MECHANICAL REASONING AND WOMEN

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November 1981

> Being prone to lofty thinking, a theory about women and mechanical things began to form in my mind. I call it Law #2. . . Remembering Law #2 during the hard times has been very useful to me and my friends. It states: Whenever a woman tries to do something mechanical for the first time (i.e., bleeding brakes, building a wall, screwing in a screw), she will have no luck and everything that can go wrong seemingly will go wrong. The first time any job is done it will be the most difficult. . . Mechanical endeavours take skill and diverse kinds of knowledge that many women don't have when they begin working with tools. Men have learned it slowly over the years. . .
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> (Female apprentice's advice to aspiring tradeswomen)[1]

Problem Defined

One of the major factors preventing women from entering skilled trades or technical training jobs is the assumption on the part of counsellors, technical instructors, employers, and women alike that few women possess the ability to reason mechanically. This belief has been systematically reinforced and documented by women's low scores on mechanical reasoning and comprehension tests, and by the perceived hesitation and awkwardness of women entering skilled trades training.

Is mechanical reasoning a characteristic that an individual either has or does not have? If it is not innate, why do we believe that boys in general have mechanical reasoning ability and girls do not? Can mechanical reasoning be learned?

To function competently as a skilled tradesperson, an individual has to be able to "perceive and understand the relationships of physical forces and mechanical elements in practical situations. . .and intelligently apply these principles to the use of tools and the operation and repair of complex devices".[2] In other words, they have to be able to assimilate mechanical information, develop diagnostic and problem-solving skills, and apply these facts and abilities to tools and machines.

To learn to be a skilled tradesperson, a trainee needs to have the aptitude to develop these skills. The word "aptitude" causes much confusion. It has several definitions, the most common of which is "a natural tendency or inclination,"* giving rise to the fallacy that aptitudes are innate; that is, they exist rather than develop. In our society this definition is further delineated to assert that women and men are born already programmed to "naturally" perform certain gender-related functions (i.e. it is the nature of women to be nurturers; it is the nature of men to be mechanical).

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*Webster's New World Dictionary

A more accurate definition of aptitude, used by those who develop measuring instruments which attempt to predict the potential success of a learner in a vocational field, is: "A condition or set of characteristics regarded as symptomatic of an individual's ability to acquire with training some knowledge, skill, or set of responses. . ."** (emphasis mine). Thus, aptitude is the potential to learn, and the potential to learn mechanical reasoning is developed through socio-cultural and educational institutions which provide opportunities for human-machine interactions and positive reinforcement to those individuals deemed to have the aptitude (that is, men).

The Process of Development

Men develop mechanical reasoning through a life-long process of both formal and informal learning. It begins informally with the development of sensory, motor, and language skills. Parents, friends, and relatives make the assumption that, "boys will be boys" and baby boys will want to play with cars, trucks, train sets, tinker toys, building blocks, tools, and the like. Most boys' toys are hard, solid, inanimate objects which often require and can withstand rough physical manipulations. Household chores, too, teach such concepts. Boys are traditionally assigned such tasks as taking out the garbage, raking and cutting the lawn, and helping dad build and repair things. By playing with these toys and performing these tasks, boys begin to acquire a visual, tactile, and kinesthetic familiarity with mechanical objects and a repertoire of skills and insights; by naming them, they begin to establish a technical vocabulary which will soon provide a crucial link between the doing and the understanding of a mechanical task.[3]

When a boy starts school, formal learning combines with the continuation of informal learning to teach him how to reason in a more concrete way. As he matures, his toys become more complex: bikes, chemistry sets, telescopes, short-wave radios, model airplanes, etc. He learns to follow manufacturers' instructions in order to assemble and repair his possessions. By his early teens, he is often responsible for fixing his own bike, and later the car. In school, already-learned behaviours are recognized, rewarded, and built upon. Thus, a boy is assigned such mechanical-type tasks as rearranging classroom furniture, setting up the volleyball net, and erecting the projection screen. In sports, the games he plays require and develop spatial perception, strategizing, physical manipulation, quick thinking, and teamwork. When choosing optional school studies, he is expected to be interested in industrial arts, math and science, as these are prerequisites for most jobs men hold in today's labour force. If he advances in math and science, he assimilates abstract information and systematic ways of sequencing events which, when applied to his familiar world of inanimate objects, gives him the theoretical rationale or understanding of mechanical principles he needs in order to have mechanical "know-how". He now has a sense of mastery over mechanical devices.

This socialized learning is reinforced by role modeling. A boy begins receiving very clear messages at an early age of what a "real" man does. These messages range from such things as what he can and cannot play with because he is a boy, to primary readers that tell him "boys fix things, girls have things fixed"; to his own observations of the division of labour performed by men and women in his own home, in school, and in the world of work.[4]

**Warren's Dictionary of Psychology

Expectation and anticipation are powerful motivators. Throughout his formative years, a boy is not only given exposure to and experiences in the mechanical world, but he is expected to develop at least the minimal competency which comes from familiarity with a subject. He learns quickly what behaviours are expected from him because he is recognized and rewarded when he does them, and ignored or punished when he does not.[5] He also discovers that there is a great deal of tangible satisfaction when working with mechanical devices, and he learns to anticipate the rewards: the immediate gratification and pride that comes from work well done; a sense of achievement from solving complex problems and gaining control over "things"; the visual proof of personal competency; recognition from others who can see and judge the work for themselves; and, if done as a job, the pay is very good.[6]

The learning boys acquire through play and growing experiences is uncontrived learning; that is, a two-year old child does not set out to learn spatial relations and mechanical insights when playing with trucks and train sets; a 12-year-old repairing his bicycle in a trial-and-error manner is usually motivated by dad telling him he had better fix it, not by the process itself; and the 16-year-old passing a football according to a complex scheme of strategy gives no thought to the fact that he is also sharpening his reasoning powers. But the more experiences and exposure he has, the more his curiousity seeks answers to questions which naturally arise, further encouraging him to delve deeper for more understanding. This continues until there is a time when his responses to familiar mechanical problems become seemingly 'automatic' and his ability to transfer the learned knowledge and skills to similar territory is maximized.

All these expectations, exposures, and experiences our society demands from and gives to males are key factors in men developing what appears to be a 'natural' ability to handle mechanical situations. Like possessing a green thumb when gardening, most men approach mechanics with at least a somewhat-developed greasy thumb.

The development of reasoning in women parallels that of men, but the focus and impetus of the reasoning is different. The socialization of girls emphasizes the acquisition of people skills rather than mechanical skills, verbal proficiency rather than physical manipulation, domestic work rather than paid work, cooperative interaction and support rather than solitary exploration and decision-making. Her female role teaches her to become a dependent reactor rather than an independent initiator. ("This machine is broken, who will fix it for me?" vs. "I will fix this machine.")

Her sensory development is mostly through play experiences with soft, supple, brightly coloured toys such as dolls, stuffed animals, yarns, and colouring books. Her toys are often delicate, requiring great care and gentleness when handling. Her assigned household chores are helping mom with the dinner, dishes, beds, dusting, and care of younger children. Through all these experiences she acquires a language rich in descriptive, nurturative, and cooperative vocabulary. She becomes astute in observing and coordinating intimate and fine detail. She learns how to work quietly by herself and how to serve others.

Her formal learning reinforces these social skills. She is rewarded by teachers for her classroom manners, her helpfulness, her intuitive perception, her spelling and language proficiencies. The physical games she plays are often non-competitive and seldom rough and tumble. She is expected to choose home economics, psychology, sociology and typing options. As she advances in her education, she too begins to assimilate abstract information and systematic ways of sequencing events, but when she applies these diagnostic and problem-solving skills it is to further her understanding of and relationships to other people and to perfect her domestic skills.[7]

Girls also have strong role models, and working with mechanical devices is not what she observes her mother, teachers, T.V. or movie stars doing. She notes that she gets more attention when she bakes a pan of brownies than when she learns to pass a football. She observes that no one expects her to know anything about mechanical objects; if she is involved at all in a mechanical undertaking, it is usually as the helper or observer to a male.

Just as expectations are powerful motivators, the absence of an expectation can fail to stimulate any desire or reason to learn a particular skill, or if learned by chance, can leave its manifestation unnoticed. Since there is minimal scope and encouragement offered to a girl to develop mechanically, her experiences and learnings are not the same as boys. She is not permitted to take a firm, physically active approach toward inanimate objects; nor is she given numerous opportunities to explore things that would teach her about the physical world or its governing principles. She is not assigned tasks that give long-lasting and tangible sense of accomplishment, and she is quickly rescued from frustrating mechanical and physical challenge by protective and eager-to-help adults, unlike her male counterpart who is urged on to completion and success.[8]

Misconceptions and How They Affect Behaviour

It's not that girls don't have mechanical experiences and exposures, it's just that when they do, the thrust of the learning is on performing a task or developing better human relations or providing the needed helping hand -- seldom, if ever, is it on learning about the intricacies of the machine itself. For instance, women are traditionally taught how to operate such machines as a vacuum cleaner, washer, typewriter, sewing machine, photocopier, computer, telephone, and car -- but only as a means to an end. The machine comes to her completely assembled and ready for use; in cases of faulty operation, she is expected to get a qualified repairman or a husband/father/boss/male friend to fix it. Informally, many women master repairs on all types of machines, but his is a form of invisible learning: no certificate, raise, or promotion rewards the achievement; no one, including the woman herself, expects her to reason mechanically and her doing so is thus not internalized by anyone; it is never included as part of her job description; and its accomplishment is never analyzed for its transferability potentials. It remains unclaimed and unrecognized, except as one-time aberration of that particular woman.

Thus, when she enters skilled trades training as an adult, she begins by thinking it is an entirely new experience, virtually unconnected with anything in her past. She feels awkward and slow. She's indecisive about how to hold and use tools, worried that she might break something, bewildered by concepts the men seem to understand 'automatically', hesitant about tackling projects, and limited in her ability to 'talk shop'. She feels conspicuous and out of place.

She is also aware of some of the environmental factors which negatively influence both her and her instructors and this adds to her increasing sense of inferiority and ebbing confidence:

- the skilled trades and technology fields are labelled 'non-traditional' for a woman, thus her being there is seen as 'unnatural';

- o since mechanical reasoning is thought by many to be an innate and typically male talent, counsellors often recommend that women (seldom men) take a test before committing time in training;*
- o her low score on these tests either screens her out or adds a concrete dimension to why she feels 'out of place';
- o each time she struggles with a problem, she is plagued with external and internal messages to give up, quit, acknowledge defeat.

Although this initial struggle passes quickly for her, it leaves a lasting impression on her observers and is noted by them to be further evidence of all women's inability to reason mechanically; thus fueling the next woman's self-doubts. A vicious cycle of misconceptions.

Bridging the Gap

Because mechanical reasoning is presumed to be innate and because the students who enter trades and technology training are predominantly males who have developed a repertoire of sensory information, theoretical insights, and associated problem-solving skills, most instructors design courses that assume a certain level of sophistication. Already women are disadvantaged or eliminated -- not because they do not have the potential or the aptitude, but because they have not had the benefit of the antecedent exposure and experiences necessary for the integration of the new skills and knowledge.

Thus, a learning environment needs to be established which will quickly and effectively facilitate the transfer of a woman's diagnostic and problem-solving skills from people to mechanical devices by addressing her needs to acquire experiences in the physical manipulation of tools and machines, gain sensory exposure to the sounds, smells, and feel of the industrial environment, develop a technical vocabulary, learn basic math and science concepts applicable to trades and technology, and overcome learned hesitancies and dependency.[10] To create this environment, the following requirements must be addressed:[11]

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*Mechanical reasoning tests provide a narrow or specialized indication of potential future success in given situations; they are not reflections of an individual's global capacity to learn in those given situations under optimal learning conditions which is the way they are too often interpreted. One manual designed to aid counsellors in understanding the scores states: "The score is affected by the previous experience of the subject... Formal training in physics produces an increase in score of... a few points" and goes on to acknowledge that "it is important to realize that mechanical reasoning scores are of less educational and vocational significance for girls than for boys. The mean scores for girls are lower, the reliability of measurement is poorer, and the value of the test for educational or vocational guidance is less clearly established for females".[9]

1. Transferability Potential

Of initial importance is the recognition on the part of both the instructor and the women of the mechanical skills and reasoning processes she has already developed; she does not begin with a clean slate. Within her background are many experiences from which she can build upon and transfer to the mechanical world. It's a matter of changing the mind-set from "I've never done anything like this before" to "I've done a lot of similar learning and what I need to do now is to make the connections between that to this". Tradeswomen who report no trouble reasoning mechanically consistently compare the process to cooking and sewing.[12]

2. Generic Introduction

A wide variety of experiences which will develop sensory, motor, language, math and science skills appropriate to the skilled trades must be designed. Attuning the sensory receptors to the environment is accomplished through immediate hands-on work where she not only learns the basic tool skills common to all the trades and technology fields, but also develops a familiarity and appreciation of the touch and feel of industrial materials, the smell and noise of the tools and machines, and the visual impact of a well-finished product.[13]

Physical exertion to the uninitiated happens rapidly and feels like an indecent assault to the senses, so she is given time to learn how to develop and use her body efficiently and effectively. She works on increasing her strength, flexibility and endurance, and appropriately matching the various facets of her kinesthetic capabilities to the task at hand.[14]

She acquires technical vocabulary and math and science concepts through theory and through direct application as she follows instructions and works to completion of a job. She becomes an active, independent learner when she begins to ask questions, reference resource materials, make decisions, initiate projects of particular interest and relevance to her own learning needs, and evaluates the completed tasks in terms of their stated objectives.

3. Mechanical Tinkering

Tinkering is an absorbing, self-paced, exploratory type of learning which has as its goal to work and play with an object until an increased awareness and understanding of the essence of the object emerges. Women traditionally practice tinkering (also referred to as "puttering") in a kitchen or sewing room, so here again it is more a matter of facilitating the transfer of an already learned skill to a new application. Through mechanical tinkering, an intimate familiarity is developed wherein theoretical concepts are grasped, information is processed, and a power relation is established: the tinkerer gains mastery over a complex inanimate object.[15]

Mechanical tinkering is most beneficial when it is scheduled into the learning environment as a skill module of its own so women can develop an appreciation of its educational benefits and a comfortability and facility with its unstructured format. Six conditions are necessary if tinkering is to be successfully formalized as a method of teaching mechanical reasoning:

a) sufficient time must be allowed for the learning to take place;
b) the learning is autonomous, with resource materials and people used only as the learner chooses;
c) the tasks must be of interest and of some degree of complexity;
d) observations are reflected upon and discussed or recorded;
e) the learner evaluates for herself what she has learned, assesses the quality of the work and critiques and corrects any mistakes;
f) the transferability potential of the experience is noted.

When these requirements are present in a learning environment, women can quickly develop mechanical reasoning skills and competently learn to perform the work required of them by skilled trades and technology instructors and employers.

The Women Into Trades and Technology program provides this opportunity for women.

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