Engineering Design Methology

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# Theory of Science

When performing research, a researcher makes assumptions about how and what they will learn during their studies [1]. These assumptions might also be called paradigms, or worldviews, which Creswell defines as “a general orientation about the world and the nature of research that a researcher holds” [2]. One such worldview is *post positivism*, a quantitative research approach often represented in traditional research [3]. Post positivists believe that there is no absolute truth and that knowledge is shaped from data and rational consideration [3]. According to Kuhn, an acceptable theory in within post positivism is simple, provides accurate predictions and shows compatibility with other contemporary theories [4].

On the other hand, proponents of *social constructivism* believe that knowledge is created from individuals interacting with their environment [5]. Reality is not considered universal, but instead relative and consisting of different individuals’ mental *constructs*. No such construct is considered to be truer than the other, only more or less elaborate or sophisticated. [17] Truth is not absolute nor generalizable since phenomena occur within a certain time and context [6]. According to social constructivists, values affect all aspects of research and can never be completely set aside. Instead one should be aware of their existence when conducting research.

To constructivists, *theories* are constructions and are thus created from assumptions and affected by values. According to Lincoln and Guba a theory is acceptable if these assumptions and values reinforce one and other, if not the findings should be considered invalid. [18] Furthermore they claim that a theory should aim to be more informed as well as more elaborate than earlier theories [7].

Examining a cross section of researcher Mats Magnusson’s work, one can conclude that he uses the mixed methods research (MMR) methodology. An MMR researcher exhibits methodological eclecticism [8], i.e. usage of methods from both qualitative and quantitative approaches. Magnusson uses a wide range of methods such as Case Studies [9] and semi-structured interviews [10], which are methods attributed to the qualitative domain. In [11], Magnusson uses statistical analysis which is a quantitative method. Focusing on the problem at hand and choosing the methods that work are typical characteristics of a pragmatic worldview [12] [13] which is why Magnusson is believed to subscribe to this worldview.

Examining Magnusson’s research from a social constructivist perspective, one might criticize the lack of background perspective of the test subjects. Ethnicity and cultural background are important to the results [14] and should be taken into account when drawing conclusions. In [15], the job positions of the interview subjects are presented but their social setting is ignored.

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# Quantitative methods

One quantitative research design is *survey design*. In this design the researcher uses questionaires on a sample of the population to collect numbered data. The data are then analyzed statistically to test research questions and hypothesis and to find trends [16]. One might also use the experimental research design. One uses this when one wants to examine whether or not an action or a procedure has effect on the outcome, or the dependent variable. The outcome is then compared to a reference group which did not experience the action or procedure [17].

When conducting quantitative research, researchers employ a variety of instruments, or methods. One of these is *observational and behavioral checklists* [18], where the researcher observes a group and records behavior by checking points on a scale [19]. Another alternative are *questionaires*. These are suitable for collecting structured and often numerical data [20]. Using *closed quantitative interviews*, the researcher specifies questions and response categories beforehand and the respondend chooses between predetermined responses [21].

When searching for a tool to find wear on rail road tracks using sound data, experiments were repeated under controlled circumstances in order to confirm or reject a preset hypothesis that noise measurement from rail to track can be used as a parameter to determine a shift from normal to severe wear [22]. This is a typical use of the *structured observation* instrument, observing an experiment in a very systematic way to collect numerical data. This data is then used to conform or refute the hypothesis [23].

Litwin states that surveys are subject to *content validity* which concerns whether or not the survey items include everything it should and nothing it shouldn´t. This is judged by a group of experts, or trained judges [24]. External validity deals with the generalizability of the results of a study. Winer argues that this is a very important perspective for experimental research [25].

# Qualitative methods

When employing the research design *grounded theory*, the researcher tries to create a theory of a process or an action. The theory is grounded in data collected from participants [26]. The researcher might use a variety if methods for data gathering, for example interviews and focus groups [27] [28]. *Ethnography* focuses on studying a group of people to understand and describe their cultural behavior. Data is gathered through fieldwork where the researcher makes observations and taking notes while being a part of the group [28].

Often used in grounded theory, *focus groups* are an instrument which is a sort of group interview. In focus groups, participants are encouraged to interact with each other and the interaction is an integral part of the method [30].

When researching how organizations can make use of management controls to support innovation for employees, Susanne Nilsson uses several qualitative methods. Nilsson took part as a coordinator in the innovation work at the company, thus using the *participant observation* method since the researcher herself took part in the activities of the participants of the study [31]. Another method of direct observation, Nilsson also employed the *non-participant* method when attending and observing formal innovation events of the subject companies [32].