

## Module 2.6 Validation and Verification

When designing your research and experiments, a step that you should not forget in that process is to look at how you will evaluate, validate, and verify your research and its outcomes.

In a very simplified form: How to add credibility to the work you have done.

This is a key step in research, as it allows your research to be used in a professional environment, and it also allows for academic reproducibility and transparency.

How will you know that you did what you set out to do? That you used the methods you intended to use correctly? That your data and analysis of your data is correct? And that your results and conclusions are correct and trustworthy?

By ensuring a systematic approach for validation and verification from the outset of your research design, these questions can easily be answered. Let us start by defining what we mean by validation and verification using an example: Imagine you are asked to build a shelter: You could build an Igloo or you could build a tent?

Validation is then the answer to the question of whether you build the right thing?

If you are in the Arctic, perhaps an Igloo is the right thing to build and a tent may not be.

Verification in this example would concern itself with whether you are building it the right way? Such as the entry of the igloo facing away from the prevailing wind direction.

In other words: Validation is proving that your outcomes are true and based on strong (scientific) evidence. Verification is proving that your method of research has been used in the way it is supposed to be used and is suitable for your research topic. As an engineer you may have already come across validation and verification in a more industrial setting.

Validation is seen as the quality assurance process: It establishes evidence that provides a high degree of assurance that a product, service, or system accomplishes its intended requirements. It often involves acceptance of fitness for purpose with end users and other product stakeholders, and is often an external process.

Examples are: precision, accuracy and reproducibility. Think of LEGO bricks, each of which must be precise enough to fit on top of each other. Verification in this setting is a quality control process. It is used to evaluate whether a product, service, or system complies with regulations, specifications, or conditions imposed at the start of a development phase.

Verification can be in development, scale-up, or production phase and is often an internal process. Think for instance, of a design verification test: An intensive testing program

which is performed to deliver objective, comprehensive testing, verifying all product specifications, interface standards, original equipment manufacturer requirements, and diagnostic commands.

So how do we deal with validation and verification in our research? Validity in terms of research is best defined as: “the best available approximation to the truth of a given proposition, inference or conclusion” Or put differently: “The quality of various conclusions you might reach based on a research project” We try and reach the highest level of validity,

to have the most impact with our research. It is important to stress here that our propositions, inferences and conclusion have validity, not the method, sample or measurement.

To judge the quality of validity, you can use the so-called validity staircase from Trochim: We start at the bottom step of the staircase: Conclusion validity – which looks at whether there is a relationship between cause and effect. It says something about the degree to which conclusions you reach about your relationships in your data are reasonable.

Next, you look at the internal validity: Is the relationship causal? You know by now that correlation does not always mean causation. If you can make a valid causal claim you can claim internal validity. The third step is construct validity: This reflects on the construct of your research and the subsequent measurements: Can say whether your research program that you actually carried out, reflects the construct of your research design and whether you measured the outcomes you intended to measure?

Finally, at the top of the staircase, we find external validity: Assuming that there is a causal relationship and our constructs are valid, can we generalize our findings to other people, materials, places and times?

In terms of verification in research, this refers to the mechanisms used during the process of research to incrementally contribute to ensuring reliability and validity and, thus, the rigor of a study. This is also where you have to show transparency in your data and your recordkeeping. It is incredibly important to keep a logbook of your work from the very beginning. In certain fields, this is even mandatory, as well as a good file management system and version control of your files.

To ensure validity of your results, it is important you take all these steps into account and develop verification procedures right from the start of your research, starting at your research design.