	37.1	3.71	217	2.87	0.774
Sitting height	266	864.3	31.93	129	33.44	1.047
Nose-height (to nasion)	255	53.4	3.37	177	3.82	1.134
Bizygomatic breadth	402	139.2	4.55	245	5.23	1.150
Stature	573	1652.0	49.75	296	58.87	1.183
Span	147	1740.0	59.85	102	71.81	1.200
Morphological face-height (to nasion)	249	120.5	4.91	208	6.42	1.306
Hand-breadth (direct)	65	87.4	6.19	41	4.47	0.722
Shoulder-breadth (bi-acromial)	94	370.2	19.02	80	18.87	0.992
Mouth-width	82	54.3	3.61	34	3.73	1.034
Arm-length (projective)	63	742.5	25.12	33	32.90	1.310
Chest-girth (at rest)	76	887.9	38.02	39	49.89	1.311
Head-girth	97	554.1	10.64	56	14.45	1.357
Pelvic-breadth (ilio-cristal)	71	280.3	11.63	55	16.33	1.403
Breadth between inner eye corners	104	33.1	1.62	44	2.67	1.650
Physiognomic face-height	101	184.3	5.32	46	8.94	1.681