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 [29].

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].

If the researcher doesn’t have enough understanding of the context of interviewees during qualitative interviews, lack of trust might lead to doubts whether the respondents tell the truth (as they know it) [33]. Also, in participatory observations, the presence of the observer might cause behaviors that are not representative of the natural setting [34]. This is a valid concern for Nilssons studies, where she took a leading role in the group which she studied [31]. This is also something she notices in her report [35]. To reduce the effect, one might suggest using less intrusive methods such as non-participatory observation, which she has also done. Reviewing the research questions [36], one can see that the interaction and dynamics of the group are important. This focus would also be suitable for a focus group method. To reduce the effect of the researchers presence, the researcher might stay for a longer period of time whilst observing [37].