Applied Methodology for Teachers I.

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2. Preparation of a semester assignment
3. Successful completion of the final exam
Meaning of icons used in the text

{=}  
**Objectives**  
A list of objectives is provided at the beginning of each chapter.

{!}  
**Terms to Remember (Key Words)**  
A list of important terms and main points that the student should not omit when studying the topic.

{?}  
**Review Questions**  
Verifying to what extent the student has understood the text and the issue and remembers fundamental and important information.

{🌐}  
**Literature**  
Used in the text and to complement and further one’s knowledge.
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Introduction to the Subject

This study text is intended especially for students of pedagogy, psychology and related fields of study. It contains background information on how to apply a certain methodology when writing a bachelor’s or master’s thesis or PhD dissertation as well as how to apply this methodology directly to graduate work where one faces various assignments, questions and problems which can be resolved using the procedures specified in this text.

The disciplines mentioned above normally apply either a qualitative or quantitative methodology. This study text is centred on the quantitative approach, which has numerous strengths but also certain weaknesses. The quantitative approach in research has been developing for a fairly long period of time. It has advanced so much that there are now many tools which can be used to garner essential and interesting data about selected phenomena. One needs to master basic statistical tasks to be able to get the most out of this (sometimes fairly demanding) process. Otherwise the opportunity is uselessly wasted and its information potential is insufficiently used.

Since this textbook is concerned with the quantitative approach to scientific research, the basic statistical terms, processes and methods are provided as they form the pillars of all quantitative methodology. The parameters of this study text do not make it possible to perform any deeper analyses or to quote all of the most frequently applied methods and procedures. On the other hand, it will enable the carrying out of a research survey with subsequent data analysis which might be the subject of a paper to obtain higher education qualifications.

The motivation behind the production of this text was to give students an insight into the secrets of quantitative research, which may initially seem difficult to grasp, complicated and perhaps too far removed from reality. But for curious individuals wanting to learn new things (which the readers of this text undoubtedly are), this study text might be one of the first incentives towards acquiring deeper knowledge about quantitative procedures and using them in life.
1 Science and Common Sense

Objectives
After studying this chapter:
- You will be able to define the difference between a scientific and a lay approach to facts.
- You will understand the essential character of scientific activities.

Terms to Remember (Key Words)
- science
- objectivity
- theory
- reason
- cause
- context
- scientist
- control
- cognition

If we want to know a lot about a certain sophisticated human activity, we first need to learn to understand the language and mannerisms of the people doing it. Likewise, we can apply these rules to the understanding of science and scientific research. The term ‘science’ for us has always been linked with a group of somewhat exceptional people who speak a language we do not understand, who look as if they know everything about the country and the world, who live in a world of their own which only they understand, and who communicate with each other in an incomprehensible language. The propaganda of the past told us that they were some sort of exotic beings from another world where there was no place for ordinary mortals like us. The truth is that there are many people like this who hide things behind incomprehensible words that are easy to explain without making any deplorable simplifications. To be able to understand science and everything related to science, we need to master the scientific language – at least to a certain extent – as well as the scientific approach to problem solving.

The way in which a scientist uses normal words may sometimes seem confusing to those embarking on scientific activities, though for a short period of time and with certain concerns in mind. A scientist uses new words to make things more complicated. There are undoubtedly good reasons for this specialised use of the language, but to understand it, we need to learn this vocabulary to be able to use it at least adequately and without fear of being ridiculed. For instance, when a pedagogue or psychologist tells us that he/she
has randomised his/her experimental procedures or that the results are not statistically significant, we need to know what he/she means. Also, we need to know why he/she has made this decision.

Likewise, we need to clearly understand the scientist’s approach to the problem-solving methods he/she has set. It does not matter that this approach is different from that of a layman. Of course, the scientific approach is different in many ways, but it is not unusual or mysterious. It is quite the contrary: once you understand the scientific language, you will find everything that a scientist does natural or even inevitable. Perhaps we will wonder afterwards why the scientific viewpoint is not applied more in human thinking and problem-solving and deliberately structured in accordance therewith.

It might be good to start with the question of why a scientist’s approach to a problem is often different from what we could call a common sense approach. In 1911 American Whitehead pointed out that common sense is a bad master in creative thought, because ‘its sole criterion for judgment is that new ideas shall look like the old ones’. Using only common sense, we would have never abandoned the old ‘truth’ that machines that are heavier than air cannot take off.

As common sense is sometimes defined as a chain of concepts and conceptual schemas suiting man’s practical needs, we will, of course, also find a perspective from which science and common sense are actually alike. But these conceptual schemas can be misleading: using common sense, educators in the bygone era used physical punishment as the basic means of education. But since then, we have seen a lot of evidence that motivation based on common sense may be misleading and that reward is much more important than punishment when it comes to motivation to learn.

According to Kerlinger, science and common sense differ sharply in five ways:

1. These disagreements usually revolve around the words ‘systematic’ and ‘controlled’. While the man in the street uses theories and concepts, he ordinarily does so in a loose fashion and accepts fanciful explanations of human and natural phenomena. An illness, for instance, may be thought

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to be a punishment for sinfulness, or the state’s economic crisis may be attributed to criminal bankers. (To be frank, we often accept these explanations without criticism only because we are too lazy to look up real facts and think, or we usually just make do with omnipresent stereotypes to perform an evaluation of certain phenomena.) The scientist, on the other hand, systematically builds his theoretical structures, tests them for internal consistency, and subjects aspects of them to empirical testing — and if he/she has at least average competence, he/she can abandon any indemonstrable facts without feeling humiliated or profaned.

2. The scientist systematically and empirically tests his theories and hypotheses. We also do this in normal life: However, we often choose evidence simply because we want it to confirm our hypothesis and use intransient logic: all foreigners are dangerous; my neighbour is from Asia; Asians are foreigners, ergo, he is dangerous. We have, of course, applied Aristotelian syllogism, but have we put it to an objective test? We have not made any systematic, controlled and empirical testing of the presumed statements and relations at all. But the louder we say so, the more socially successful and moral we are.

3. There is also a difference in the notion of control. The scientist tries to systematically differentiate any variables that are possible ‘causes’ of the effects he is studying from the variables that he has hypothesised to be the ‘causes’. The layman seldom bothers to control his explanations of observed phenomena in a systematic manner. He tends to accept those explanations that are in accord with his preconceptions and biases (here, again, we often encounter many sorts of stereotypes).

4. The fourth difference between science and common sense is not so sharp: the scientist pursues relations consciously and systematically; the layman does not. The layman’s preoccupation with relations is subject to moods, emotions; it is superficial, non-systematic. For instance, the layman often regards the fortuitous occurrence of two phenomena as a discovery of cause and effect. We have already used the example of punishment and learning by using 'common sense'. Depending on previous experience and practice, the parent or educator can say: punishment (reward) functions effectively on the level of learning. However, the relation between reward (punishment) and learning must be researched in a larger sample on a repeated basis, both reward and punishment must be balanced, and both types of possible relations must be tested (reward vs. learning; punishment vs. learning).

5. The fifth difference between science and common sense lies in their different interpretations (explanations) of observed phenomena. When
attempting to explain observed phenomena, the scientist must purposefully avoid vague, ‘metaphysical’ interpretations for which no evidence has been found and which cannot be tested. Although it is possible to say that people are poor because God wills it or that delinquency is a consequence of a lack of morals, none of these propositions can be precisely tested. The scientist, of course, does not necessarily have to spurn such statements, rule them out as being a priori untrue or ridiculous, but he has to be concerned with things that can be publicly observed and tested.

The scientific approach is capable of self-correction where control mechanisms monitor and verify the scientist’s activities and conclusions in order to reach reliable cognition, independent of the researcher. So even if an experiment confirms the hypothesis, the scientist must test an alternative hypothesis which can cast doubt on the first one if it is also confirmed. Therefore, the scientist must insist on proposition testing with the option of public inspection and repeatability. The term objectivity seems to be the most suitable here.

Scientific research is then defined as the ‘systematic, controlled, empirical and critical investigation of hypothetical propositions about the presumed relations among natural phenomena’. 3

**Theory** is the basic aim of science, i.e. general explanations of natural phenomena must be found. Instead of trying to explain each and every separate behaviour of children, the scientist seeks general approaches to the behaviour of children in certain situations by observing a large number of children. Kerlinger 4 mentions other aims of science: explanation, understanding, prediction and control.

Kerlinger 5 defines theory as a ‘set of interrelated constructs (concepts), definitions and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena’.

For instance, we want to investigate a theory of failure in school. Our variables might be the child’s intelligence, verbal and numerical aptitudes, anxiety,

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motivation, and reactions to reward and punishment. The phenomenon to be explained is achievement or failure in school. Failure in school is specified by a combination of the six variables described above and their relations with the aim of understanding the causes of failure. Only then we can explain the causes of this failure and also predict or prevent any future failure thanks to the knowledge of these variables.

Kerlinger says that the scientific approach starts with the problem-obstacle-idea triad. On the way to understanding, the scientist usually experiences obstacles, a vague feeling of unsettledness about observed and unobserved phenomena, and curiosity: why something is as it is. The scientist is pushed to experience the 'adventure of understanding'. The first and most important step is to have an idea, to express the problem in some reasonably manageable form. The problem will only rarely spring fully at this stage. We must examine it in detail, 'live with it'. Sooner or later the problem is stated, but it is always a tentative statement.

After intellectualising the problem, after using our previous experience and studying the relevant literature, we can formulate a hypothesis.

**Review Questions**

1. What is the difference between a lay and a scientific approach to facts?
2. And – on the contrary – what do some parameters of scientific research and normal life have in common?
3. How can we ensure that scientific theory is not burdened with low-quality or incorrect research?
4. What are the basic aims of science?
5. Think over the manner in which your reasoning about various phenomena changed after you started your university study.
6. Please state why it might be risky in certain cases to rely on common sense.
7. Please try to recall when in your life you applied scientific knowledge.
2 Formulating Hypotheses

Objectives
After studying this chapter:

- You will have an insight into the basic types of hypotheses.
- You will be able to formulate (state) a testable hypothesis.
- You will be able to differentiate individual variables.

Terms to Remember (Key Words)

- substantive hypothesis
- statistical hypothesis
- null hypothesis
- independent variable
- dependent variable
- testability
- cause
- consequence

A hypothesis is a conjectural statement of the relation between two or more variables. Hypotheses are always in the form of a declarative sentence, and they state, either generally or specifically, the relation of variables to other variables.

According to Kerlinger⁶, there are two criteria for good hypotheses:

1. Hypotheses are statements about the relations between variables.

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2. Hypotheses carry clear implications (if → then) for testing the stated relations.

These criteria mean that hypothetical statements contain two or more variables that are measurable or potentially measurable and that they specify how the variables are related. This means that a hypothesis is a statement which relies on assumptions, a tentative statement about the relations between two or more observed (or not directly observed, in particular in pedagogy and psychology) phenomena or variables. When constructing a hypothesis, we say: 'If this and that happens, it has this and that result'.

A good hypothesis must be formulated in a testable form! A hypothesis that cannot be tested, i.e. directly verified, has no immediate meaning for science. A question begs to be asked: When is a hypothesis not testable?

Ferjenčík\(^7\) specifies three main types of non-testable hypotheses:

1. A hypothesis that contains vague, unclear and multivocal concepts.
2. A hypothesis that is tautological (circular). This happens when a certain phenomenon or fact is explained using the same phenomenon or fact. For instance, gamblers like to play games because the game brings them enjoyment. But getting enjoyment from the game means the same thing as to like playing games, does it not? Such a hypothesis keeps 'spinning round and round again'.
3. A hypothesis that refers to forces or ideas which science does not know yet; for instance, it is impossible to test the hypothesis that humans are endowed with moral principles by some supernatural force, because we are unable to examine it and prove it empirically.

Hypotheses have some kind of special power: it is the most powerful tool that humans have invented to achieve reliable knowledge.

We observe certain phenomena and think about their possible causes. We live in a culture that offers hundreds of answers to and explanations for the majority of phenomena; many of these answers are correct and many are not, as they vary between a mixture of facts and myths to pure myths and mythology.

The scientist's aim is to systematically doubt, which is why the scientist provides explanations in the form of hypotheses. The hypothesis is also a

**prediction:** if Phenomenon A occurs, Phenomenon B occurs as well. This means that B is predicted on the basis of A’s existence. When we cause (through an experiment or various forms of observation) A to happen (or change as a result of our activity or treatment) and see that B happens as well, the hypothesis is upheld. But a hypothesis has absolutely the same power even if it is not upheld and is rejected! Negative results are no less important than positive ones because they tell us: this is not the right direction!

In each and every scientific activity, we work on two levels (or switch between them):

1. the theory-hypothesis-construct level
2. the observation level.

If we say that intelligence affects school results, we have set up a hypothesis from the terms ‘intelligence’ and 'school results' and connected them with the relational word 'affects'. But we need to test and verify this statement, gather data, and move from the level of constructs to the level of observation. That is, we must define the constructs to be able to observe them. And here is where another term comes in: ‘variables’.

### 2.1 Variables

A variable is a characteristic with a variety of values; it can be dependent or independent.

**An independent variable is the predicted cause of a dependent variable, i.e. of the predicted effect.** If we use our example, intelligence is an independent variable and school achievement is a dependent variable. Loosely speaking: we assume that the higher (lower) one’s intelligence is, the higher (lower) the level of one’s school achievement will be. However, this statement must be converted to symbols (numerical symbols in particular) which can be used statistically.

To be able to subject this hypothesis to statistical testing, we must use methods to convert the terms ‘intelligence’ and ‘school achievement’ into numerical data: by applying these methods that express intelligence in numerical values, we get a certain individual result with each tested person (e.g. 85, 87, 102 points), and, by giving the same school test to everyone (e.g. in mathematics), we establish that a person with 85 points has 60 points on the test; a person with
In the text above, we learned how to formulate (state) a substantive hypothesis (if A (intelligence), then B (school achievement)). However, this form cannot be tested as we have no means to do this. We need to ‘translate’ our substantive hypothesis into a statistical hypothesis, i.e. to use statistical terms: thus, we express the meaning of the original substantive hypothesis in quantitative, statistical terms. The statistical hypothesis expresses a hypothetical statement about the relations deduced from the relations in the substantive hypothesis, i.e. the mean of one variable will be significantly different from the mean of the other variable. This means that it is a prediction of how the statistics used in the analysis of the quantitative data of the research problem will be reflected.

If we want to test a statistical hypothesis, we always need to test it ‘against something’. An assumption as such cannot be tested. This means that we test the original substantive hypothesis assuming a relation between intelligence and school achievement (the higher one’s intelligence is, the better their school achievement and vice versa) against an alternative assumption, the so-called null hypothesis which says that there is no relation between the variables we are considering (here intelligence vs school achievement)! In our case, the null hypothesis states that there is no relation between intelligence and the level of school achievement.

The null hypothesis says: you are wrong; there is no relation; disprove me if you can. The formulation of the null hypothesis, usually denoted as $H_0$ (see below), is currently increasingly used, and more sophisticated statistical programs (e.g. SPSS, NCSS) will usually tell us in hypothesis testing whether they reject or do not reject the null hypothesis.

**Review Questions**

1. Explain the difference between a substantive hypothesis and a statistical hypothesis.
2. Give at least three examples of a correctly stated hypothesis.
3. Now apply null hypotheses to your examples.
4. When is a hypothesis non-testable?
5. Decide which variables are dependent and which are independent in the examples below:
   a. the style of parental education and a child’s self-valuation
   b. quality of life and social support
   c. intelligence and the highest completed level of education
   d. school achievement and number of rewards

Is it possible in any of these cases to switch the dependent and independent variables?

Literature


3 Basic Statistical Terms

Objectives

After studying this chapter:
- You will gain insight into the basic parameters of a set.
- You will be able to determine the measures of centre and variability of a given set.
- You will know when a hypothesis can be rejected.

Terms to Remember (Key Words)
- set
- element
- symbol
- set range
- mean
- median
- modus
- standard deviation
- statistical significance
Below we will try to explain the use of the Excel spreadsheet in the statistical testing of hypotheses using practical examples. Before we do that, we believe it is important to explain some of the common statistical terms we will be using. The list will not be exhaustive: to get an overall picture, the reader must study specialised, monographic statistical sources (see the list of reference sources at the end of this study text).

We will mention only the essential terms normally used to process the characteristics of certain sets, e.g. to process a research survey when preparing a bachelor’s or master’s thesis or to verify our marking method as teachers in relation to the learners' abilities or to evaluate this method in parallel classes in which we teach or in our profession’s chronological order.

### 3.1 Set

This is a group of people or their products considered in a hypothesis where we have made some kind of measurements and obtained quantitative data, for instance a class or a group of employees at a firm we have chosen. We will deliberately disregard other set characteristics such as homogeneity or representativeness where we again refer you to specialised sources.

A set is made up of **elements** (learners, employees, their products). All of the elements of a statistical set must have at least one investigated feature, called a **characteristic**. Characteristics can be **quantitative** or **qualitative**:

- Quantitative characteristics are obtained through measurement (e.g. height, test scores, product size, age, number of cigarettes smoked per day). We must decide in advance in what units and at what degree of accuracy the characteristics will be established.
- We express qualitative characteristics (e.g. sex, type of vehicle, nationality, marital status) through a variety of quantitative scales (e.g. marks at school, dichotomic identification: man 1, woman 2). A characteristic does not acquire different values but is either present or not, or an element is categorised into one of two (or more) groups or variants.

A set is therefore made up of elements with certain characteristics. The total number of elements (learners who have completed the test; number of
products we have measured, etc.) in a statistical set is called a **range** and is identified as **N**.

### 3.2 Basic Characteristics of a Set

We also use other methods to express the basic characteristics of a set by using numbers.

#### 3.2.1 Measures of Location

**Arithmetic mean** (denoted as MEAN\(^8\) in Excel; or M). This is the most well-known indicator of what can be considered the centre of the collected data. It is the sum of the values of the individual data divided by the number of these data. The arithmetic mean is at the geometric centre of distribution; it is a balance point, the centre of distribution. However, it has one weakness: it is sensitive to extreme values.

**Median.** Another representation of the centre of distribution, the median (Me; \( x \sim \); MEDIAN in Excel) does not have this weakness. The median can be characterised as a point dividing the data collected and putting it in order from the lowest to the highest level in two parts having the same quantity. Optimally, the median and the arithmetic mean should not differ much. If the quantitative data obtained are ‘disturbed’ by extreme values at one or the other end of the distribution, the median is an optimum solution (e.g. the marks of the entire class are not normally distributed according to the Gaussian curve of normal distribution; there are usually more As than Es).

**Modus** (Mod; MODE in Excel). The modus is defined as a variable value occurring with the largest frequency in a set of data. The modus is the value having the highest frequency in the investigated set and the highest frequency of repetition.

**Quantile.** If the data are ordered by size, then the P-percentile point (quantile) is the value that says that the \( p \)-percentage of data has a lower or the same value. The quantile is an umbrella term for:

- the median – 50% quantile;

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\(^8\) The abbreviations given in brackets can be found in Excel after clicking on \( fx \).
- the quartile – 25% quantile; 50% quantile (= median) and 75% quantile;
- the decile – deciles are quantiles in tens of percent;
- the percentile – percentiles express quantiles in units of percent.

### 3.2.2 Measures of Variability

We are often interested not only in the measure of the centre, but also to what extent the data around the centre are concentrated or dispersed. The standard deviation and variance are therefore established.

**Standard deviation.** This is the most reliable indicator of the measure of variability of the data in a given set (denoted as **SD**; STD DEV in Excel). It is the square root of the variance.

**Variance.** Variance (VAR in Excel) is denoted as $s^2$. It is the average quadratic deviation from the arithmetic mean. To calculate the variance, one needs to know the arithmetic mean of the set from which all values of the set are subtracted, and then the result is squared. The sum of these results is then divided by the value representing the number of elements in the set less one.

Example: Members of two groups scored the following values on a test:
- Group 1: 2, 4, 9, 15, 17, 20, 21, 40 – the arithmetic mean is ‘16’;
- Group 2: 12, 14, 16, 16, 16, 17, 17, 20 – the arithmetic mean is also ‘16’;

But:
- Group 1: The variance is ‘144’; the standard deviation is ‘12’;
- Group 2: The variance is ‘5.428571429’; the standard deviation is ‘2.32992949’;

### 3.3 Statistical Significance

Scientific literature usually contains the following formulation: ‘the result is statistically significant at the five- (ten-, one-) percent level of significance, or at 0.05; 0.01’. Often this is stated in an abbreviated manner (usually under the table with an overview of the results): $p < 0.05$; or $p < 0.01$. 
The level of 0.05 (0.01) means that the result obtained might occur a maximum of five times or once in 100 attempts due to chance alone. In other words, if the result we obtain – when compared to the tabulated critical values for the given range of a set – is above these values, we can say that it is not caused by chance. The tables of critical values are stable and can be found in the applicable statistical testing method tables (see selected examples in the appendices).

If the testing results in any values above the tabulated critical values, we can reject the null hypothesis.

Example: We want to compare the scores (times) achieved by a group of boys and girls running a distance of 100 metres. We set the null hypothesis that there is no difference between the times achieved by boys and girls. While adhering to the given set criteria, we calculate that the average time of 20 boys ($n_1$) is 14.5 s and the average time of 20 girls ($n_2$) is 16.2 s. It is immediately obvious that the results are different. Can this really be true? We cannot answer this question without the respective testing. But using the so-called t-test (see below), we get the result $t = 3.025$. We compare this value with the table where the critical value for the 5% level of significance is 2.025 for 38 degrees of freedom (in the t-Test, this is calculated as $n_1 + n_2 - 2 = 38$). Our result is above this critical value, i.e. we can say that the difference in the times achieved by the boys and girls in our set is statistically significantly different (i.e. boys are faster) at the 5% level of significance, and we will reject the null hypothesis. But were the t-value lower than the critical value, then we would have to uphold the null hypothesis despite the obvious difference between the mean times and say that there is no statistically significant difference between the times of boys and girls.

Review Questions

1. Why can the arithmetic mean be a misleading value?
2. What measure of location can express, for instance, an idea about the income level in the Czech Republic?
3. How would we use measures of location when characterising class performance?
4. Establish the mean, median and modus for the following set: 4, 8, 9, 4, 5, 1, 7, 5, 8, 4, 5, 8, 9, 6, 3, 6, 5, 5, 2, 3, 2, 4, 7, 4, 5.
5. What does the following statement (proposition) mean? ‘The result is significant at the 5% level of significance’. When can we say it is significant?
6. Classify the following characteristics as qualitative or quantitative: school marks, IQ, type of temperament, number of siblings, education, marital status.

Bibliography


4 Fundamentals of Hypothesis Testing

Objectives
After studying this chapter:
- You will know the procedure for testing a statistical hypothesis.
- You will be able to analyse the differences or relations within the data obtained.
- You will be able to decide whether to reject a hypothesis based on a comparison of various sets.

Terms to Remember (Key Words)
- hypothesis
- test criterion (test statistic)
- statistical error
- test power
- t-Test
- F-Test
- chi-square
- correlation
- covariance

The testing of statistical hypotheses is a form of statistical induction. Its theory is concerned with searching for procedures which make it possible to decide whether or not an investigated hypothesis is true with a pre-defined risk of
error. For instance, they enable us to establish whether the differences observed in a sample are only accidental (caused by the sample) or whether we really can expect differences in the entire population.

A test of a statistical hypothesis is used as a rule to objectively prescribe a decision on whether or not the tested hypothesis should be rejected on the basis of the results established from the random sample. When testing a statistical hypothesis, we distinguish the null hypothesis $H_0$ and the alternative hypothesis $H_1$. The test is expected to determine whether or not the null hypothesis should be rejected. The alternative hypothesis is the one we accept if the null hypothesis is rejected.

### 4.1 Statistical Hypotheses

A statistical hypothesis is a presumption about the distribution of probability of one or more random variables. This presumption can concern the parameters of the distribution of the random variable in a population or it can relate only to the law of distribution of the random variable.

As stated above, statistical tests are essentially based on two hypotheses: the null hypothesis and the alternative hypothesis. The null hypothesis is commonly denoted as $H_0$ and presumes that there is a null difference between the compared characteristics or that there is a null deviation from the presumed value of the given distribution parameter or that two compared populations have the same value of the surveyed parameter (i.e. that there is a null difference between the parameter values of the two populations). The null hypothesis can also contain a statement that there is no relation between two or more characteristics of the given population (i.e. there is a null relation). The null hypothesis usually expresses a statement which is the opposite of the one we want to prove.

Opposing the null hypothesis is the alternative hypothesis $H_1$, which can either be two-sided (stating ‘is not equal to’) or one-sided (stating either ‘it is larger’ or ‘it is smaller’). $H_1$ is the opposite of $H_0$ in a way.

### 4.2 Hypothesis Testing

Hypothesis testing is based on the calculation of a test criterion or statistic that is a random variable. The test statistic says that if $H_0$ is true, then
probability is normally distributed. The most frequently used test statistics have normal, Student’s, Fisher-Snedecor or chi-squared distributions.

The hypothesis $H_0$ is tested on the basis of the significance level observed and the respective calculated statistical value in the given theoretical model. **The null hypothesis is rejected if the significance level observed is smaller than or equal to the significance level we have chosen.** (Statistical programs are used to calculate the exact significance level.)

When deciding whether or not to reject the null hypothesis $H_0$, the following aspects must be considered:

1. Rejecting the hypothesis $H_0$ does not mean that the tested null hypothesis is not true. If the hypothesis $H_0$ is rejected, it only means that we do not believe in its validity (for which we have an objective reason based on the test result). Rejecting $H_0$ must thus be understood that when we continue our work after the test result, we will assume that $H_0$ is not true, i.e. that $H_1$ is true.
2. If we do not reject the hypothesis $H_0$, it does not mean that we have accepted it. It only means that the test result has not shown such a large inconsistency between the fact established and the hypothesis tested which would provide a sufficient reason to reject the hypothesis. This means that if $H_0$ is not rejected, it can be presumed in our further work that either $H_0$ or another hypothesis which, however, is not much different from $H_0$ is true.

### 4.3 Statistical Errors in Hypothesis Testing

Two types of errors are associated with hypothesis testing. They result from the possible occurrence of one of the following four situations:

1. $H_0$ is true and we do not reject $H_0$ – no error occurs.
2. $H_0$ is true and we reject $H_0$ – type I error occurs.
3. $H_0$ is not true and we do not reject $H_0$ – type II error occurs.
4. $H_0$ is not true and we reject $H_0$ – no error occurs.

The type I error occurs if we incorrectly reject $H_0$ or incorrectly accept $H_1$. For the probability of making the type I error, there is a requirement that it cannot exceed a pre-defined number close to zero. The value $\alpha$ equalling 0.05 or 0.01 is most commonly used. This number is called the **significance level**. Then we
say that a test has been performed at the $\alpha$ level or that $H_0$ has been or has not been rejected at the significance level $\alpha$. If we choose a significance level of 0.05 (or 5%), then in five cases out of 100 we reject the hypothesis $H_0$ in a statistical test as $H_0$ is true and should not be rejected. Therefore, there is a 95% probability that we have made the right decision.

The type II error occurs if we incorrectly fail to reject $H_0$, i.e. we incorrectly reject $H_1$. The probability of the type II error is usually denoted as $\beta$. The term power of the test that equals $1-\beta$ is connected with this type of error. The error is not usually known, but the error $\beta$ grows with a decreasing $\alpha$. This is why it is not appropriate to choose too low a significance level. For the same reason, if we do not reject $H_0$, we make an uncertain statement about it and say that we do not reject $H_0$ at the significance level $\alpha$. Ergo, we cannot say in this case that we accept (do not reject) the hypothesis $H_0$. This is because we do not know the probability of to what extent this statement is right. This probability can be inadmissibly low. A small range or high sample variability are frequent reasons for a failure to reject $H_0$.

### 4.4 Procedure for Testing a Statistical Hypothesis

1. Formulation of the null hypothesis $H_0$ and alternative hypothesis $H_1$ depending on the nature of the problem.
2. Selection of the significance level $\alpha$.
3. Selection of the test statistic, i.e. the function of random sample values with a known distribution of probabilities in case the null hypothesis is valid or invalid.
4. Determination of the critical region of the test statistic based on its probability distribution and significance level.
5. Obtaining of the random sample, calculation of the test statistic and its quantiles constituting the limits of the critical region.
6. Decision whether
   a) to reject the hypothesis $H_0$ and accept $H_1$ if the calculated value of the test characteristic falls within the critical region;
   b) not to reject the hypothesis $H_0$ if the calculated value of the test characteristic does not fall within the critical region.

### 4.5 Data Analysis

Further to the postulated hypotheses, we commonly research two data areas: differences and relations.
4.5.1 Differences Between Data (t-Test, F-Test)

The most frequent hypotheses regard whether there are any significant (not random) differences between the data obtained: for instance, differences between men and women, respondents having different places of residence (village, town, city), different level of education (primary, apprenticeship, secondary, higher education). These independent variables considered in our hypotheses are then subject to testing in relation to the hypothetically stated differences.

We normally use **Student’s t-Test** (Student is the name of the test’s creator!) to establish the difference between two variables (women, men), while the **F-Test** is used for multiple variables (place of residence, level of education obtained). We test whether there are any significant differences in the arithmetic means of the variables.

**Test of concordance of mean values (concordance test)**

Student’s t-Test makes it possible to test the hypothesis $H_0: \mu_x = \mu_y$ against the alternative $H_1: \mu_x \neq \mu_y$ if both sample assumptions are fulfilled:

**If $\sigma_x^2 = \sigma_y^2$, the test statistic is:**

$$T_1 = \frac{\left| \bar{x} - \bar{y} \right|}{\sqrt{(n_1-1)s_x^2 + (n_2-1)s_y^2}} \sqrt{\frac{n_1n_2(n_1+n_2-2)}{n_1+n_2}}$$

If the hypothesis $H_0$ is true, this test statistic has Student’s distribution with $\nu = n_1 + n_2 - 2$ degrees of freedom. If it is true that $T_1 > t_{1-\alpha/2(\nu)}$, the hypothesis $H_0$ with a concordance of middle values at the significance level $\alpha$ is rejected.

**If $\sigma_x^2 \neq \sigma_y^2$, the test statistic is**

$$T_2 = \frac{\left| \bar{x} - \bar{y} \right|}{\sqrt{\frac{s_x^2}{n_1} + \frac{s_y^2}{n_2}}}$$

Obor: Učitelství – společný základ dvouoborových studií
If the hypothesis $H_0$ is true, this test statistic has Student’s distribution with ‘equivalent’ degrees of freedom:

$$
V = \frac{s_x^2 + s_y^2}{\frac{n_1}{s_x^4} + \frac{n_2}{s_y^4}}
$$

$$
= \frac{s_x^4}{n_1(n_1 - 1)} + \frac{s_y^4}{n_2(n_2 - 1)}
$$

If it is true that $T_2 > t_{1,\alpha/2}(\nu)$, the hypothesis with a concordance of middle values at the significance level $\alpha$ is rejected.

4.5.2 Relations Between Data (Correlations)

We have so far attempted to introduce some procedures within bivariate statistics (which is concerned with the relation between two variables) centred on the valorisation of the significance of the differences between data sets. Methods focusing on the establishment of a measure of relation between two variables – the measure of their correlation – are another significant part of bivariate statistics.

We assume mutual dependence between two types of data, i.e. variables, which we have available within independent variables. For instance, we compare the age of the respondent to the data obtained through the research method (test score results, numerical data on the Likert scale for individual questionnaire statements, etc.).

Example: We are comparing the age of the respondents and the number of squats they can do within a given amount of time. This would be the null hypothesis: There is no relation between the age of the respondents and the number of squats they can do.

We investigate these types of relations through correlation analyses. In the broadest sense, correlation means the degree of association between two variables. This means that it is the relation between two variables whose values are arranged in pairs (age, number of squats). One usually says that two variables correlate if certain values of one variable (age) tend to occur together with certain values of the other variable (squats). The measure of this tendency can range from non-existent correlation, where there is no relation between the variables and they are independent phenomena, to absolute correlation.
To calculate correlation we use the **correlation coefficient** \( r \) (CORREL in Excel), which can range from 1.0 to -1.0. Positive correlation means direct proportion (the higher one’s age, the more squats one can do); negative correlation means indirect proportion (the higher one’s age, the fewer squats one can do). This is an expression of the relation between age and the number of squats.

**ATTENTION:** If we consider school marks as an independent variable, we must be careful: the ‘higher’ the marks are, the worse the student is doing!!!

The correlation coefficient is in fact a number expressing the ratio between **covariance** (the joint variation of both variables – if the values of one variable go up, the values of the other also go up, or vice versa) and the product of standard measures of variation of each variable separately (this is a product of the standard deviations of both variables). The correlation coefficient will have a value of zero where there is no joint variation of both variables, i.e. they behave independently of each other. The ideal correlation is 1. Correlation coefficient values can also be negative as a result of a variable’s variation in one direction. Then we speak about the **measure of indirect proportion**: the higher the value of one variable is, the lower the value of the other.

There are several types of correlation coefficients and their application depends on the character of the variables.\(^9\) One has to remember that the correlation coefficient does not necessarily provide information about causal relationships. If one variable highly correlates with another ‘on paper’, this does not mean that one of them necessarily needs to be a cause and the other a consequence; the type of data correlated is crucial for the interpretation of the coefficient (this means that we can get a statistically significant correlation between, for instance, the sun’s height during the day and men’s hair loss ‘on paper’, but this is quite a daring hypothesis and it is fairly difficult to interpret; for instance, it could serve to emphasise the quality of magic tonics against hair loss and specify the time of the day when they have the strongest effect).

So, we also even need to compare the correlation coefficients to the table of critical values. When entering data into a table processor, both data sets (here measured intelligence and school achievement) must have the same size and the individual numerical values per respondent must be entered in the same row.

\(^9\) Detailed characteristics can be found in specialised sources – see bibliography.
The correlation coefficient obtained must then be compared to the table of degrees of freedom: we need to find the degree of freedom of our set, i.e. the number of individual set elements, in the relevant table (here the number of respondents; for instance, if we want to establish with 100 respondents whether intelligence has an impact on school achievement, then the degree of freedom = 100), and we will find the critical value for the degree of freedom in the same row in the columns of statistical significance: if our calculation of the correlation coefficient is higher than the critical value, we can consider a relation to exist. If it is lower, this measure of feelings cannot be exceeded despite all of the researcher’s wishes and we must say that no relation has been found in this sample and by using this method.

Correlation can therefore be both positive and negative. If we stick to our well-known hypothesis about a relation between intelligence and school achievement and perform measurements in 100 learners, the correlation coefficient can be $r = 0.2155$. For 100 degrees of freedom (number of learners), the table shows a critical value of 0.195 with a 5% significance level. Our result exceeds it and we can therefore say that there is a direct relation between intelligence and the level of school achievement (or: the more intelligent a learner is, the better his/her school achievement is). For instance, if we correlate intelligence and the time necessary to master an assignment, we might get the correlation coefficient $r = -0.2155$. The negative sign does not mean a negative result but says that the more intelligent a learner is, the faster (in a shorter time, i.e. in fewer minutes) he/she will master an assignment. Or to be more accurate: learners with higher intelligence perform assignments statistically significantly faster than learners with lower intelligence.

The measure of relation is therefore expressed depending on the number of respondents. The lower the number of respondents, the higher the critical value of the coefficient and vice versa. We can virtually agree with Říčan: ‘Even a very low or virtually insignificant correlation can be conclusive if the number of persons is high.’

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4.5.3 Chi-square Test of Independence

If we observe only two statistical characteristics (variables), the best way to get an idea about their dependence is to arrange them in a two-dimensional table (a contingency table for qualitative variables and a correlation table for quantitative variables). This is a table where the legend contains the variants of one characteristic (variable), the table header contains the variants of the other characteristic (variable) and where individual panes contain entries of the frequency of combinations of both characteristics (variables). These frequencies are called observed (empirical) frequencies and are denoted as $n_{ij}$ (empirical frequencies in the 'i'-row and in the 'j'-column). The last row of the table contains the column totals and the last column contains the row totals. These total frequencies are then called marginal frequencies. The grand total is given in the lower right corner.

**Table 1 – Contingency Table Scheme**

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>+</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable 2</td>
<td>a</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td></td>
<td>a+c</td>
<td>b+d</td>
</tr>
</tbody>
</table>

**Table 2 – Correlation Table Scheme**

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>+</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable 2</td>
<td>$n_{11}$</td>
<td>$n_{12}$</td>
</tr>
<tr>
<td></td>
<td>$n_{21}$</td>
<td>$n_{22}$</td>
</tr>
<tr>
<td></td>
<td>$n_{11} + n_{21}$</td>
<td>$n_{12} + n_{22}$</td>
</tr>
</tbody>
</table>

The chi-square test of the independence of two characteristics (variables) is used to verify the dependence of statistical characteristics (variables) arranged in both the contingency and the correlation table. It is a nonparametric test,
which is why the normality of the distribution of statistical variables need not be investigated.

The null hypothesis $H_0$ states in the chi-square test that the characteristics (variables) observed are independent, while the alternative hypothesis $H_1$ is a hypothesis about their dependence. In order to assess and uphold or disprove the hypothesis $H_0$ about the independence of both characteristics (variables), the theoretical (expected) frequencies $e_{ij}$ must be determined (i.e. frequencies which would occur in the table with the same marginal frequencies in the case of independent characteristics).

Calculation of theoretical frequencies:

$$ e_{ij} = \frac{n_i n_j}{n} $$

The test criterion (test statistic) is based on the differences between the observed and theoretical frequencies $n_{ij} - e_{ij}$

$$ K = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{(n_{ij} - e_{ij})^2}{e_{ij}} $$

r.... number of rows

c.... number of columns

Number of degrees of freedom $\nu = (r-1)(c-1)$

The hypothesis $H_0$ on independence is then rejected at the significance level $\alpha$ if

$$ K \geq \chi^2_{1-\alpha, \nu} $$

Example: The reading and writing achievements of first class pupils are subject to assessment. A total of 60 pupils were tested and the results were entered into a table. Reading and writing are alternative characteristics. We investigate their mutual dependence, e.g. whether it is true that one who reads well also writes well.
Table 3 – Observed and Theoretical Data for the Chi-square Test

<table>
<thead>
<tr>
<th></th>
<th>reading</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>+</td>
<td>14 (12.4)</td>
<td>17 (18.6)</td>
</tr>
<tr>
<td>-</td>
<td>10 (11.6)</td>
<td>19 (17.4)</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>36</td>
</tr>
</tbody>
</table>

Theoretical frequencies are calculated in brackets:
Observed frequency 14 - theoretical frequency \((24\times31)/60\)
Observed frequency 17 - theoretical frequency \((36\times31)/60\)
Observed frequency 10 - theoretical frequency \((24\times29)/60\)
Observed frequency 19 - theoretical frequency \((36\times29)/60\)

The result of the chi-square test is given in the chapter Procedure for Statistical Hypothesis Testing in MS Excel.

Review Questions and Practical Tasks

1. In what cases do type I and type II errors occur?
2. What statistics would you use to establish whether children’s school achievement is affected by their parents’ highest level of education?
3. How would you verify a hypothesis about the impact of sex on school achievement?
4. Interpret the following result established in 25 university students and related to the relation between the time spent on social networks and the level of intelligence: \(r = -0.81\).
5. Interpret the following result related to a student’s weighted study average and the time spent on self-instruction: \(r = -0.62\). (Be careful!)
6. Search the statistical tables and find the critical value of t-distribution for 25 degrees of freedom at a 95% significance level. Interpret what it means if the result established from data analysis is above this value.
7. When establishing the difference between 15 male and 15 female students in respect of the average number of hours spent at seminars...
during one academic year, we get the result $t = 2.86$. Determine whether the null hypothesis will be rejected at a 5% significance level.

8. When establishing the influence of the highest level of education achieved (primary, secondary, university education) on the measure of one’s autonomy, we get the result $F = 3.15$ for 60 respondents at a 5% significance level ($\alpha = 0.05$). Determine whether this is a significant result and if it is, give your interpretation of it.  

Literature


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11 All the data in the examples are fictitious.
5 Procedure for Statistical Hypothesis Testing in MS Excel

Objectives
After studying this chapter:
- You will be able to code the data obtained in a research survey into a data matrix, a table.
- You will be able to install the statistical functions of MS Excel.
- You will know the procedure for hypothesis testing in MS Excel using statistical functions.

Terms to Remember (Key Words)
- statistical program
- data tabulation
- data coding
- respondent
- statistical function

No data analysis can be done today without using specific software that is able to perform frequency and descriptive analyses and measures of location and variability, as well as more sophisticated statistical testing. Such programs include NCSS or SPSS, which are, however, not widely available. But many functions are contained in the commonly used program MS Excel, which is also compatible with the above programs.

The procedure below shows how to establish, for example, whether the marks of pupils in a class in a given subject are materially different in the first term from the marks at the end of the school year. This means that we must determine whether or not there is a statistically significant difference.

5.1 Installation of Analytical Tools

In order to be able to do the following calculations, you must have the analytical tools (Analysis Toolpak) installed. (You need to install the analytical tools that are included in the Excel add-ins when you install MS Office.).
If the Analysis Toolpak is installed and accessible, the Data menu contains the component Data Analysis.

![Data Analysis](image)

**Figure 1 – Checking the Installation of Data Analysis Add-ins**

In the event that the Analysis Toolpak is installed and the Data Analysis component is not included in the Tools pull-down menu, you need to make it available. Choose Options → Add-ins. You will now have an overview of the active and inactive add-ins. Click Go in the lower part of the dialogue box.

![Add-ins Dialogue Box](image)

**Figure 2 – Dialogue Box for Selecting Add-ins**

Even if you have MS Office without the Analysis Toolpak, you can install it and make it accessible at any time after installation.
Another dialogue box appears where you need to tick the component **Analytical Tools** (Analysis Toolpak) and confirm it by clicking **OK**. The installation of the add-ins will begin. Wait until it has completed.

![Add-Ins](image)

**Figure 3 – Dialogue Box for Starting Installation of the Analysis Toolpak**

### 5.2 Data Tabulation

First, you need to create a table where you will enter the class marks in the first term and in the second term. For your convenience, it is useful to give the table and its columns headings as shown in the picture below.

![Table](image)

**Figure 4 – Table with Entered Data**
The data obtained must be converted into numerical form and tabulated. When you enter the data obtained into Excel, you must stick to the main principle of **one respondent per row!!!**

Normally we tabulate the independent variables considered in our project in the first Excel columns: here it is better not to specify any data (male, female, address, etc.), but rather to code them:

- sex: male = 1, female = 2;
- place of residence: village = 1, town = 2, city = 3;
- etc.

A mathematician would say that we are using metrical data.

After entering the independent-variable data, we continue row by row and enter the numerical data obtained using the research methods applied (tests, questionnaires).

When you are finished, we recommend that you do a thorough visual check of what you have entered to avoid any typing errors (e.g. 55 instead of 5) which could devalue our calculations.

**5.3 Establishing Equality or Difference of Variances (F-Test)**

We use the F-Test function to compare variances. Based on your result, you will see what type of test you must use.

First, click on any empty cell **under the list of marks** (you will write the result of the F-Test function into this cell). Functions are inserted by clicking on the \( f_x \) button.

![Figure 5 – Location of the \( f_x \) Button](image-url)
Doing so will bring up a dialogue box for selecting a specific function. Choose the **Statistical** component and you will be offered another list.

**Figure 6 – Dialogue Box Offering a Selection of Function Categories**

Choose **F.TEST** from the list. Confirm your choice by clicking **OK**.

**Figure 7 – Dialogue Box for Choosing a Statistical Function**
You will see a dialogue box for entering function parameters. Click on the button for **Array 1**.

![Function Arguments](image)

**Figure 8 – Location of the Button for Choosing Arguments for Array 1**

The **F-Test** dialogue box will disappear. Choose the area which contains the marks from the first term. Click to confirm your choice.

![F-Test](image)

**Figure 9 – Choosing Function Arguments**

The **F-Test** dialogue box will reappear.

Using the same method, choose the area with the marks from the second term for **Array 2**.

The **F-Test** result will appear in the dialogue box.
Click **OK**. The function result will be displayed in the cell you chose at the beginning.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td><strong>0.583184962</strong></td>
</tr>
</tbody>
</table>

**Figure 11 – Displaying of the F-Test Result in the Selected Worksheet Cell**

### 5.4 Establishing the Existence of a Statistically Significant Difference (t-Test)

First, using the table below, you need to determine what type of **t-Test** you must choose for data analysis.

<table>
<thead>
<tr>
<th><strong>F-test</strong> result</th>
<th>necessary <strong>t-test</strong> type</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-test ( \leq 0.5 )</td>
<td>with unequal variances</td>
</tr>
<tr>
<td>F-test ( = 0.5 )</td>
<td>with equal variances</td>
</tr>
</tbody>
</table>

Choose **Data → Data analysis**.
A dialogue box for selecting an analytical tool will appear. In the table, select \textbf{Two-Sample t-Test Assuming Equal Variances} or \textbf{Two-Sample t-Test Assuming Unequal Variances}.

A similar dialogue box will appear in both cases. As the input data for the first set, choose the area with the marks from the first term (in the same manner as for the F-Test) and do the same with the marks from the second term. Leave 0.05 in the Input \textbf{Alpha} field and check the \textbf{New Worksheet Ply} option in the \textbf{Output Options}. Click \textbf{OK}.
The t-Test results will appear on a new worksheet.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Mean</td>
<td>Variable 1</td>
<td>Variable 2</td>
</tr>
<tr>
<td>4</td>
<td>1.92</td>
<td>2.16</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.576667</td>
<td>0.723333</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>25</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>t Stat</td>
<td></td>
<td>-1.05247</td>
</tr>
<tr>
<td>11</td>
<td>P(T&lt;=t) one-tail</td>
<td></td>
<td>0.148927</td>
</tr>
<tr>
<td>12</td>
<td>t Critical one-tail</td>
<td></td>
<td>1.677224</td>
</tr>
<tr>
<td>13</td>
<td>P(T&lt;=t) two-tail</td>
<td></td>
<td>0.297854</td>
</tr>
<tr>
<td>14</td>
<td>t Critical two-tail</td>
<td></td>
<td>2.010635</td>
</tr>
</tbody>
</table>

**Figure 15 – New Worksheet with t-Test Results**

Compare the absolute values $t$ Stat and $t$ Critical (2) to uphold or reject the hypothesis.
Table 5 – Hypothesis Evaluation Based on a Comparison of Absolute and Critical Values

<table>
<thead>
<tr>
<th>t Stat</th>
<th>t Critical (2)</th>
<th>There is a statistically significant difference between the sets.</th>
<th>There is not a statistically significant difference between the sets.</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If there is a statistically significant difference between the two observed sets, then the marks in the first term are significantly different from those at the end of the school year. If there is no statistically significant difference between the two observed sets, the marks are comparable.

**Note:** This procedure can be used to compare the mean values of any sets which can be subject to statistical analysis (e.g. to compare the results of two classes in the same subject, to compare the climate in individual classes using questionnaires, to evaluate teachers using scaling questionnaires, etc.).

### 5.5 Chi-square Calculations

**Entering data**

First, we need to create two tables. The first will contain the observed frequencies and the other will contain theoretical frequencies.

![Figure 16 – Tables Containing Data for the Chi-square Test](image)
Function selection

Click on the $f_x$ button to bring up a dialogue box for selecting a specific function. Select **CHISQ.TEST**.

![Dialogue Box for Choosing the Chi-square Function](image1.png)

Figure 17 – Dialogue Box for Choosing the Chi-square Function

You will see a dialogue box for entering function parameters. Click on the button for the **actual-range** box and choose the range of observed reading and writing values. Likewise, select the range of expected values (highlight the range of theoretical values). The result will appear at the bottom of the CHITEST function. If you click **OK**, the result will appear in the selected cell.

![Data Range and Chi-square Test Result](image2.png)

Figure 18 – Data Range and Chi-square Test Result

Comparing function results to table values
We calculate the number of degrees of freedom according to the following relation: \( \nu = (r-1) (c-1) \). In our case, we have \((2-1) (2-1) = 1\). At the selected significance level \( \alpha = 0.05 \), we find the table value \( K = 3.841 \). The table value \( 3.841 \) is greater than the calculated value \( 0.399 \), i.e. the hypothesis \( H_0 \) about the independence of the observed characteristics (reading and writing) is true.

**Practical Tasks**

1. Install the statistical functions in MS Excel on your computer.
2. Create a table where you enter your marks for the first term of your first year of secondary school and calculate the arithmetic mean, modus and median.
3. Enter your marks for the first term of your last year of secondary school in the neighbouring column (only the same subjects must be compared) and do the same calculations as above (assignment 2). Choose a method to establish any statistically significant difference between the marks from both school reports. Calculate a result and try to interpret it.
4. Create a table with data from 25 respondents: sex of respondents (1 – boy, 2 – girl) and (fictitious) marks in the Czech language. Choose a method to establish any statistically significant differences in school achievement in the Czech language in the two sets of data.
5. Create a table including 25 respondents of any age and their IQ values. Determine whether there is any dependence between the two variables in your set.

**Bibliography**


6 Research Stages

Objectives
After studying this chapter:

- You will have an insight into the structure of and procedure for addressing a research problem.
- You will be able to design and plan your own research.
- You will know the problems that might occur during the individual stages of your research.

Terms to Remember (Key Words)

- research topic
- information research
- summary
- research sample
- pre-research
- administration
- interpretation
- final report

6.1 Inspiration, Topic Selection

As we said at the beginning of this text, humans are curious individuals that ask many questions and wonder about a variety of phenomena. Using one’s own initiative in the form of scientific research is one of the alternative ways of understanding these phenomena and answering these questions. Despite being human like everyone else, a scientist is distinguished by 'his childlike ability to wonder about things that other people find normal and boring [...]. Amazement, inquisitiveness and problem-sensitivity are crucial characteristics for scientific exploration. It is not only sensitivity to any questions but also flexibility, the ability to see reality from an unusual perspective. The birth of a specific subject (topic) of investigation is preceded by the classical stages of the creative process, in particular by scientific preparation (which can include lifelong expertise) and incubation, i.e. problem maturation, without one’s conscious and systematic involvement.

The definition of the very idea of the problem to be addressed emerges at the same time inspiration, an idea or a thought appears. The questions to be asked

by the researcher are primarily related to his/her own motivation to perform research, its benefits and options, and his/her own capabilities.

The researcher will naturally be concerned with an area about which he/she has certain knowledge. But to avoid investigating something that has already been explored by someone else, one has to know about the findings that have already been made in the given area. At the same time, research cannot be built without a foundation; it must be a continuation of previous theories and thoughts. This leads us to the very important second stage – establishment of the current state of cognition.

6.2 Establishing the Current State of Cognition

Information preparation helps concretise the subject matter and investigative objectives. It has at least two functions: it provides a theoretical basis for research and helps define and specify its direction. An exploration of the current state of knowledge makes it possible to define a research problem.

Good information preparation involves visiting the library/libraries. A catalogue or union catalogue provides an insight into the collection of books available in the library. A search of the scientific databases which provide access to periodicals with the latest information from all over the world is another, even more important step. This is a highly enriching stage both for the researcher, who will glean a great deal of information about the field of study, research methods and research structure, and for the project, which will thus be even more precise. Becoming familiar with other research leads one to avoid approaching the topic the same way someone else did (which would be a waste of time and also a possible pretext to being accused of borrowing someone else’s idea\(^\text{14}\)). Moreover, we can learn lessons from the errors and mistakes made in the previous research.

Depending on the purpose of the final report, this stage provides background information on its theoretical part, which constitutes the equal opposite of the empirical part in the case of qualification papers.

\(^{14}\) Doing the same or similar research as such is not a violation of scientific ethics. Moreover, science would not be science if its control mechanisms did not work. The value of research is also assessed by the possibility of its potential repetition, especially if the quantitative approach to investigation is applied. This approach, however, must be provided for by the researcher’s consent, by the information provided to the researcher, and specification of this fact in the final report.
Summarisation of the given topic, of the given key word, is an important information-research tool. It is not just a passive listing of sources but an active activity involving the evaluation and sorting of the established sources into relevant sources, possibly applicable sources and unnecessary sources. This is normally not the final categorisation as certain previously irrelevant sources can be used in the end depending on the amount of the studied material and the degree of penetration into the issue.

Depending on your experience, you can start with ‘simpler’ sources such as university textbooks, dictionaries and encyclopaedias. They provide a basic overview of the issue and help you familiarise yourself with it. It is then more appropriate to direct your attention towards more specialised sources such as foreign monographs, journal articles or contributions to anthologies both in printed and electronic form.\(^\text{15}\)

### 6.3 Setting a Research Approach and Research Strategy

During this stage, the researcher has a clear goal that he/she wants to achieve. He/she has discovered that there is a part of reality which has attracted him/her and which has not yet been sufficiently explored. The researcher must now choose an adequate research approach which will be as effective as possible in respect of the collection of data and the solution of the research problem. The most appropriate research strategy is then selected which is directly reflected in the methods to be used to collect the data. As Gavora\(^\text{16}\) points out, the researcher must avoid any adjustment of the research question to suit a preferred methodology, i.e. the researcher must set an optimal research approach once the research problem is determined.

#### 6.3.1 Research Approach

The author can choose between two alternative research approaches – qualitative or quantitative. If mixed, they provide an approach which combines selected elements of both approaches and uses such elements that provide for as complex and accurate a view of the selected issue as possible. Looking at

\(^{15}\) Electronic documents have many advantages, including fast access to sources, targeted searching (e.g. full text search), and up-to-datedness. Electronic periodicals are today one of the fastest ways of transmitting information from the scientist to the reader.

the development of psychological methodology, we are currently witnessing a rise in the qualitative approach. However, quantitative methods are developing as well, which sometimes provides an effective solution despite the higher requirements posed on the researcher.

**Quantitative approach**

This approach is based on working with numbers, i.e. the data subject to analysis are in numerical form. It is centred on the investigation of measurable variables, which can concern only a limited part of one’s selected reality in the case of psychological phenomena, i.e. it is usually impossible to explore an object in a comprehensive manner and within the given context. The quantitative approach builds on the manipulation of variables and prepares specific situations (in the case of an experiment) or topics (in the case of a questionnaire), which is slightly limiting for the natural aspect of the entire process. However, its benefits include the option of limiting the intervening variables, which can result in a pure relation between cause and effect. The quantitative approach is also suitable from the temporal perspective as the collection of data and their subsequent analysis; mostly using computers, do not usually take long.

The results obtained are free from the researcher’s subjective approach because the researcher keeps his/her distance from the respondents or does not meet them at all and is therefore free from any influences such as liking, appearance, etc. However, this distance also makes it more complicated to delve deeper and find details or any concealed context. But if the investigated persons are chosen properly, there is an advantage to making general conclusions about the population. Quantitative research is carried out in larger populations (the larger the better), which enables this operation to be in line with the theory of probability.

Quantitative methods include experiments and non-experimental research where the manipulation with variables is absent.

**Qualitative approach**

The primary difference between the qualitative approach to research and the quantitative approach is in the form of the established data. They are provided in non-numerical, i.e. verbal form, which offers greater accuracy and plasticity of expression. It is a lengthier and more complicated process to obtain and analyse such data; sometimes the process involves cyclical repetition. However, it results in the description of the observed phenomenon within the given context, in detail and complexity, and a brand new theory of the observed
A phenomenon can also be created on the basis of the research. The advantages of the qualitative approach include in-depth penetration under the surface where even hidden contexts can be discovered, as well as unforeseen determinants or motives. If any new dimensions of a phenomenon emerge, it is much easier to react to them with the qualitative approach and flexibly adjust one’s research.

The qualitative approach starts with the setting of the topic and research questions, continues with data collection and their analysis, and ends with interpretation and the drawing of conclusions, which can, as we have said, enrich theory with a new phenomenon.

A researcher that uses the qualitative approach is much closer to the investigated individuals with whom he/she is in direct or even everyday contact and in whose normal lives he/she can take part. The researcher does not focus on a large group, but rather on individuals or a small community. No situations are manipulated; the phenomena are recorded in their natural form.

Qualitative research also has certain negatives and drawbacks despite its unquestionable advantages, which include, according to Hendel\textsuperscript{17}, the limited validity of its results, a low level of generalisation, and great dependence on the researcher as such (from his/her expertise to his/her personality).

**Combined approach**

Despite being considered mutually incompatible in the past, representing opposites of one another, the qualitative-quantitative approach represents a scientifically desirable step towards the enrichment of scientific cognition (in spite of the protests of those who prefer the quantitative or qualitative approach). As we have stated, the combined approach is enjoying increasing popularity. This is because it provides a broader view of the selected research topic.

An example of the combined approach involves the planning of individual research stages so as to use both quantitative and qualitative methods. It includes an interview with the respondents on the basis of which a questionnaire is prepared; its results will subsequently provide a basis for the preparation of another interview aimed at clarifying the data established by the questionnaire.

The difficulty of applying the combined approach in research lies in having to be masters of both research approaches and their combination possibilities. Therefore, researchers having no or minimum experience (including university students) should choose only a one-sided approach.

### 6.3.2 Research Strategy in the Quantitative Approach

Setting one’s research strategy is an important aspect of research planning. There are at least three types of strategies:

1. **Observation study**
   
   With this research strategy, we observe individuals and measure variables but we do not interfere in the phenomenon observed. The data can be collected using questionnaires or tests.

2. **Sample survey**
   
   This involves a collection of relatively small amounts of data in standardised form from a relatively small group of individuals. A sample of a known population is selected. Questionnaires, tests or structured interviews are also most frequently used in this case.

3. **Experiment**
   
   In an experiment, we select a group of subjects where we apply a certain intervention (e.g. type of training); the dependent variable is normally measured before and after the experiment. A *comparative* experiment uses another procedure, commonly working with two groups: an experimental group (where intervention is applied) and a control group (where no intervention is applied).

   In all types of experiments, we need to be aware of the *hidden (intervening) variable* which can harm the experiment. We need to know this variable in advance and count on it: for instance, when we are to establish a pharmaceutical’s effect on blood pressure, the age of the subjects can work as an intervening variable.

   According to Hendl\(^\text{18}\), an experiment has the following procedure:
   
   1. research participants are ensured and assigned to categories;

2. manipulation of the exactly defined variables is started; the researcher centres his/her attention on these variables and measures any changes in them;
3. measurements are subsequently evaluated and hypotheses are tested.

### 6.4 Setting of Research Questions and Hypotheses

Research questions and hypotheses are sometimes confused. We have already said a lot about hypotheses. Now we have to concentrate on what a research question is.

A research question gives a specific form to the selected problem. It is formulated through an interrogative sentence which begs to be answered. The answer must be provided at the end of the research.

Skutíčone{
19} points to the necessity to be precise when articulating the research question. Some formulations can prove to be too courageous or improper because they in fact cannot be answered using the available information and the selected methods. This means that we must choose such formulations which are adequate to the importance of the research (they will always differ in the case of research carried out for a bachelor’s thesis and for a grant project investigated by a team of researchers). Questions must have the possibility of being answered, and not only with a ‘yes’ or a ‘no’; there must always be a more sophisticated verbal construction. Research questions should contain a relation between the variables, but never in the form of specific quantitative data. The main questions need to have a wider definition while particular questions can be more specific, depending on the level of the research question. The research question can be further developed into hypotheses; in this case, the research question is superordinate to the hypotheses.

### 6.5 Selection of Research Methods and Techniques

The researcher in the pedagogical and psychological disciplines can choose from a variety of available methods. In quantitative research, these include

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observation, experiment, interview, scaling, questionnaire and product analysis. Each method has its pros and cons and that is why its selection ought to be well considered in order to get as large an effect as expected, which is also aided by the researcher being well vested in the said method.

It can sometimes happen that the researcher assesses the application of only one method as insufficient and will then apply multiple methods. This solution gives a more comprehensive view of the issue and enhances objectivity.

A technique can be a specific form of the method chosen, i.e. in the case of the questionnaire, the technique may involve establishing the climate in a school class, a system to observe the communication style in a class, etc. If the technique is standardised, it contains an instruction for implementation, its methods of evaluation, or even comparison standards.

6.5.1 Observation

Observation is a controlled and intentional, purposive and systematic activity aimed at identifying relations and contexts within the chosen phenomena. It is carried out in the natural environment of the research subjects where the researcher focuses on pre-defined categories (in the case of quantitative research) and their occurrence is entered in a sheet or protocol prepared in advance. This type is called structured observation.

Observation types:
- individual and group observation;
- direct and indirect observation;
- short-term and long-term observation;
- structured and unstructured observation;
- participant and non-participant observation.

Each of these has its pros and cons which must be considered when choosing the specific technique. The positive aspects of observation usually include low costs and the possibility of obtaining information which is not available through the use of other methods (appearance, expression, etc.). Its disadvantages include the possible distortion of results as a result of the observer’s selectiveness, perception errors and subjective approach to the phenomena observed.
The research procedure starts with the definition of the problem, i.e. the phenomenon or object of observation, and with theoretical preparation. This is followed by actual observation where it is necessary to describe and record the phenomena observed. The data are subsequently analysed and interpreted.

6.5.2 Experiment

Experiment is a method partly related to observation but is much more secure as far as the input factors are concerned. The research subject is observed in his/her reactions to the changed conditions, or, to be more specific, the change of the dependent variable is observed in reaction to the changed independent variable.

Types of experiments:
- laboratory and natural experiment;
- true experiment and quasi-experiment.

Experiment’s advantages include the option of inducing situations which could not be captured in a natural way (in this amount), as well as relatively easy control of the input factors, the possibility of repeating the situation, etc. However, its disadvantages include high costs and certain artificiality in the subjects’ behaviour resulting from their awareness of being part of an experiment.

6.5.3 Interview

Interview is a method which makes it possible to acquire different information than that acquired above and to see a bit more under the surface. It is carried out through questioning where a personal approach and the option to observe non-verbal signals play an important role.

Types of interviews:
- individual and group interview;
- structured, half-structured and free (non-directed, unstructured) interview.

This method’s advantages include face-to-face interaction, the option to react promptly to developments, and a high probability of obtaining unexpected information. However, its disadvantages include time consumption and
complications when recording information (the writing down of notes interferes with the interview's seamlessness, which can be fairly easily resolved through recordings) and the high demands placed on the researcher (preparedness, foreknowledge, promptness).

An interview starts with making contact with the subject and creating an atmosphere of trust and security; it continues with actual questioning and ends with the respondent being reassured about adherence to the rules agreed (e.g. that the information obtained will be used solely for research purposes). The success of one’s research also depends on the conditions surrounding the interview, whether it is the environment or the type of questions.

6.5.4 Scaling

Scaling is a method which enables one to investigate the measure or intensity of phenomena which cannot be measured in a standard manner. A rating scale is the basic means applied in this method. This is a scale with a varied number of degrees where the respondent records his/her subjective attitude.

Types of scales:
- numerical – the degrees are expressed in numbers;
- graphical – the degrees are expressed in a graphic way (e.g. points on a line);
- verbal – the degrees are expressed verbally;
- Likert – this type of scale expresses the degree of agreement or disagreement with a statement;
- preferential (or ‘ordinal’ or ‘rank-order’ scale) – this type of scale asks the respondent to order items by preference;
- multidimensional – a verbal scale assessing multiple characteristics at the same time.

The advantages of scaling include easy and rapid data acquisition and subsequent analysis using statistical methods. Among its disadvantages is the major subjectivism of respondents.

6.5.5 Questionnaire

The questionnaire method is similar to the interview method, but it offers different options in terms of the depth of investigation and number of respondents. Well-prepared questionnaires are formulated in such a way that it is difficult for a respondent to identify what phenomenon the questionnaire is...
focused on. This method makes it possible to investigate both qualities and attitudes.

Types of questions:
- open, closed and semi-closed – depending on the option to give a free or ‘forced’ answer;
- dichotomous and polytomous – depending on the number of answers from which the respondent can choose.

The advantages of the questionnaire method include having a wide range of respondents along with easy administration and result quantification. The disadvantages include the possibility of intentional distortion by respondents, major subjectivity, and the impossibility of obtaining additional information.

The questionnaire has a header, information providing the purpose of its completion, and procedural instructions. It is followed by actual questions and at the end the respondent is thanked for his/her time.

**6.5.6 Verbal Product Analysis**

This method is typical for its content analysis of written materials providing the background information about the research object. Using the quantitative research approach, the frequency of occurrence of individual words is measured, as is their order, etc.

According to Gavora\(^\text{21}\), educational analysis must be centred on documents such as school legislation, educational programmes, textbooks, teachers’ lesson plans, and learners’ written papers or their assessment. The procedure starts with the setting of a set of texts, a semantic unit (word, topic, idea) and the investigated categories in order to perform quantification and subsequent interpretation of the data established.

This is a good method especially due to its enabling the acquisition of a specific type of information which does not burden the respondent and cannot be subjectively distorted. Its disadvantages include time consumption and complicated evaluation.

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6.6 Research Sample Definition

The majority of research is implemented on a research sample of individuals selected from a population. That is, the population is an aggregate of all members of a certain group or category (all citizens of the Czech Republic, all students of faculties of education, all pupils with dyslexia) while the research sample is reduced to a fraction of this population.

There are numerous methods for selecting a sample from the population:²²

- **Simple random sample** – based on the prerequisite that all members of a population have the same chance of being selected for the research sample. Lots are drawn for this purpose or tables of random numbers or random number software generators are used.

- **Group sample** – used in educational and psychological research fairly frequently as it distributes the population into similar groups. If this condition is satisfied, groups (such as school classes) can again be chosen by drawing lots or using another similar method.

- **Stratified sample** – typical for its internal segmentation which can be used to ensure a higher level of representativeness of the sample. The researcher determines categories from which subjects are selected on a random basis. A typical example is stratification by age categories.

- **Intentional sample** – aims at ensuring that a sample of research subjects which will have the adequate qualities for the investigated problem. This means that it is possible to determine the conditions to be satisfied by each respondent to become a member of the research sample.

The sample size depends on the population size. The smaller the population, the more members a sample should have.

6.7 Research Project

In this text, the chronological order of the creation of a research project is given for reference purposes only. This chapter about the research project has been included here to elaborate on the stages described above.

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The research project answers the following questions:

- What should be investigated?
- Why should it be investigated?
- How should it be investigated?
- Who should be investigated?

Although the primary function of the project is to submit it to the assessors to inform them about one’s intended research, it can be used for at least two other purposes. Therefore, it should be given due attention.

1. It helps clarify the complex context and details of the research; it encourages many questions to be asked which would have never emerged during cursory research planning; it prevents errors caused by insufficient contemplation or devaluation of the research work.

2. It becomes an outline and schedule of activities and makes orientation in one’s research activities easier; it is a timetable.

According to Gavora\textsuperscript{23}, a research project has the following structure:

1. cover page with the title of the research work, the name of the author(s), and the name of the institution to which the project will be submitted for assessment;
2. introduction – motivation for research, its reasoning, and a brief description of the subsequent chapters;
3. the current status of the problem solution – research and theories related to the chosen topic, as well as definitions of terms;
4. definition of the research problem, research questions and hypotheses – reasoning of the research problem and its contextualisation in a theoretical framework;
5. definition of the research sample – parameters under which research participants will be selected, description of groups or institutions taking part in the research;
6. research methods and tools – reasoning of the selection of methods, description of research tools, especially in cases where they are newly constructed;
7. organisational issues – schedule, method of generation or pre-research design;

8. research funding (not applicable to qualification papers) – cost-benefit analysis stating remuneration, travelling expenses, office supplies, etc.;
9. bibliography – an alphabetical list of sources on which the research will be built and which will become a theoretical basis for the research;
10. appendices – full wording of questionnaires, test assignments, informed consents, and other relevant documents.

Although the development of a research project may seem to be redundant and uninteresting, it is a creative activity in the truest sense of the word. If the plan is to be of high quality, it must mature; it must be cultivated, considered, thought over and consulted. It is not developed for disposable purposes, quite the contrary: the researcher often returns to it and uses it, including its schedule, as well as the specific formulations contained in it.

6.8 Pilot Survey and Pre-research

Before the researcher starts collecting data, it is appropriate to perform a pilot survey to become familiar with the research field. For a planned experiment, interview, or for questionnaire administration, the researcher should know the conditions of the location where the research will take place. If the research is to be carried out in school(s), it would be appropriate to know the local environment and people (students, teachers) in order to eliminate any moments of surprise or unpreparedness.

Pre-research concerns the chosen method and technique of data collection, verifying, for instance, whether the instructions are comprehensible, whether the questionnaire items are correctly articulated, whether the experiment conditions are set correctly and any penetration of an undesired variable is prevented or whether the order of questions in a structured interview is functional. Pre-research also aims at establishing the conditions for implementation, an appropriate procedure or definition of time, and last but not least, the options for data analysis and subsequent hypothesis verification. It is often typical for starting researchers to use tools (especially of their own construction) that are not in fact able to provide the relevant data with regard to the hypotheses defined.

Pre-research might also focus on establishing the validity and reliability of the research tool, which must be carried out even prior to the actual data

25 Validity is the evaluation of whether the research technique measured what is expected to be measured.
evaluation (in quantitative research) because it provides a larger sample and more objective measurements.

**6.9 Data Collection**

Data collection is the stage where the data collection methods and techniques are applied. As the researcher often has only a single change to acquire the desired data, the entire process must be well-considered and planned in advance.

Depending on the method chosen and the scope of research, it is good if the researcher is personally present during the data collection. For instance, it may happen during questionnaire administration that if the author copies templates and worksheets and distributes them to institutions, they are often not returned even though it was agreed in advance. Moreover, there can be a problem resulting from the misunderstanding of an instruction, failure to adhere to the same conditions, etc.

**6.10 Data Analysis**

Quantitative research provides a relatively high amount of data which must be analysed. Coding into data matrices is most frequently used for this purpose, which enables the subsequent application of statistical procedures. Table rows reflect individual respondents while columns provide the variables established. A variety of tables and charts are used, making a host of data more transparent.

We have already dealt with these procedures and so we can only summarise that data analysis involves their description from the viewpoint of the basic methodological parameters for reducing large amounts of data, e.g. factor analysis (grouping individual variables and creating new, general, aggregate variables).

**6.11 Data Interpretation**

Data interpretation is a process where the results established are compared with the results known from one’s own and other researchers’ previous work in relation to the set hypotheses and compared with the known theory. As

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26 Reliability expresses the measure of accuracy of the research tool, i.e. how sensitively it can measure the given variable, and its reliability. Reliability is also proved by repeated measurements.
Gavora\textsuperscript{27} points out, data interpretation is a highly creative activity resulting not only in a brief commentary on the numerical data, but primarily in their explanation and evaluation. Although many researchers consider the specification of their results to be the peak of their research, it is in fact the interpretation of these results that is of greater significance.

Interpretation is a process which involves investigating the context, highlighting important moments, clarifying causal relationships, and reasoning why the results are as submitted.

Compared to the previous mechanical activity (data collection, table entries, etc.), it is an activity where creativity is used. In order to be reflected in its full intensity, one has to adhere to certain conditions, including the time necessary for ideas to mature and the induction of an inspiring mood when one gets new ideas and sees new contexts and possibilities of result interpretation.

However, even during the interpretation ‘flight’, one needs to remain in contact with reality and make one’s interpretations as objective as possible. This is because certain explanations can be too broad, putting the results in a context with phenomena which are not the object of research and causing one to handle data in an impulsive and rash manner, which is sometimes caused by insufficient preparedness and a lack of experience.\textsuperscript{28}

It is also suitable to combine one’s interpretation of results with a discussion. Although this term normally connotes an exchange of information between communicating individuals, in the case of result interpretation, it is a critical view of the results and their analysis made by the researcher who takes the paradoxical position of unbiased and objective assessor of one’s own work. If this process is present, it is evidence of the professionalism and professional erudition of the researcher who is able and willing to point to research issues that still remain open and possible discrepancies, the possibility of a different interpretation, the possible existence of hidden variables, etc.

\textbf{6.12 Final Research Report}

The final report is the official outcome of all research activities, which is why it deserves major attention. It serves to publish the research results.

Execution of the final report depends on the following two basic parameters:


1. the purpose of the research report
2. the type of reader/listener

All final reports have a similar structure; there are only differences in their depth, details and style, the proportion between individual parts, etc. A report describing research carried out for the purpose of a qualification paper will be different from that written for experts, a professional commission which makes decisions on research funding, employers (sponsors) of the research survey, or the readers of a professional periodical.

Generally, there are several types of research reports, the most frequent being:

- an article in a periodical;
- a conference contribution (normally followed by a published version, i.e. a contribution to conference proceedings);
- a monograph;

Before starting a research report, one needs to become familiar with the terms and conditions required by individual institutions. If it is an article for a periodical or a monograph, these include author instructions, the requirements of the research-funding entity, or the internal regulations of a university where the paper is submitted in the case of qualification papers. These requirements are normally governed by national or international standards specifying the structure or formal requirements for documents such as the final report as well.29

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29 See CSN ISO 690 Informace a dokumentace – Pravidla pro bibliografické odkazy a citace informačních zdrojů (ISO 690: Information and documentation – Bibliographic references – content, form and structures); CSN ISO 7144 Dokumentace – Formální úprava disertací a podobných dokumentů (ISO 7144: Presentation of theses and similar documents); CSN ISO 214 Dokumentace – Abstrakty pro publikace a dokumentaci (ISO 214: Documentation – Abstracts for publications and documentation); CSN ISO 2145 Dokumentace – Číslování oddílů a pododdílů psaných dokumentů (ISO 2145: Documentation – Numbering of divisions and subdivisions in written documents), etc.
6.12.1 Research Report Structure

The general model of the research report contains the following parts: introduction, methodology used, results obtained, and final evaluation. A closer look at the structure identifies the following parts:

**Title**

The title of the report must be apt, yet brief. A subtitle can be used for any specification. The naming of the topic is an important moment which can have an impact on whether a potential reader will read the report or not.

**Abstract**

The abstract of the final report is a brief characterisation of the research, especially its objectives, methods applied, results and conclusions. This structure is typical of the informative abstract used especially in research reports. Research objectives provide a brief explanation of the research motives and intentions; the methodological part contains a short description of the methods and techniques applied or the method used to evaluate the data established. The statement of major results established by the research, i.e. relations and differences between data, correlations and other data, is the most important part of the abstract. In the case of qualitative research, the statement contains the phenomena observed. The last part of the abstract is devoted to the research conclusions, a discussion about the results, or the direction of another significant act.  

**Table of Contents**

The content of the document is included if the paper is a larger one. It comprises the titles of the chapters, sections and subsections, with references to the respective pages. A table of contents is not used in contributions to conference proceedings or articles in professional periodicals.

**Introduction**

The introduction forms a separate section in the case of larger reports. It provides information about the topic of research, its motivation and objectives, or even about the structure of the subsequent text. If the research report is larger, the introductory part also contains theoretical starting points (see below) which may also form a separate chapter.  

**Theoretical starting points**

This part provides a theoretical definition of the research problem; the issue is addressed at the level of the current status of cognition; it contains information about similar research and theories, i.e. relevant information in support of the significance of the research, embedding it in theory and giving it continuity and context. The quality of the theoretical introduction is a guideline for the reader to assess the author’s professional qualifications, which indirectly influences the reader’s attitude towards the quality of the research, e.g. its credibility.

Major attention must be paid to the selection of reference sources to be used by the author. Generally, primary sources should mostly be used, as should current sources and sources from abroad, depending on the topic. The use of appropriate sources (i.e. credible and scientific, not popular sources) is another requirement. Electronic sources, especially Internet encyclopaedias and various websites, are very risky in this respect as they are not subject to any scientific criticism, evaluation or review. On the other hand, scientific periodicals available on various databases and in e-book form are highly desirable.

**Methodology**

The next part is devoted to a description of the methods used to collect the relevant data. In addition to individual methods and tools, this part also provides a characterisation of the individuals or the group of research participants and defines the sampling of the respondents and the selection of the research sample. In quantitative research, this part also specifies the statistical procedures used to analyse the data.

The definition of the research objective is a crucial moment in this part (if it has not been defined previously), as are the definition of research questions, operationalisation, and the formulation of the hypotheses to be tested.

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31 The schedule of executing individual parts of the text is not binding, which is primarily related to the introduction that can be formulated during later stages of preparing the final report.
A specific description of how the research will be implemented is also desirable, as one can specify the schedule, the sequence of individual steps, the implementation of pilot research, and subsequent method (tool) optimisation. The provision of such detailed information obviously depends on the specific purpose of the final report and the given length, which is sometimes limited. It is not a problem for a bachelor’s or master's thesis to include this type of information.

**Statement of results and their interpretation**

The form of the result statement depends on the type of research. In quantitative research, the values established are submitted on a continuous basis and such values can be and sometimes must be supplemented with tables or charts. Individual data are interpreted, i.e. explained, compared with the known data or put in the given context. The hypotheses are continuously verified and the research questions are answered.

The data established must be provided in a well-arranged manner for the reader to make sense of them and not get lost in a chaotic jumble of numbers, tables and graphs. It is therefore good to adhere to the formal requirements, especially to typographical rules.

**Discussion**

Discussion is a specific part of the final report where the author polemicses on the established results, evaluates the appropriateness of the methods and particular tools used from a detached point of view, admits the limits of the research, states any hidden variables which could impact on the results, etc. This part may seem a bit paradoxical to a certain extent as the author doubts his/her own work, but it is quite the contrary. The ability to take a critical view and make an assessment of the information established reflects professionalism, a desire for objective scientific cognition, and avoidance of distorted and erroneous procedures.

Depending on the type of final report, discussion is part of the previous section and elements of it are intermixed with the statement of results and their interpretation.

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32 Beware of information redundancies if you use a table and a graph for the same data. If there is not an important reason to do this, choose only one of these supplementary methods.
Conclusion

The conclusion summarises all the material information from the research and supplements other options for directing research activities which could further enrich the topic. It states the benefits of the research and its possible application in practice.

References used

The conclusion is followed by an alphabetical listing of the printed, electronic and special reference sources used during the execution of the final report. The final list contains only such sources to which the actual text refers.

Appendices

Appendices include any material which would disrupt the main text, is too large, or is of lower significance. They contain verbatim transcripts of interviews, graphical documentation, large-sized tables and graphs, etc. The bibliography forms a specific appendix, including a list of sources of information providing those who are potentially interested with enriching and supplementary information about the given topic.

6.12.2 Formal aspect of the research report

The formal preparation of the final research report is governed primarily by the requirements of the sponsor, publisher, university, etc. These requirements are normally based on and correspond to the selected standards on the processing of information and documents.

Adherence to the ethical rules of scientific and research activities and acceptance of the copyright act is the most important formal requirement applicable to any type and purpose of the final report. If someone else’s idea, theory, opinion, etc. is used in the text, this fact must be clearly stated. Therefore, references to bibliographic citations are given in the text in order to facilitate the looking up of the source document. If this principle is not adhered to, we can speak about plagiarism, which can result both in personal and social sanctions.

The quoting of sources and bibliographic references is defined in the standard ‘CSN ISO 690 Informace a Dokumentace – Pravidla pro bibliografické odkazy a citace informačních zdrojů’ (ISO 690: Information and documentation –
Bibliographic references). This standard offers instructions on how to structure bibliographic references from a variety of sources and offers methods to be used to make reference to sources in the text.

Other formal requirements pertain to typographic rules and text arrangement. If these are adhered to, the reader feels comfortable with the text; the text is well-arranged and reader-friendly: a solid text without any diversification, lacking appropriate captions for inserted objects (illustrations, tables), without highlighted passages or with too many font changes, sections or changes in the font size (or ‘enriched’ by many spelling or stylistic mistakes) can spoil the impression of otherwise high-quality and well-performed research.

### Review Questions

1. Create your own simple research project about ‘The attitudes of university students towards the copyright act’.
2. In what cases is it appropriate to arrange pre-research?
3. What issues must be addressed during data collection from respondents?
4. What do you have to pay attention to when interpreting the results established in your research?
5. What is the structure required for the final research report?

### Literature


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34 It is important to note citations from electronic sources where copying the URL address is not sufficient (as it can change), but additional information must be specified in order to identify the source.

35 For the final report, it is appropriate to adhere to the Czech standard CSN 01 6910 ‘Úprava písemností zpracovaných textovými editory’.
Objectives

After studying this chapter:
- You will have an idea of what constitutes a concrete research project.
- You will be able to create an attitude scale.
- You will know the risks of attitude scales.

Terms to Remember (Key Words)

- scale
- method
- data analysis
- Likert scale
- hesitation item

The investigation of people’s attitudes towards various things is the most popular area of investigation into the human psyche. This chapter will show how to design such research. However, we will first make a short excursion to the theory of attitudes as provided by social psychology.
7.1 Theoretical Introduction

An attitude is most frequently defined as a "relatively enduring system of positive or negative evaluations, emotional feelings and pro and con action tendencies with respect to a social object."\(^{26}\)

Object of an attitude

This can be anything that exists for a person: items of the physical world, people, actions, social groups, political systems, social organisations, art, philosophy, the human being. An individual can also have attitudes towards objects existing in his/her mental world. (The fact that an object objectively exists does not necessarily mean that the human has an attitude towards it.) An attitude represents the tendency to evaluate an object or its symbol in a certain manner. (A mere judgment without evaluation is not an attitude!) Evaluation is the *attribution of qualities in the dimension of desirable vs. undesirable; good vs. bad.* Evaluation always contains cognitive and affective elements. An attitude always contains some evaluation.

Attitude = evaluated opinion.

Allport\(^{37}\) formulates four conditions of attitude formation:

- individual experience is combined with the object of an attitude and integrated in the form of a combined attitude;
- an initially diffuse attitude can become differentiated under the influence of experience;
- a stable attitude can be formed even suddenly as a result of single traumatic experience;
- the imitation of attitudes expressed in the behaviour of friends, parents, etc. (other declared – author’s note) can be a source to mediate an individual’s ready attitudes.

Attitudes are normally described as being comprised of three dimensions (components), each of which contributes to the whole:

  **a) cognitive:** related to the opinions, information and thoughts a person has about the object of an attitude;

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b) **affective** (emotional): related to the way a person makes emotional evaluations, to what he/she feels towards the object of an attitude; we make positive and negative emotional evaluations:

- **positive:** we tend to be concerned with the object of an attitude, get closer to it and be in contact with it;
- **negative:** a tendency to avoid, postpone, cause harm, punish, destroy.

c) **behavioural** (conative): related to the tendencies towards behaviour or conduct in respect of the object of an attitude. It corresponds to the term ‘attitude orientation’ characterising an action tendency provoked by the object of an attitude. If we know cognitive information about an individual, we can make an attempt to predict his/her behaviour. Then we can assume that he/she will behave in a certain manner as compared to an individual without such cognitive data. A human with a certain attitude not only tends to view things in a certain way and reacts accordingly, but also prefers specific goals.

**Creation of attitudes**
Attitudes are created through the **satisfaction of needs**. **Positive attitudes** are created towards persons or things which satisfy one’s needs (a positive attitude towards the doctor healing me, to the partner giving me feelings of security and love). **Negative attitudes** are created towards objects inhibiting the satisfaction of one’s needs.

### 7.2 Method

**Attitude measurements**
Attitude measurement is a popular research technique giving the researcher fairly free hands and the possibility to creatively focus on the to-be-investigated area. Generally speaking, attitudes are measured by using **attitude scales** setting the intensity of the positive or negative affects towards the object of an attitude. In general, scales comprise a certain number of statements (propositions) with which the subject agrees or disagrees to a certainly strong extent. In the aggregate, scale items are related to the object of an attitude, e.g. a person, social situation, social group, human activities, etc. Scale items are characterised by individual statements about the object and are formulated in short and simple sentences. This is, however, the biggest trouble when constructing an attitude questionnaire. Answers are summarised and as a
whole, they display individual attitudes of the respondents which may be fairly different.

When measuring an attitude, it is not enough to know whether the subject agrees or not with the object of an attitude, but to what extent he/she does so; two individuals can have a differently strong positive or negative relation to the object. This is why such scales are developed providing an individual with personal space to express individual degree of agreement or disagreement as a demonstration of their personal position.

7.2.1 Principles for creating attitude scale

If we decide to investigate attitudes of people, we need to search what we are interested in and choose a correct statement arousing a need to make an emotional commentary on it.

The individual attitude items that we set should result from our study of the attitude object (e.g. if we examine an attitude to the representatives of another race, we need to search how it is 'seen' by people, how they speak about it, what values they ascribe to them and what stereotypes we need to consider). Item formulation need not explicitly indicate what type of an attitude is measured; one can use hidden questions which seemingly have no relation to the attitude measured. We can also use a ‘projecting’ technique where the statement starts with the following words: ‘Some people believe …’ where we remove the need to think over from the respondent even though he/she actually does so.

To avoid ambiguity of statements, it is recommended that terms such as ‘everybody’, ‘always’, ‘no’, or ‘never’ should not be used. The statements should also be directed to the present, not to the personal past (as attitudes can change with age).

We must choose items of which we presume that they will be discriminating in various places of the dimension measured. Not all respondents will just strongly disagree or strongly agree.

These efforts finally result in an attitude questionnaire where the scale values are attached to individual items or where the respondent checks items where he/she agrees or disagrees according to the instructions.

Social psychology developed a wide variety of scales that are now used as a standard. We will focus on one of the mostly used scales designed by Rensis Likert in the 1930s. It is called the Likert scale. It is in fact a bipolar scale but only in extreme values; otherwise, it provides an opportunity to gently differentiate an individual’s attitudes. The scale has normally five points (but it can have even seven points).
Example: We investigated the attitudes of people towards citizens’ behaviour in our country. We also provide one of the factors illustrating the tolerance of other people as a civil virtue.

**Tolerance of foreign people and cultures**

*He/she is a good neighbour in the place of residence.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

*He/she recognises that other people can be different.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

*He/she rejects corruption and bribing.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

*He/she has conscious respect to others.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

*He/she recognises the opinion of another if it is different.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

*He/she acknowledges other nations.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

*He/she defends the right of another to be what he/she is.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

*He/she respects the rights of minorities.*

I strongly agree    I slightly agree    Sometimes yes, sometimes no    I rather disagree
I strongly disagree

The respondent checks the phrase in the scale which corresponds to his/her attitude as much as possible. For the purpose of statistical analysis, we normally assign a numerical value to each scale word and this value is then used in tables. Here:

- I strongly agree = 5
- I slightly agree = 4
- Sometimes yes, sometimes no = 3
- I rather disagree = 2
- I strongly disagree = 1
We commonly avoid zero which can cause significant complications during data processing by the computer program.

If we emphasise it in the instructions, we can use a different presentation of the scale, e.g.

Statement ...........

I strongly disagree 1 2 3 4 5 I strongly agree

Such entries are better to guide us in the tabulation of the individual research data obtained.

**False Likert scale**

If we are asking about attitudes to objects of which we anticipate that the respondents do not know much about (Kuwait’s foreign policy, molecular gastronomy, etc.) and still, we want to learn something about attitudes to these objects, we normally omit the middle (mean, hesitating, etc.) item (*sometimes yes, sometimes no* in our case). This will force the respondent to make a choice and not to ‘hide behind the average’.

### 7.3 Data Analysis

The data obtained from each respondent are then entered into a table and we work with these data in the usual way as indicated above where we, for instance, are looking for the measure of relation between the statement and age of the respondent (correlation) or the measure of difference, e.g. by sex (F-Test). If we have a sufficiently reliable questionnaire, we can use factor analysis to put together individual ‘clusters’ of statements which will altogether create one factor. We will not discuss this further as factor analysis is a fairly sophisticated process going beyond the centre of this publication’s focus.

### Review Questions

1. Explain what the ‘Likert scale’ means.
2. Create your own attitude scale focused on the difficulty of university studies.
3. Think up a system for coding information obtained from the respondents.
4. What do we have to look out for when creating an attitude scale?
5. What are the other methods which can be used to design a questionnaire?

**Literature**


Citations


### Appendices

#### Appendix A

**Critical Values of T-distribution**

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## Critical Values of Chi-square Distribution

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### Appendix C

**Critical Values of F-distribution (α = 0.05)**

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### Appendix D

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**Appendix E**

*Spearman’s Correlation Coefficient*

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