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Gregory T. Papanikos, President, ATINER.

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- Submission of Paper: **23 May 2022**

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- Athens Sightseeing: Old and New-An Educational Urban Walk
- Social Dinner
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- Submission of Paper: **23 May 2022**

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Didactic Connection between Spreadsheet and Teaching Programming

By Gábor Törley[*], László Zsakó[±] & Péter Bernát[°]

When we talk about problem-solving skills, then, generally, programming comes to our minds as an activity that can develop algorithmic thinking and abstraction. Regarding the spreadsheet, the software application area could be our first, and mathematics could be our second thought. When spreadsheets and programming are mentioned together, programming of macros is in focus, which is in fact programming. In this paper, we want to focus on how these two areas impact each other, and we want to emphasize that the spreadsheet is an efficient tool to develop algorithmic thinking. Moreover, there is more "crosstalk" between these two tools. This paper will show through examples that there is a two-way connection between spreadsheet and programming; that is why it can be useful to build the concepts of these two topics mutually on each other.

Keywords: *spreadsheet, programming, problem solving, algorithmic thinking, teaching methodologies*

Introduction

Usually, spreadsheet teaching is not classified as a problem-solving tool. For example, according to the Curriculum Framework of the National Core Curriculum (NAT) 2012, the topic "Problem-solving with Information Technology (IT) tools" deals with only programming and algorithms (NAT 2012). Spreadsheets are part of the topic "Using application systems", and the goal of spreadsheets is retrieving information.

The new Curriculum Framework 2020 (NAT 2020) adopts a different and more suitable approach according to which spreadsheets are a new topic in the field of "Developing problem-solving skills". With this change of approach, teaching methods developed earlier by the Faculty of Informatics of Eötvös Loránd University, are followed (Zsakó 2015a, 2015b). In our work, we will show that the new Curriculum Framework has the right approach.

In our paper we will go through the key concepts of programming and we will demonstrate how these concepts can be taught by spreadsheet. We will focus, in particular, on how to present and teach programming theorems in spreadsheets. For this reason, we will define the concept of programming theorems after the literature review.

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Literature Review

The spreadsheet teaching field includes basic programming concepts (Tort 2010), like data types, operations, variables, and functions. Tort also suggests adding procedures, scopes of variables, data tables, sorting, etc. because a spreadsheet can be considered as a program and building a spreadsheet is partly programming. If we use a model of a spreadsheet explicitly, then we can help learners in the process of abstraction, which is a very important part of programming.

According to Szalayné Tahy (2016), a table spreadsheet can be considered as a program with data and pre-defined algorithms. Although students can see a table/spreadsheet on their screens, they need to understand the "program", which consists of their solutions implemented by functions.

Csernoch and Bíró (2015) claim that spreadsheet software can be used as a problem-solving tool. Their method, called Sprego, "is a deep approach metacognitive problem-solving environment, which has borrowed and combined proven methods from high level programming languages. The three milestones of Sprego are

- using as few and as simple general-purpose functions as possible,
- building multilevel formulas,
- building array formulas." (Csernoch and Bíró 2015 p. 27)

This method can develop students' computational thinking and algorithmic skills. Teaching spreadsheet has an important role in Information and Communications Technology (ICT) education because students learn several aspects of computer science and develop skills connected to this field, for example, handling data structures, database management, programming principles, logical and computational thinking, and algorithmic skills. Sprego also promotes schema construction through authentic problem-solving and algorithm construction (Csapó et al. 2020).

Many fundamental programming concepts have their equivalents in spreadsheet. Kankuzi et al. (2017) propose that before an introductory programming course, students should learn spreadsheet programming, where the fundaments of programming are indirectly introduced to them through problem solving by using spreadsheet.

According to Warren (2004), if we use spreadsheet before teaching a programming language, then it takes less time to get to more complicated algorithms.

Programming Theorems/Patterns of Algorithms

Programming tasks can be categorized into groups according to their types, which is useful because for each group we can create an algorithm rule/schema that solves all the tasks in that specific group. These task types are called *programming theorems* because their solutions are justifiably the correct solutions.

Essentially, programming theorems/patterns of algorithms are abstract specifications and algorithms that we want to use as schemas in order to solve a programming task. The aim of *specification* is to give the task in a formalized way (it can be an "interface" between the programmer and the customer). Specification has four components: input, output, precondition and postcondition. *Input* is the input data of the task; *precondition* gives information on the input (i.e., which statements should be fulfilled by the input data); *output* is the result of the task; and *postcondition* is statements used to get the result (how we reach the result-state from the first input-state) (Harangozó et al. 1998).

We can recognize the suitable programming theorem from the task description. Once we have done this, we can use the specific data of the general task type, and in the general algorithm substitute them with the task-specific data. Applying this method will lead us to the correct solution.

In these tasks we usually have to assign a certain result to one (or more) data collection(s), which, for simplicity's sake, we will handle as some sort of sequences. In simple cases sequences can be illustrated as arrays (Szlávi et al. 2019).

Programming theorems/patterns of algorithms are proven templates as a basis on which we can build our solutions later. (This way development will be quicker and safer.) We note here that our term "Patterns of algorithms" differs from the usual definition (LMU n.d.). According to our wording, pattern refers to a task-schema and not to a problem-solving strategy.

We can categorize programming theorems in three groups. We would like to summarize the essence of these algorithms (Szlávi et al. 2019).

Basic Programming Theorems

- **Sequential computing (sequence calculations):** We have an input sequence, and we have to calculate a single value from that. We will use the same operation on every element of the sequence.
- **Counting:** We have an input sequence, and we have to count how many of them have a given attribute.
- **Decision:** Let us determine if there is an item with a given attribute among the elements of an input sequence.
- **Selection (linear selection):** We have an input sequence, and we have to select an element which has a given attribute, assuming that at least one such element exists in the input sequence.
- **Search (linear search):** We have an input sequence, and we have to search for an element that has a given attribute, and we do not know whether such an element exists in the sequence. (Search is the construction of *decision* and *selection*.) Dijkstra calls this algorithm "Linear search theorem" (Dijkstra 1976, p. 105).
- **Maximum selection:** We have to pick/find the greatest (or smallest) value from the input sequence.

Complex Programming Theorems

- **Copy (calculation with a function):** We have an input sequence with N elements, and we have to assign N other elements to these. The type of assigned values can differ from the type of original values, but the count (N) remains the same, as well as the order. In other words, we will use the same operation on each of the elements of the sequence, but the output will be a sequence.
- **Multiple item selection:** We have to list all elements from the input sequence which have a common attribute A.
- **Partitioning:** We have to list all elements from an input sequence which have a common attribute A, and then also list those ones not having attribute A. So, we "assign" all the elements of the input to one of the output sequences. (Of course, there can be more than two attributes.)
- **Intersection:** We have two sets as input (with elements of the same type), and we have to list all elements that are part of both sets. (This is the construction of *multiple item selection* and *decision*.)
- **Union:** We have two sets as input (with elements of the same type), and we have to list all elements that are included at least in one of the sets. (This is the construction of *copy, multiple item selection* and *decision*.)

Constructed Programming Theorems

- **Conditional copy:** We will calculate the same operation on each element of the sequence which have the given attribute and another operation on each element which does not have the given attribute. (This is the construction of *multiple item selection* and *copy*.)
- **Conditional summation:** Sum of elements with a certain attribute. (This is the construction of *multiple item selection* and *summation*.)
- **Conditional maximum search:** find the maximum of the elements that have a certain attribute. (This is the construction of *decision* and *maximum selection*.)
- There are at least K elements with the given attribute (This is the construction of *search* and *counting*.)

Basic Programming Concepts in Spreadsheet

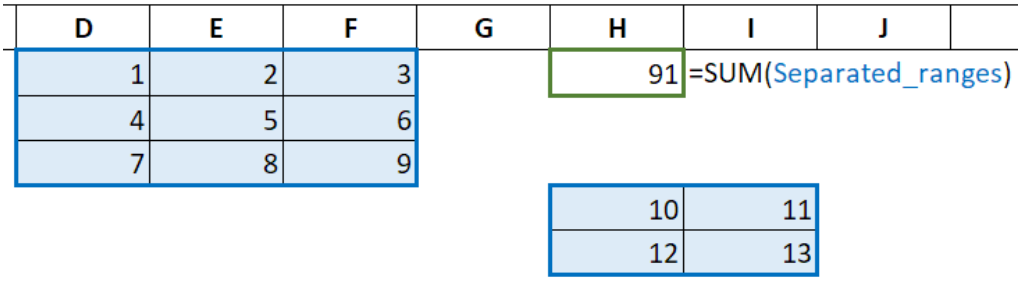
Variable and Data Type

Cells, one of the most important basic concepts of spreadsheets, are comparable with variables, one of the most important basic concepts of programming. Like variables, cells are named containers (they have a default name, but can also be renamed) in which data can be written and from which the same data can be retrieved. If the user enters the data, it corresponds to reading a value from the user into a variable. If a formula enters the data, it corresponds to storing the result of a

calculation in a variable. However, unlike variables, cell content is constantly visible, so no instruction for displaying output is required. It is important to note that in spreadsheet it is not the cell that has a type, but the value stored in it, as even values from different types can be written in the same cell. However, data validation can be set to a cell to limit the type of data that can be entered in it, which is like declaring the type of a variable.

An example of the specialty of spreadsheet's variable concept is that we can assign a name to separated ranges as well and we can use it as a parameter (see Figure 1); we cannot do this in programming.

Figure 1. *Separated Ranges as a Single Variable and as a Parameter in Spreadsheet*



The first column of Table 1 contains the "data types" of spreadsheet, while the second one shows the construction of these types in programming from primitive data types. "Data types" are enclosed in quotation marks in the first case because the spreadsheet does not implement them as true data types. We add that professional programming languages often include the appropriate composite data types so that the programmer does not have to construct them.

Table 1. *"Data Types" in Spreadsheet and Their Construction in Programming*

"Data Type" in Spreadsheet	**Construction in Programming**
Number	integer, real
Currency	integer, real + output formatting
Accounting	integer, real + output formatting
Date	integer, real + output formatting or record type (struct)
Time	integer, real + output formatting or record type (struct)
Percentage	integer, real + output formatting
Fraction	record type (struct) + output formatting
Scientific	integer, real + output formatting
Text	string
Logical	Boolean

Behind the scenes, in fact, spreadsheet deals with 4 data types: logical, number, text and error (error data type is not the subject of our paper). All the "data types" of spreadsheet are real numbers except text and logical. This means

that all numeric "data types" of spreadsheet are representations; more precisely, they are output formatting (see Table 2).

Table 2. *Representations of Spreadsheet's Number Type*

"Data Type"	**Displayed in Cell**	**Stored Number**
Number	123456.00	123456
Currency	$123 456.00	123456
Accounting	$123 456.00	123456
Date	01.03.2238	123456
Time	12:00:00	123456.5
Date and Time	01.03.2238 12:00 PM	123456.5
Percentage	75.00%	0.75
Fraction	2/3	0.66666667
Scientific	1.23E+05	123456

There is a great similarity between the spreadsheet's cell format and programming languages' formatted output (i.e., decimal places, format numbers in thousands, etc.).

Function and Data Type

Understanding spreadsheets requires a function-like way of thinking (introduction to functional programming). Using parametrizing functions and nested functions in spreadsheet can support the understanding of parametrizing and parameter passing in conventional programming languages.

In order to form the correct type-concept, spreadsheet has an important role because there are specific functions that can be interpreted only on specific types. For example, SUM and AVERAGE functions can be interpreted only on numeric data, and each arguments of the logical functions, such as AND or OR, must be logical values. Students can understand that the type is not only a set but the applicable operations as well. There is a great difference between digits as string and numbers (difference between "23" and 23). Constant data show this difference as well.

Array and Matrix

Although spreadsheet has a special variable concept (Szlávi et al. 2018), a deeper understanding of functions can support students' understanding of the difference between scalar and sequence and what it means to travers a sequence. In spreadsheet, a sequence can be stored in an array or in a matrix. The best tool for comprehending the concept of indexing can be the INDEX function that executes the indexing operation on a selected range.

A single cell is not suitable for storing complex types, such as a record, but using several adjacent cells can be a solution.

Record

If we view a table in spreadsheet as a table in a database, then its rows can be considered records, the fields of which are defined by the columns. That is, the table can be considered an array of records, or even an array of objects, which can lead to the concept of object-oriented programming.

Conditional and Loop

The IF function can help to understand the conditional control structure as well as the logical (Boolean) type and operations (AND, OR functions).

Loop, as a language element, is not part of spreadsheets, but its concept can be discovered on different levels. For example, if we perform the same operation on all elements of a column in an adjacent column using a copied formula (for example, calculating prices increased by some percentage), we are processing the elements of the column just as a loop traverses an array. In addition, elements of columns (or ranges) can be traversed using array formulas.

Deeper comprehension of lookup functions can lead to the concept of conditional loops because if we look for something, then we can pose a question whether we need to examine all of the elements of the sequence in order to give a definite answer.

Programming Theorems in Spreadsheet

Programming theorems can be demonstrated in three different levels in spreadsheet:

1. with the appropriate built-in functions, students can become familiar with the concept of programming theorems;
2. using spreadsheet as an algorithm visualization tool, students can understand how programming theorems work;
3. most programming theorems can be implemented using array formulas based on the postconditions of their specifications.

In the following, we would like to present these three levels.

Understanding Programming Theorems Using Built-in Functions

Problems to solve with spreadsheet and with programming are often similar, so it is no surprise that the spreadsheet has the functions that implement most of the programming theorems. Table 3 summarizes the connections between spreadsheets and patterns of algorithms.

Table 3. *Connection between Spreadsheet and Patterns of Algorithms*

Patterns of Algorithms	**Built-in Functions in Spreadsheet**
sequential computing (conditional as well)	SUM, SUMIF, SUMIFS, AVERAGE, AVERAGEIF, AVERAGEIFS, DSUM, DAVERAGE, CONCAT
counting	COUNTIF, COUNTIFS, DCOUNT, DCOUNTA
decision	IF(COUNTIF), IF(COUNTIFS)
selection	VLOOKUP, HLOOKUP, XLOOKUP, INDEX(MATCH), DGET
search	*decision + selection*
maximum selection	MAX, MIN
copy (map)	there is not any special function, it can be implemented by copying the reference/formula (Figure 6.) or by creating an array formula
multiple item selection	filter and advanced filter
conditional maximum	MAXIFS, MINIFS, DMAX
K^{th} maximum	LARGE, SMALL
Sort	SORT (sorting criteria exists but we do not know anything about the method)

It should be noted that the *selection* programming theorem can only be implemented in spreadsheet with crucial limitations. In the case of this programming theorem, the attribute to be examined can be any logical condition. On the contrary, lookup functions (except DGET) can only find an item equal to a specified value in an arbitrary (unordered) range. Although the DGET function can search using any logical condition, it only provides a solution if exactly one element meets the condition.

We would like to highlight *decision, selection* and *search* algorithms, showing how they can be implemented in spreadsheet. It can be presented that VLOOKUP and MATCH functions implement only the *selection* algorithm because they do not give any meaningful answer if the element which we looked for does not exist. *Decision* algorithm should be rephrased: Does the specific element or the element with the specific attribute exist? This way of thinking is connected to the postcondition of *decision* algorithm. As we deduct *linear search* algorithm from the construction of *decision* and *selection* algorithms, we will use the same construction in spreadsheet. For example:

IF(COUNTIF()>0;VLOOKUP();“None”)

Algorithm Visualization of Programming Theorems

As mentioned above, spreadsheet has the functions with which most of the programming theorems can be implemented. However, these functions hide the actual calculations from the user. Spreadsheet can also support understanding an algorithm step by step and in this way it can support understanding how an algorithm, such as a programming theorem, works. In other words, spreadsheet can visualize the input, the output and the state of the output variable at each step of the algorithm. This means that spreadsheet can show us the whole state space (i.e., input, output, local variables). As examples, we would like to present a

possible visualization of the following programming theorems: *counting*, *maximum selection*, *decision*, *conditional maximum search*, and *copy*.

The *counting* programming theorem stores the current number of elements having a given attribute A in an auxiliary variable. It first sets the auxiliary variable to 0, then uses a For loop to traverse the sequence, and if the current element has attribute A, it increments the value of the auxiliary variable by 1.

In our example (see Figure 2), the sequence has 10 elements in an array, and the attribute A is whether the element is greater than 5. Our visualization shows the current value of the auxiliary variable in column Count using the formula shown in Figure 2.

Figure 2. *Visualization of Counting Programming Theorem*

	A	B	C	D	E
1	**i**	**X[i]**		**Count**	
2				0	initial value
3	1	3		0	=IF(B3>5;D2+1;D2)
4	2	7		1	=IF(B4>5;D3+1;D3)
5	3	5		1	=IF(B5>5;D4+1;D4)
6	4	6		2	=IF(B6>5;D5+1;D5)
7	5	4		2	=IF(B7>5;D6+1;D6)
8	6	8		3	=IF(B8>5;D7+1;D7)
9	7	9		4	=IF(B9>5;D8+1;D8)
10	8	8		5	=IF(B10>5;D9+1;D9)
11	9	1		5	=IF(B11>5;D10+1;D10)
12	10	4		5	=IF(B12>5;D11+1;D11)

```
N=10
A(X[i]) → X[i]>5
```

```
Counting(N,X,Count):
   Count:=0
   For i:=1 to N do
      If A(X[i]) then
      Count:=Count+1
   End For
End.
```

Figure 3 shows how to visualize the *maximum selection* programming theorem. This algorithm uses a For loop and checks whether the current value of the sequence (in our example: the array) is higher than the local maximum. If yes, then we change the value of variable MaxVal to the current value of the array. In the first step, the local maximum is the first element of the array and that is why we start the loop counter from 2.

Figure 3. *Visualization of Maximum Selection Programming Theorem*

	A	B	C	D	E
1	**i**	**X[i]**		**MaxVal**	
2	1	3		3	=B2
3	2	7		7	=IF(B3>D2;B3;D2)
4	3	5		7	=IF(B4>D3;B4;D3)
5	4	6		7	=IF(B5>D4;B5;D4)
6	5	4		7	=IF(B6>D5;B6;D5)
7	6	8		8	=IF(B7>D6;B7;D6)
8	7	9		9	=IF(B8>D7;B8;D7)
9	8	8		9	=IF(B9>D8;B9;D8)
10	9	1		9	=IF(B10>D9;B10;D9)
11	10	4		9	=IF(B11>D10;B11;D10)

```
N=10
```

```
Maximum(N,X,MaxVal):
   MaxVal:=X[1]
   For i:=2 to N do
      If X[i] > MaxVal then
      MaxVal:=X[i]
   End For
End.
```

The *decision* algorithm checks the elements of the array until attribute A becomes true for the current element. In our example attribute A is that the value is even. Since we do not need to always check all the elements of the array, there is a while loop in the algorithm. In the while loop, we check whether the current

element has attribute A and then we increment variable i, which means we go to the next element. If there are elements to be checked and the current element did not have attribute A, we go into the loop, otherwise we exit from the loop.

The visualization in spreadsheet in Figure 4 shows well that as soon as the current element has Attribute A, the variable Exists changes from false to true and after that it will not change back to false (if there is not any element with attribute A then Exists will remain false). According to the algorithm, however, if Exists is true then there is no need to check further. To emphasize this, we can easily create a conditional formatting that darkens (or even hides) the cells belonging to the skipped steps. In our example, conditional formatting was applied to range $D$3:$D$12 with rule "=D2".

Figure 4. *Visualization of Decision Programming Theorem*

	A	B	C	D	E
1	**i**	**X[i]**		**Exists**	
2				FALSE	initial value
3	1	3		FALSE	=OR(D2;MOD(B3;2)=0)
4	2	7		FALSE	=OR(D3;MOD(B4;2)=0)
5	3	5		FALSE	=OR(D4;MOD(B5;2)=0)
6	4	6		TRUE	=OR(D5;MOD(B6;2)=0)
7	5	4		TRUE	=OR(D6;MOD(B7;2)=0)
8	6	8		TRUE	=OR(D7;MOD(B8;2)=0)
9	7	9		TRUE	=OR(D8;MOD(B9;2)=0)
10	8	8		TRUE	=OR(D9;MOD(B10;2)=0)
11	9	1		TRUE	=OR(D10;MOD(B11;2)=0)
12	10	4		TRUE	=OR(D11;MOD(B12;2)=0)

```
N=10
A(X[i]) → X[i] is even
```

```
Decision(N,X,Exists):
   Exists:=False
   i:=1
   While i≤N and not Exists
      Exists:=A(X[i])
      i:=i+1
   End While
End.
```

The *conditional maximum search* programming theorem searches for the largest item in the series that satisfies the specified condition. Of course, it is not certain that there is an element in the series that satisfies this condition, which is why the output will also contain a logical value (variable Exists) that will be true if and only if the condition was true for at least one element.

This programming theorem is based on the *maximum selection* programming theorem described above. Now, however, it is not certain that the first element can be considered the maximum so far; instead, minus infinity will be the initial value of the conditional maximum (variable CMax). Furthermore, the current maximum value is substituted with a larger element only if that larger element satisfies the condition. At the end, the output logical value is set to true if and only if the value of the conditional maximum differs from minus infinity (see Figure 5).

Figure 5. *Visualization of Conditional Maximum Search Programming Theorem*

	A	B	C	D	E
1	**i**	**X[i]**		**CMax**	
2				-1E+99	initial value
3	1	3		-1E+99	=IF(AND(MOD(B3;2)=0;B3>D2);B3;D2)
4	2	7		-1E+99	=IF(AND(MOD(B4;2)=0;B4>D3);B4;D3)
5	3	5		-1E+99	=IF(AND(MOD(B5;2)=0;B5>D4);B5;D4)
6	4	6		6	=IF(AND(MOD(B6;2)=0;B6>D5);B6;D5)
7	5	4		6	=IF(AND(MOD(B7;2)=0;B7>D6);B7;D6)
8	6	8		8	=IF(AND(MOD(B8;2)=0;B8>D7);B8;D7)
9	7	9		8	=IF(AND(MOD(B9;2)=0;B9>D8);B9;D8)
10	8	8		8	=IF(AND(MOD(B10;2)=0;B10>D9);B10;D9)
11	9	1		8	=IF(AND(MOD(B11;2)=0;B11>D10);B11;D10)
12	10	4		8	=IF(AND(MOD(B12;2)=0;B12>D11);B12;D11)
13					
14				**Exists**	
15				TRUE	=D12<>-1E+99
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					

```
N=10
A(X[i]) → X[i] is even
```

```
Maximum(N,X,Exists,CMax):
   CMax:=-∞
   For i:=1 to N do
      If A(X[i]) and X[i] > CMax then
      CMax:=X[i]
   End For
   Exists:=CMax≠-∞
End.
```

There is not any function that can directly implement the *copy (map)* algorithm. If we execute the same operation on the elements of the input sequence, the output will be a sequence. The "copying formula" (actually copying reference) feature of the spreadsheet shows that during the *copy* algorithm we "copy" the formula so we "copy" the operation as well. This way we can visualize the *copy* programming theorem (see Figure 6).

Figure 6. *Visualization of Copy Programming Theorem*

	A	B	C	D	E
1	**i**	**X[i]**		**Y[i]**	
2	1	3		6	=2*B2
3	2	7		14	=2*B3
4	3	5		10	=2*B4
5	4	6		12	=2*B5
6	5	4		8	=2*B6
7	6	8		16	=2*B7
8	7	9		18	=2*B8
9	8	8		16	=2*B9
10	9	1		2	=2*B10
11	10	4		8	=2*B11

```
N=10
f(X[i]) → 2*X[i]
```

```
Copy(N,X,Y):
   For i:=1 to N do
      Y[i]:=f(X[i])
   End For
```

Implementation of Programming Theorems based on their Postconditions

In the case of advanced spreadsheets, array formulas can map all the patterns of algorithms (programming theorems), and there can be a connection among array formulas and postconditions of programming theorems.

To understand the postcondition of some programming theorems, spreadsheet can be a good support. We need to use array formulas. In many cases, the implemented solution by spreadsheet is obvious: for example, *summation*, *counting*, *conditional summation*, *copy*, and *conditional copy*. For instance, the postcondition of *counting* looks like this:

$$Count := \sum_{\substack{i=1 \\ A(Array_i)}}^{N} 1$$

Where A is the attribute function, N is the size of the sequence (in this case: array). This means if the given array-element has attribute A then we add 1 to Count. In spreadsheet, this formula can be implemented literally with the array formula. The Greek letter great sigma means that we add more elements to each other and the condition below that decides at which elements we should add 1 to Count. The operation of great sigma will implement the SUM function, and the operation of the conditional will implement the IF function. That is why the following spreadsheet formula will implement the postcondition of count algorithm correctly:

{=SUM(IF(A(array);1;0}

The SUM function will sum an array with elements 0 and 1 (the output of IF function) and those elements will be 1 that has A attribute (in other words: where the value of A function is true).

In our previous work (Szlávi, Törley & Zsakó, 2019), we have proven that all the programming theorems can be deduced to the *sequential computing* theorem. We have claimed that the *decision* algorithm deduced to *sequential computing* gives the correct solution based upon a Boolean array where the i^{th} element of the array is true if the i^{th} element of the input array has A attribute. *Decision* algorithms have two variants: the first one checks if there is an element in the input array that has attribute A, while the second one checks if every element in the input array has attribute A. It can be proven easily that the following array formulas implement the *decision* algorithm:

- existing element with A attribute: {=OR(A(array_element))}
- every element with A attribute: {=AND(A(array_element))}

We note here that we could implement this theorem with “normal” (i.e. not array) formulas (for example COUNTIF, COUNTIFS functions) but this way of

thinking would not lead us to an efficient algorithm and we could not connect it to the postcondition.

Array formulas could help to understand the combination/construction of programming theorems. A good example of this is the *conditional maximum search* algorithm that is the construction of *decision* and *maximum search*. We will combine the postcondition of these algorithms, which means if an element exists that has attribute A in the array then we calculate the maximum of these elements:

{=IF(OR(A(array_element));
MAX(IF(A(array_element);array_element; “”));“NONE”)}

The connection between algorithm patterns’ postconditions and array formulas can be seen in Table 4.

Table 4. *The Connection of Algorithm Patterns’ Postcondition and Array Formulas*

Pattern of Algorithm and Postcondition	**Array Formula Implementation**
Summation (sequential computing) $\sum_{i=1}^{N} Array_i$	{=SUM(array)}
Counting $\sum_{\substack{i=1 \\ A(Array_i)}}^{N} 1$	{=SUM(IF(A(array);1;0))}
Decision (exists) exist := ∃i∈[1..N]: A($Array_i$)	{=OR(A(array)}
Decision (all) all := ∀i∈[1..N]: A($Array_i$)	{=AND(A(array))}
Conditional sum $\sum_{\substack{i=1 \\ A(Array_i)}}^{N} Array_i$	{=SUM(IF(A(array); array;0))}
Conditional maximum exist := ∃i∈ [1..N]: A($Array_i$) and exist à MaxVal = $MAX^{N}_{\substack{i=1 \\ A(Array_i)}} Array_i$	{=IF(OR(A(array)); MAX(IF(A(array); array; “”));“NONE”)}
Copy ∀i∈[1..N]: F($Array_i$)	{=F(array)}
Conditional copy ∀i∈[1..N]: A($Array_i$) is true: F($Array_i$) else $Array_i$	{=IF(A(array);F(array); array)}
Multiple item selection $Count := \sum^{N}_{\substack{i=1 \\ A(Array_i)}} 1$ and $\forall i \in [1..Count]: A(Y_i)$	{=IF(A(array); array; “”}

We can see a connection between the formulas of postconditions and the formulas of spreadsheet. This can be seen on Table 5.

Table 5. *The Connection between Formulas in Postcondition and Formulas in Spreadsheet*

Formula in Postcondition	Formula in Spreadsheet
$\sum_{i=1}^{N} Array_i$	SUM(array)
$MAX_{i=1}^{N} Array_i$	MAX(array)
F($Array_i$)	F(array)
A($Array_i$)	IF(A(array);array; “”)
∃i∈[1..N]: A($Array_i$)	OR(A(array)
∀i∈[1..N]: A($Array_i$)	AND(A(array)

Table 5 shows that we have “building blocks” and by combining these “blocks” a more complex postcondition can be built. This combination shows how programming theorems can be constructed.

We should take a note on *maximum selection* and *multiple item selection* programming theorems. *Maximum selection* cannot be implemented with an array formula because we cannot compare and refer to the elements of the array in the memory (like we showed in Figure 3). CMax can be implemented with an array formula because IF function can select those array elements for MAX function which have A attribute.

The result of *multiple item selection* is an array (which is Y in the postcondition). Count will be the number of those elements which have A attribute (like at count programming theorem) and it will be the number of elements of the output array in Figure 8. In spreadsheet, we do not need to output the number of the output array.

The implementation of some programming theorems with scalar output using array formulas, based on the postconditions of their specifications can be seen in Figure 7.

Figure 7. *Implementation of Summation, Counting, Decision (in Two Variants), Conditional Summation and Conditional Maximum Search Programming Theorems*

	A	B	C	D	E	F	G
1	**i**	**X[i]**			**Attribute**	**Solution**	
2	1	3		**Summation**	—	55	{=SUM(B2:B11)}
3	2	7		**Counting**	X[i]>5	5	{=SUM(IF(B2:B11>5;1;0))}
4	3	5		**Decision (exists)**	X[i] is even	TRUE	{=OR(MOD(B2:B11;2)=0)}
5	4	6		**Decision (all)**	X[i] is even	FALSE	{=AND(MOD(B2:B11;2)=0)}
6	5	4		**Conditional summation**	X[i]>5	38	{=SUM(IF(B2:B11>5;B2:B11;""))}
7	6	8					
8	7	9		**Conditional maximum search**	X[i] is even	8	{=IF(OR(MOD(B2:B11;2)=0); MAX(IF(MOD(B2:B11;2)=0;B2:B11;"")); "NONE")}
9	8	8					
10	9	1					
11	10	4					

Similarly, Figure 8 shows the implementation of some programming theorems with array output. Due to the particularity of spreadsheet, the continuance of array cannot be kept at *multiple item selection* algorithm.

Figure 8. *Implementation of Copy, Conditional Copy, and Multiple Item Selection Programming Theorems*

	A	B	C	D	E	F	G	H
1	**i**	**X[i]**		**Y[i]**	**Copy**		**Y[i]**	**Conditional copy**
2	1	3		6	{=2*B2:B11}		3	{=IF(B2:B11>5;B2:B11*2;B2:B11)}
3	2	7		14			14	
4	3	5		10			5	
5	4	6		12			12	
6	5	4		8			4	
7	6	8		16			16	
8	7	9		18			18	
9	8	8		16			16	
10	9	1		2			1	
11	10	4		8			4	
12								
13								
14				**Y[i]**	**Multiple item selection**			
15					{=IF(B2:B11>5;B2:B11;"")}			
16				7				
17								
18				6				
19								
20				8				
21				9				
22				8				
23								
24								

Summary of the Three Levels through an Example

As stated earlier, programming theorems can be demonstrated at three different levels in spreadsheet. The first one is about the comprehension and usage of programming theorems using the proper built-in functions. The second one visualizes the algorithms of the programming theorems using only basic operators and functions. In the third level we can implement most of the programming theorems using array formulas, according to their specifications, or more precisely, postconditions. Consequently, all levels can help learning programming theorems from a different aspect.

For comparison, Figure 9 shows the appearance of the *counting* programming theorem at the mentioned three levels.

Figure 9. *Appearance of the Counting Programming Theorem at the Three Levels (The Solution Has a Thick outside Border in Each Level)*

	A	B	C	D	E	F	G	H	I
1	**i**	**X[i]**							
2	1	3							
3	2	7							
4	3	5							
5	4	6							
6	5	4							
7	6	8							
8	7	9							
9	8	8							
10	9	1							
11	10	4							
12									
13	**Built-in function**				**Algorithm visualization**			**Implementation**	
14	5	=COUNTIF(B2:B11;">5")			**Count**			5	{=SUM(IF(B2:B11>5;1;0))}
15					0	initial value			
16					0	=IF(B2>5;E15+1;E15)			
17					1	=IF(B3>5;E16+1;E16)			
18					1	=IF(B4>5;E17+1;E17)			
19					2	=IF(B5>5;E18+1;E18)			
20					2	=IF(B6>5;E19+1;E19)			
21					3	=IF(B7>5;E20+1;E20)			
22					4	=IF(B8>5;E21+1;E21)			
23					5	=IF(B9>5;E22+1;E22)			
24					5	=IF(B10>5;E23+1;E23)			
25					5	=IF(B11>5;E24+1;E24)			

Conclusions

Our paper showed why the spreadsheet (except table formatting and graphs) is part of computational thinking (together with algorithm and programming) rather than digital literacy. Spreadsheets and algorithms both involve problem-solving (skills).

We can find a great similarity between the topics (data, patterns and algorithms) of the two areas and that is why they can support each other when teaching students to learn and understand key concepts.

In the classical order of IT education, students learn spreadsheet before programming. That is why programming knowledge could be built upon spreadsheet (NAT 2012, NAT 2020, Szalayné Tahy 2016). In Hungary, array formulas are taught only in talent development in secondary schools (Molnár 2014), that is why they will not be the part of the regular teaching order); nevertheless our article intended to show that they could be essential tools in programming education.

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Digital University: Investigating the Impact of the Pandemic on the Acceptance of E-Learning

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This article explores a comparative study on the Digitalization in Teaching conducted by the FHWien der WKW (FHW) at the very beginning of the pandemic, with a follow-up one year later, after the complete changeover to distance learning. The study investigated behaviour and preferences of students and teaching staff as linked to their experience with digital tools both initially and after that year. The results were compared to the results of similar studies, focusing on answering the question about the impact of digital education on the acceptance of the digital tools and processes. This paper presents the findings of the FHW study examining the acceptance or rejection of e-learning by students and teaching staff by exploring their needs, questions, and requests. The research uses acceptance theory in its theoretical underpinnings. Its methodology consists of a quantitative survey of students and teaching staff, as well as the review of studies on related topics. The outcome of this study shows that, after a year of being forced to work with digital tools, attitudes among students and teaching staff generally became more accepting and shifts in their needs and requests could be observed.

Keywords: *distance learning, digital tools, post-secondary education, e-learning, acceptance*

Introduction

The COVID-19 pandemic, the most profound health crisis of the past hundred years, has been with us for about two years. The effects of this crisis have changed the ways in which we live, affecting all aspects of our lives. No other phenomenon in recent years has so fundamentally shaken our societies, nor to spread across the world at such speed (Skillsoft 2020).

The specific research area of this paper is the education sector, which was particularly affected by the imposition of measures enforcing social distancing and resulting in the closure of the majority of higher education institutions (Al-Kumaim et al. 2021, Holzer et al. 2021, Taga et al. 2020, Mohamed et al. 2020). The sudden closure of many educational institutions created challenges for both students and university staff. During this time, many educational institutions surveyed their students and employees on the impact of the sudden changes (Arndt et al. 2020, Pausits et al. 2021). Generally speaking, even those educational institutes that were already familiar with digital educational tools and distance

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learning were caught off-guard by the pandemic and the measures enacted to control it (Berghoff et al. 2021. Marczuk et al. 2021). While scholars acknowledge that the concept of online learning is not new, they also recognise that the digitalization of higher education accelerated dramatically during the pandemic (Hargitai et al. 2021, Al-Kumaim et al. 2021, Kreulich et al. 2020).

Vienna's University of Applied Sciences for Management and Communication – FHWien der WKW – is a rather small Austrian university with approximately 3,000 students spread across 10 Bachelor and 8 Master programs. The implementation of pandemic mitigation measures triggered a digitalization push throughout FHW's teaching and learning activities, with the rapid deployment of digital tools and methods across a wide range of course types. Such changes have fundamentally changed the way online teaching is approached by universities, where digital skills are in greater demand than ever (Farnell et al. 2021, Berghoff et al. 2021, Kreulich et al. 2020). While the trend towards digitalization in higher education is nothing new – also at the FHW, which has long embraced digitalization in teaching – the novel conditions of 2020 and 2021 necessitated a faster and wider implementation than many had previously expected (Kreulich et al. 2020).

"Pre-pandemic" efforts towards digitalization in teaching were constantly surrounded by concerns about effects on the quality of teaching and about the acceptance of the tools (Söbke and Reichelt 2016). At the same time, the introduction of digital/virtual distance learning is recognized as bringing advantages, such as the promotion of individual learning, independent of time and space, as well as greater flexibility during studies through video conferencing, interactive exercises, streaming, and online learning platforms (Marczuk et al. 2021, Berghoff et al. 2021, Kreulich et al. 2020). Given recent upheavals and arguments on each side of the equation, this is an opportune moment to investigate how students and faculty view these developments, and how they deal with the digitalization and virtualization of teaching after more than a year of first-hand experience.

This article is based on studies conducted by a team of experts in the digitalization of communication at FHW, who have been investigating digital trends in higher education since 2019. This research project, funded by the city of Vienna, focuses on digital communication trends in higher education and developments in digital communication studies. Since the outbreak of COVID-19 in Austria during March 2020, the project has expanded its research interest to include students' and lecturers' experiences during the pandemic. Accordingly, four surveys have been conducted so far, with two targeted at each group: students and lecturers. This study includes four waves of data collection, from Spring 2020 to Spring 2021.

This longitudinal data on attitudes and experiences, collected during a period of substantial regulatory and institutional change, enables exploration of the acceptability of digital teaching in light of the changes brought about by social-distancing measures. Thus, the guiding research question addressed here is:

> How did the sudden shift to online education during the COVID-19 pandemic affect students' and educators' acceptance of digitalization in Austrian post-secondary education?

The COVID-19 pandemic can be considered as an exceptional set of circumstances, which, in many cases, forced the rapid transition to e-learning, distance learning, and distance teaching. In this light, results of the aforementioned surveys into students' and lecturers' acceptance of digital teaching and learning can be understood as short-term consequences (Farnell et al. 2021). These factors notwithstanding, the longitudinal analysis of this data by the Competence Team for the Digitalisation of Communication can provide important lessons for improving the overall online learning experience for all parties involved in higher education (Marczuk et al. 2021, Walwyn 2020).

This paper is structured in the following format: After this introduction the next section presents a short literature review and the theoretical framework of the research question. Then the methodology that is followed by the results section, in which the empirical findings are explained, and the last section concludes the study.

Literature Review

The changes caused by the COVID-19 pandemic made it necessary for universities to regard digitalization as a strategically relevant topic, with many forced to implement a rapid transition to virtual teaching and learning in early 2020. During this adaptation to e-learning, and despite the extra workload implied, universities also seemed to increasingly launch surveys related to the digitalization process (Arndt et al. 2020). In the final report of the research project BRIDGING, Arndt et al. (2020) question the extent to which digitalization influences traditional transfer strategies for the development and dissemination of concepts and content in higher education. Accordingly, the research team conducted a supplementary qualitative study of internal surveys of teachers and students at German universities carried out during the summer semester of 2020. Likewise, the report "Distance Learning at Austrian Universities and Colleges in the Summer Semester 2020 and Winter Semester 2020/21" (Pausits et al. 2021) attempts to bundle and systematize the research work of Austrian universities into "distance education" during 2020. The main results of these two studies have substantially informed the current research.

The research project BRIDGING (Arndt et al. 2020) investigated what influence do the procedures to implement digital educational concepts during the first months of the pandemic have on higher education. For this purpose, the researchers conducted a qualitative study on internal university surveys among teachers and students in the summer semester 2020.

This content analysis by Arndt et al. (2020) of surveys related to digitalization within universities identified 13 areas of relevance: (a) workload, (b) life situation, (c) progress through studies, (d) examinations and forms of assessment, (e) learning progress and organization, (f) communication and interaction, (g) previous experience, (h) media-technical and didactical competences, (i) technical equipment, (j) technical infrastructure and tools, (k) virtual teaching and learning scenarios, (l) support and support needs, and, finally, (m) evaluation of the change process. The

FHW surveys on which this paper is based focused particularly on areas (a), (b), (c), (h), (e), (h), (i), (j), (k), and (l). For the purposes of this paper, however, areas (a), (b), (h), (j), and (k) are of particular relevance and a short summary of Arndt et al.'s results in these areas is presented below to facilitate comprehension of the similarities and differences between the FHW study and other related studies:

Ad (a) workload: Arndt et al.'s research stated that the workload was considered by the majority of both students and instructors to be (significantly) higher compared to face-to-face semesters – as a rule, more so by teachers than students.

Ad (b) life situation: Particularly the lack of workplaces for concentrated work and learning, financial burdens, and psychological stress can make learning and teaching more difficult. These may also be reasons for the often-expressed desire for physical presence in the sense of reopening learning spaces.

Ad (h) media-technical and didactical competences: Both teachers and students reported an increase in competence and saw this as creating opportunities for virtual teaching in coming semesters. In addition to the competence from a technical perspective, also the improvement of didactical competencies comes here into focus.

Ad (j) technical infrastructure and tools: The majority of teachers use learning management systems and video conferencing systems, primarily Zoom, on account of its high performance. Differentiation between knowledge and ability proves to be critical with respect to infrastructure and tools.

Ad (k) virtual teaching and learning scenarios: As students consider exchanges with teachers as important, they desire more than just self-learning materials. Combinations of asynchronous and synchronous teaching and learning scenarios meet the different needs and desires of both instructors and students. The designing of virtual teaching and learning scenarios, and particularly maintaining communication and interaction, generated a high workload for lecturers and various support staff actors at the universities both before and during the 2020 summer semester. Meanwhile, however, they adapted their offers to meet the needs of students and teachers.

Pausits et al. (2021) came to the conclusion that successful conversion to distance learning required of lecturers the following competencies:

(a) skilled handling of Internet-supported teaching technologies, such as the operation of video conferencing systems and learning management systems (media informatics),
(b) knowledge of possibilities for the methodological-didactic design of courses in distance learning (media didactics),
(c) knowledge about the design of digital learning resources, such as learning videos (media design), and
(d) independent management of their full scope of professional activities, including exchanges with colleagues for research activities, from their homes with the help of Internet technology.

Regarding the results for universities students, Pausits et al. (2021) concluded that the initial surveys paint a positive picture of universities' rapid responses in crisis mode, but at the same time list some key challenges that have become ever more prominent as the pandemic has progressed. These are related to:

(a) a lack of physical learning spaces,
(b) a lack of social contact with colleagues (Gabriel and Pecher 2020, Lehner and Sohm 2021, Schwab et al. 2020, Pausits et al. 2021, Meyer and Mara 2020, Weinberger 2020),
(c) less enjoyment of studies conducted through individual learning (Schwab et al. 2020),
(d) limited possibilities for group work (Gabriel and Pecher 2020, Lehner and Sohm 2021, Schwab et al. 2020),
(e) increased difficulties in communication with individual teachers (Schwab et al. 2020, Pausits et al. 2021, Ledermüller et al. 2020),
(f) high workloads in distance learning resulting from an underestimation of the workload by instructors (Schwab et al. 2020, Weinberger 2020, Ledermüller et al. 2020).

Eventually, Heinz Faßmann (in Pausits et al. 2021) states: "It has been shown that digital forms of teaching and learning are only innovative if they are implemented in a professional and didactically meaningful way." This is the reason the Pausits et al.'s (2021) study concludes by identifying research concerns, including the impact of distance learning on skill acquisition or any consequences and disadvantages for educational biographies.

The reviews by Arndt et al. (2020) and Pausits et al. (2021) expose a raft of important considerations that helped to inform the current study, as well as revealing common experiences at other universities, against which the FHW data can be benchmarked. First, two key aspects of the research question are defined in detail in the sections below: 1) distance learning and distance teaching, which are of equal significant here, as the main survey addresses the challenges and needs of both students and teachers; and 2) the concept of acceptance, which we operationalize by drawing on the theoretical foundations of acceptance research. A further important aspect is the context of the study, which was conducted with students and lecturers of the FHW, who experienced the pandemic-related changes in a common context. An explanation of this context is integrated in the following sections to increase the validity of the comparative analysis by setting the data within a realistic framework, while demographic data on the study participants are presented in the methodology section.

Distance Learning and Distance Teaching

Distance Education is nothing new: already in the 19th century distance learning courses were offered to soldiers (Kentnor 2015), while institutions made course content available to students for the purpose of self-study. Some of the most defining characteristics are the physical separation of teacher and learner,

learning in the context of (yet not within) an educational institution, and the use of communication media such as radio, television, mail, internet, etc. in teaching (Fidalgo et al. 2020).

Meanwhile "[o]nline education is no longer a trend, but mainstream. Of the 18.2 million students enrolled in higher education in the fall of 2007, 3.9 million (21.4%) were enrolled in at least one online course" (Kentnor 2015).

In Germany, the term "distance education" is defined in the 1977 Distance Education Protection Act as the transmission of knowledge and skills on a contractual basis, in which the teacher and the student are exclusively or predominantly physically separated, and the teacher or their representative monitors the learning success of the students (FernUSG 1976).

With the advent of the Internet as a knowledge exchange platform providing possibilities for online data transfer, a previously unimaginable variety of distance education methods and tools has emerged. "Distance education was based on the premise that education was possible without the face-to-face interaction between the student and teacher. [...] Today, with the advancements in communications technology and the connectivity of computers and the Internet, distance education is commonplace" (Kentnor 2015).

Recent developments in communications technologies have increased usage of the term "distance learning", placing it in close relation to e-learning, virtual learning, or online learning. The FHW uses the potentials of e-learning to better address individual needs and to achieve a wider reach of teaching content. Digital infrastructures enable, among other things, asynchronous teaching, educational games, the creation of discussion forums, and synchronous virtual contact between students and teachers. Digital teaching methods thus offer extraordinary flexibility in designing learning processes and should therefore provide for improved learning motivation among students (Reiss and Steffens 2010).

Before the year 2020, the FHW was not interested in radically replacing traditional learning content with virtual content, but rather in enhancing it by blending real and virtual learning offerings. The terms "augmented learning" and "blended learning" accurately express FHW's original intention, yet this intention changed significantly when pandemic mitigation measures forced a complete change to distance learning in a very short time period. The FHW used this as an opportunity to learn more about the possibilities for digital design in teaching as well as to better understand the acceptance of distance learning by students and teachers, given the circumstances.

Despite being two sides of the same coin, this article distinguishes between distance learning and distance teaching in order to precisely address the challenges that are experienced differently by students and teachers in distance education.

Acceptance Definitions

In discussing the acceptance of digital teaching, we apply the term as defined by Simon (2001) with respect to the acceptance of innovations: Acceptance stands in opposition to the term rejection and denotes the positive acceptance decision of an innovation by the users. The central elements of acceptance research are (a) the

acceptance concept (What does acceptance of an innovation mean?), (b) the users (who has to accept an innovation and how?) as well as (c) the innovation (what is to be accepted?) (Simon 2001).

Attitudinal acceptance (Müller/Müller 1986) comprises both affective (emotional) and cognitive (rational) components. The affective component considers motivational-emotional states associated with the innovation. The cognitive component weighs the costs and benefits of an innovation, taking into account personal context. Attitudinal acceptance by users is not directly observable. Behavioral acceptance (Müller-Böling and Müller 1986) extends the acceptance concept by an activity aspect. Behavioral acceptance is spoken of when innovations are accepted in the form of an observable behavior, such as use (Simon 2001).

Acceptance research also investigates the reasons for the acceptance of technological innovations with the aim of identifying and counteracting, undesirable developments as early as possible (Schlohmann 2012). The research interest of this article, the digitalized teaching program of the FHW, is considered as the innovative "product" and is examined according to its acceptance by students and teachers. Because the digitalized educational program relies on technological implementation and technical skills, the Technology Acceptance Model (TAM) is adopted as the reference model for our analysis.

The TAM aims to describe the motivational processes involved in using technological systems. It postulates that the characteristics of the system determine the degree of use by individuals and presents the relevant determinants of acceptance. The TAM assumes that the user's attitude toward the system is an important determinant of the decision to actually use it (Schlohmann 2012). According to Davis et al. (1989), the developer of the model, perceived usefulness and perceived ease of use are the key determinants of attitude toward technological systems. In addition, perceived ease of use influences perceived usefulness (Schlohmann 2012).

The TAM offers tools to observe users' satisfaction with their experience with new technologies. In a study about the contribution of technology acceptance to learner satisfaction in distance education, Ilgaz and Aşkar (2013) showed that students who perceived online learning systems as easy to use and useful for their learning were more satisfied with distance education, as were students who were able to develop a sense of community. Perceived usefulness was found to explain 45% of the variance in satisfaction and to have the highest predictive power. The researchers further determined that students in undergraduate degrees are more positive about distance education than students in higher degrees (Ilgaz and Aşkar 2013).

Methodology

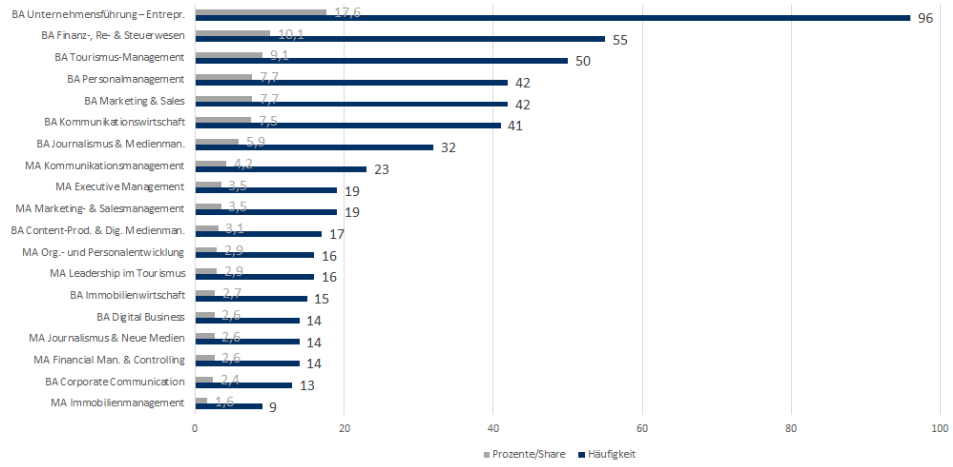
This paper examines the acceptance of e-learning by students and teaching staff at the FHW University of Applied Sciences for Management and Communication by exploring their needs, questions, and requests. The research uses acceptance theory as its theoretical underpinnings to analyze quantitative

surveys of students and teaching staff in light of review studies on related topics (Arndt et al. 2020, Pausits et al. 2021).

Data collection consisted of four online surveys conducted at the FHW, two surveys which were conducted with students of the FHW and two surveys which were conducted with lecturers at the FHW. The surveys were generated via the online survey tool Unipark and distributed via email. Students were first surveyed from April 8th to April 22nd, 2020, with a follow-up survey conducted from March 2nd to March 20th, 2021. The student survey in 2020 achieved a response rate of 70%, attracting 510 participants comprising 70.7% female and 29.3% male respondents. The average age of students was 20.15 years in 2020. The latter student survey in 2021 achieved a response rate of 66.3%, attracting 561 participants comprising 69.1% female and 30.9% male respondents. The average age of students was 21 years in 2021. Similarly, the initial survey of lecturers ran from April 20th to April 22nd, 2020, and the follow-up from June 3rd to June 17th, 2021. The first survey of lecturers in 2020 achieved a response rate of 75.94% with 150 respondents comprising 49.6% female and 50.4% male respondents. The latter survey of lecturers in 2021 yielded a completion rate of 70.35%, with the 159 respondents showing a gender distribution of 56.6% male and 43.3% female. The average age of lecturers was 37.81 years in 2021.

The surveys were distributed amongst all students and lecturers of the FHW, which offers ten different Bachelor programs and eight different Master programs, which are the following (see also Figure 1): Content Production & Digital Media Management, Corporate Communication, Digital Business, Finance, Accounting & Taxation, Real Estate, Journalism & Media Management, Corporate Communication, Marketing & Sales, Human Resources Management, Tourism & Hospitality Management, Management & Entrepreneurship (Bachelor studies) and Digital Innovation Engineering, Executive Management, Financial Management & Controlling, Real Estate Management, Journalism & New Media, Communication Management, Leadership in Tourism & Hospitality, Marketing & Sales Management, Organizational & Human Resources Development and Urban Tourism & Visitor Economy Management (Master studies).

Figure 1. *Share of Participants/Study Program in Percent (2021)*



Source: Author

Lecturers at the FHW University of Applied Sciences are qualified in different fields of Management and Communication and work either as full-time employees or as external lecturers. The In 20201 the composition of lecturers at the FHW survey consisted of 1,025 lecturers in total from which 943 lecturers were external lecturers. 81.6% "external lecturers" and 18.4% "full-time employees" of the university.

In order to ensure that the participants were anonymous and that the study was confidential, no sensible data was asked throughout the study, apart from the demographic information. Anonymous participation was made possible through an online link invitation which was sent out to all participants through the university's email database.

The following two main questions guide the elaboration of the surveys. The first one offered guidance to the survey directed to students and the second one to the survey aiming the teaching staff.

1) What impact does the situation around COVID-19 ("Corona Crisis") have on the studies (perception of digital learning processes, dealing with changed learning conditions (100% Distance Learning), use, application and suitability of tools, communication and cooperation among students, compatibility of studies and job, etc.) of FHWien der WKW students from the students' perspective?
2) What impact does the situation around COVID-19 ("Corona crisis") have on the teaching (use, application and suitability of tools, communication and collaboration with students) of FHWien der WKW teachers from the teachers' point of view?

Following, the content of the conducted surveys will be discussed in detail. Starting with the two surveys conducted with the students of the FHW, the main topics leading the online surveys were: (a) burden of the pandemic on students, (b) burden of Distance Learning on students, (c) preferred forms of Distance Learning (synchronous, asynchronous), (d) ideal duration of Distance Learning, (e) tools of Distance Learning and how useful they are, (f) efficiency of tools for Distance Learning, (g) personal experience of Distance Learning and learning process, (h) Online Communication tools, (i) workload during Distance Learning, (j) Satisfaction of Distance Learning. An attempt was made to compare the results of 2020 and 2021 to see changing preferences, habits or experiences.

Regarding the two surveys conducted with lecturers at the FHW, the main topics leading the online surveys were: (a) burden of the pandemic on lecturers, (b) burden of Distance Learning on lecturers, (c) preferred forms of Distance Learning (synchronous, asynchronous), (d) ideal duration of Distance Learning, (e) tools of Distance Learning and how useful they are, (f) efficiency of tools for Distance Learning, (f) support of lecturers through the university, (g) quality of submissions, (h) collaboration of students, (i) attendance and motivation of students, (j) online exams, (k) workload of lecturers.

Along the following lines a selection of scales used in the surveys will be presented (for a detailed list of questions and their scales see Tables 1 and 2):

When students and lecturers were asked about the degree of burden caused by the pandemic or Distance Learning, the following scale was used: from 1-10, when 1 meant not a burden at all and 10 meant very much of a burden. When students and lecturers were asked about the appropriation of specific tools for Distance Learning, the following scale was used: from 1-5, when 1 meant very appropriate, 2 meant appropriate, 3 meant partially appropriate, 4 meant less appropriate, 5 meant not appropriate at all, and there was an option for not used yet. When students and lecturers were asked about their agreement, e.g., in the context of the appropriate workload estimation, the following scale was used: from 1-5, 1 meant full agreement, 2 meant rather agreement, 3 meant partially agreement, 4 meant less agreement and 5 meant no agreement at all. When students and lecturers were asked about their satisfaction, e.g., in the context of overall Distance Learning the following scale was used, from 1-5, when 1 meant very satisfied, 2 meant satisfied, 3 meant partially satisfied, partially unsatisfied, 4 meant pretty unsatisfied and 5 meant very dissatisfied.

After the collection of the data the results of the surveys were analyzed using SPSS and will be presented in the results section.

Table 1. *Students Survey 2020*

Students Survey 2020			
	Question	**Representation**	**Labeling**
1	In general, how do you feel your personal burden from the current COVID-19 crisis? Drag the slider to the desired position.	Scale (1 to 11)	1 = "Not a burden," 11 = "A great deal of a burden"
2	How do you feel about the stress in your studies due to the current COVID-19 crisis?	Scale (1 to 11)	1 = "Not a burden," 11 = "A great deal of a burden"
3	What is your preferred form of distance learning?	List	(1) synchronous teaching units (2) asynchronous teaching units
4	What do you feel is the optimal duration for synchronous (= simultaneous, with presence) teaching?	Dropdown	List: from 15 minutes until 180 minutes
5	Which of the following tools were used in a course you attended? Moodle, Microsoft Office 365 Apps, Adobe Connect, Zoom, Skype, Panopto video platform, Other communication tools, namely:	List of tools. Possible Answers: yes, no & I don't know	1 = "yes", 2 = "no", 98 = "I don't know"
6	In your experience, how appropriate are the following tools for use in distance learning teaching? Moodle, Microsoft Office 365 Apps, Adobe Connect, Zoom, Skype, Panopto video platform, Other communication tools, namely:	Matrix & Scale (1 to 5)	1 = "very suitable", 5 = "not suitable at all"

7	In general, how well do the following online activities help them capture instructional content? Synchronous online teaching with Microsoft Office 365 apps, Asynchronous online teaching with Microsoft Office 365 apps, Live online teaching with Adobe Connect, Live online teaching with Zoom, Live online teaching with Skype, Learning videos on-demand with Panopto video platform, Livestream with Panopto video platform, Online quizzes, Exchange with instructors via email, Presentations set to music and video insertion of instructors, Presentations set to music, Group work with Microsoft Teams, Group work with Zoom (break out rooms).	Matrix & Scale (1 to 5 + 98)	1 = "very good", 5 = "very poor", 98 = not yet used
8	The following is about how you experience the digital learning environment. How much do you agree with the following statements? 8.1) It is clear to me at all times what purpose the digital teaching and learning materials fulfill (exercises, pre/post-processing, further information, etc.) 8.2) Distance Learning activities are associated with clear tasks and goals. 8.3) The material provided is sufficient to complete the tasks. 8.4) For me, the course content is clear and understandable for the most part. 8.5) In my opinion, the Distance Learning offerings are, for the most part, carefully and competently created. 8.6) The tasks to be completed through Distance Learning activities are well suited for distance learning. 8.7) The learning materials are regularly maintained so that the content (information, course materials, exercises, links, etc.) is, for the most part, always up to date. 8.8) In the current phase of 100% Distance Learning, I generally feel well supported. 8.9) Most instructors correctly estimate the workload for independent assignments. 8.10) The quality of Distance Learning offerings varies greatly from course to course.	Matrix & Scale (1 to 5)	1 = "fully agree", 5 = "do not agree at all"
9	The following is about how you experience your learning through the use of 100% Distance Learning. How much do you agree with the following statements? 9.1) By using 100% Distance Learning, I engage with the content more intensively. 9.2) By using 100% Distance Learning, I learn more independently 9.3) By using 100% Distance Learning, I can better monitor my learning progress.	Matrix & Scale (1 to 5)	1 = "fully agree", 5 = "do not agree at all"
10	How much do you agree with the following statement: I would have learned more if the topics and assignments worked on in Distance Learning had been covered in face-to-face sessions.	Scale (1 to 5)	1 = "fully agree", 5 = "do not agree at all"
11	What communication tools do you use to stay in touch with your fellow students (for study purposes)? Smart Phone, Facebook, WhatsApp, Facebook Messenger, Telegram, Instagram, Email, Google Hangouts, Skype, SMS, Zoom, Slack, Jitsi, Microsoft Teams, Other communication tools, namely:	List of tools. Possible Answers: yes, no & I don't know this tool	1 = "yes", 2 = "no", 98 = "I don't know this tool"
12	Overall, the increased use of online communication tools (WhatsApp, Facebook, Zoom, Microsoft Team, etc.) has improved collaboration in student workgroups/with my fellow students.	Scale (1 to 5)	1 = "fully agree", 5 = "do not agree at all"
13	How much has your workload increased with the switch to 100% Distance Learning?	Scale (1 to 5)	1 = "very much", 5 = "not at all"

14	We would now like you to think of a specific course in the current semester that has been converted to 100% Distance Learning. 2 treatment groups randomized (random selection), i.e. half of the subjects get version A: Please name a course that you think has been particularly well converted to 100% Distance Learning: And the other half of the test persons gets Version B: Please name one course that in your opinion has been particularly poorly converted to 100% Distance Learning: Which of the following tools were used in this course? Moodle, Microsoft Office 365 Apps, Adobe Connect, Zoom, Skype, Panopto video platform, Other communication tools, namely:	List of tools. Possible Answers: yes, no & I don't know	1 = "yes", 2 = "no", 98 = "I don't know"
14 (1)	This question contains 12 statements. Please think about each statement in relation to the course you indicated and indicate how true it is. 14.1.1)The quality of the content and information provided in this course helped me stay attentive. [Note: (A)ttention] 14.1.2) I was able to stay motivated even when the lector wasn't online all the time. [Note: (A)ttention] 14.1.3) The online tools used helped to stay attentive. [Note: (A)ttention] 14.1.4) It will be easy for me to apply what I learned online in this course in practice. [Note: (R)elevance] 14.1.5) The way the content was delivered made me feel like the content was worth knowing. [Note: (R)elevance] 14.1.6) The content of this course will be useful to me. [Note: (R)elevance] 14.1.7) When I worked on the assignments for this course, I felt confident that I would learn the content. [Note: (C)onfidence] 14.1.8) As a result of this course, I feel well and adequately prepared for the exams. [Note: (C)onfidence] 14.1.9) The organization of this course has helped me to feel confident that I am learning the content. [Note: (C)onfidence] 14.1.10) I enjoyed the course so much that I would like to learn more about this topic. [Note: (S)atisfaction] 14.1.11) I really enjoyed the course. [Note: (S)atisfaction] 14.1.12) It was a pleasure to participate in such a well-designed course. [Note: (S)atisfaction]	Matrix & Scale (1 to 5)	1 = "does not apply", 5 = "applies"
15	How much do you agree with the following statements about distance learning? 15.1) I can complete my assignments even if there are online distractions (e.g., sending emails or websites to browse). 15.2) I can complete my tasks even when there are distractions at home (e.g., television, children, and the like). 15.3) I can manage conversations well using online tools. 15.4) Sometimes I prefer to have more time to prepare answers to a question. 15.5) Regular contact with lecturers is important to my learning success in Distance Learning. 15.6) Quick technical and administrative support is important to my learning success in Distance Learning. 15.7) I feel that previous experience with online technologies is important to my success with Distance Learning. 15.8) The ability to use course materials immediately is important to my success with Distance Learning.	Matrix & Scale (1 to 5)	1 = "fully agree", 5 = "do not agree at all"
16	Overall, how satisfied are you with the distance learning opportunities at FHWien of WKW?	List	

17	I would like to see more traditional face-to-face courses replaced by distance learning in the future. Please indicate to what extent you agree with the statement.	Scale (1 to 5)	1 = "fully agree", 5 = "do not agree at all"
18	How would you rate your ability to grasp, understand, and use digital content for the tasks at hand?	Scale (1 to 5)	1 = "fully available", 5 = "not available",
19	How much does FHWien of WKW promote the (proficient) use of digital teaching content?	Scale (1 to 5) & I don't know	1 = "very good", 5 = "very poor", 98 = "I don't know"
20	Do you have any further comments and/or requests regarding Distance Learning at FHWien of WKW?	Open question + no answer	

Source: Author.

Table 2. *Teaching Staff Survey 2020*

Teaching Staff Survey 2020			
	Question	**Representation**	**Labeling**
1	In general, how do you feel your personal burden from the current COVID-19 crisis? Drag the slider to the desired position.	Scale (1 to 11)	1 = "Not a burden," 11 = "A great deal of a burden"
2	How do you feel about the burden in your teaching activities due to the current COVID-19 crisis? Drag the slider to the desired position.	Scale (1 to 11)	1 = "Not a burden," 11 = "A great deal of a burden"
3	What is your preferred form of distance learning?	List	(1) synchronous teaching units (2) asynchronous teaching units
4	What do you feel is the optimal duration for synchronous (= simultaneous, with presence) teaching?	Dropdown	List: from 15 minutes until 180 minutes
5	Which of the following tools have you used in any of your courses? Moodle, Microsoft Office 365 Apps, Adobe Connect, Zoom, Skype, Panopto video platform, Other communication tools, namely:	List of tools. Possible Answers: yes, no & I don't know	1 = "yes", 2 = "no", 98 = "I don't know"
6	In your experience, how appropriate are the following tools for use in distance learning teaching? Moodle, Microsoft Office 365 Apps, Adobe Connect, Zoom, Skype, Panopto video platform, Other communication tools, namely:	Matrix & Scale (1 to 5)	1 = "very suitable", 5 = "not suitable at all"
7	Which of the following tools would you like to see added to one of your courses in the future? Moodle, Microsoft Office 365 Apps, Adobe Connect, Zoom, Skype, Panopto video platform, Other communication tools, namely:	List of tools. Possible Answers: yes, no & I don't know	1 = "yes", 2 = "no", 98 = "I don't know"
8	Can FHWien of WKW support you in the planned use of these tools? Provide training, Manuals on Moodle, Premium accounts/licenses, Overview of tools and their possibilities, Helpdesk, Other support possibilities, namely: [Are there any other support options you would like FHWien of WKW to provide?].	List of actions. Possible Answers: yes, no & I don't know	1 = "yes", 2 = "no", 98 = "I don't know"
9	In general, how well do the following online activities help you teach content? Synchronous online teaching with Microsoft Office 365 apps, Asynchronous online teaching with Microsoft Office 365 apps, Live online teaching with Adobe Connect, Live online teaching with Zoom, Live online teaching with Skype, Learning videos on-demand with Panopto video platform, Livestream with Panopto video platform, Online quizzes, Exchange with instructors via email, Presentations set to music and video insertion of instructors, Presentations set to music, Group work with Microsoft Teams, Group work with Zoom (break out rooms).	Matrix & Scale (1 to 5 + 98)	1 = "very good", 5 = "very poor", 98 = not yet used
10	In the process of switching to Distance Learning, I have adapted/changed X% of my course content to Distance Learning.	Scale (1 to 5 + 6)	1 = 80%, 5 = 10%, 6 = I didn't have to change anything
11	During or after Distance Learning sessions, students actively contact me with questions.	Matrix & Scale (1 to 5)	1 = "fully agree", 5 = "do not agree at

			all”
12	What communication tools do you use to stay in touch with your students? Smart Phone, Facebook, WhatsApp, Facebook Messenger, Telegram, Instagram, Email, Google Hangouts, Skype, SMS, Zoom, Slack, Jitsi, Microsoft Teams, Other communication tools, namely:	List of tools. Possible Answers: yes, no & I don’t know this tool	1 = “yes”, 2 = “no”, 98 = “I don’t know this tool”
13	Overall, the increased use of online communication tools (WhatsApp, Facebook, Zoom, Microsoft Teams, etc.) has improved student interaction.	Scale (1 to 5)	1 = “fully agree”, 5 = “do not agree at all”
14	Please indicate to what extent you agree with the following statements: 14.1) I have had good experiences with online performance assessments. 14.2) I find online performance assessments to be an adequate form of performance assessment. 14.3) The quality of student submissions is higher in asynchronous distance learning units than in face-to-face teaching. 14.4) Student participation is more active in synchronous distance learning units than in face-to-face teaching. 14.5) It is more difficult to formulate digital teaching content clearly and comprehensibly than in face-to-face teaching. 14.6) It takes longer to convey content if the course is held exclusively digitally. 14.7) I have the impression that distance learning promotes students' independent learning.	Scale (1 to 5) & I don’t know	1 = “very good”, 5 = “very poor”, 98 = “I don’t know”
15	How much has your workload increased with the switch to 100% Distance Learning?	Scale (1 to 5)	1 = “very much”, 5 = “not at all”
16	How satisfied are you overall with the distance learning opportunities at FHWien of WKW?	List	1 = “very satisfied”, 5 = “not satisfied at all”
17	I would like to see more traditional face-to-face courses replaced by distance learning in the future. Please indicate to what extent you agree with the statement.	Scale (1 to 5)	1 = “fully agree”, 5 = “do not agree at all”
18	How would you rate your ability to capture, understand, and use digital content for teaching?	Scale (1 to 5) & I don’t know	1 = “fully available”, 5 = “not available”, 98 = “I don’t know”
19	How much does FHWien of WKW promote the switch to digital teaching content?	Scale (1 to 5) & I don’t know	1 = “very good”, 5 = “very poor”, 98 = “I don’t know”
20	How much does FHWien of WKW support the technical introduction to individual tools? Moodle; Microsoft Office 365 Apps; Adobe Connect; Zoom; Panopto Videoplattform	Scale (1 to 5) & I don’t know	1 = “very good”, 5 = “very poor”, 98 = “I don’t know”
21	How much does FHWien of WKW support the didactic introduction to formats of Distance Learning?	Scale (1 to 5) & I don’t know	1 = “very good”, 5 = “very poor”, 98 = “I don’t know”
22	Whenever I have questions regarding Distance Learning, I get quick and competent help from FHWien of WKW.	List	1 = “fully agree”, 5 = “do not agree at all”
23	Are there specific communication and support measures that you would like to see from FHWien of WKW as a teacher?	Open question + no answer	
24	Do you have any further comments and/or requests regarding Distance Learning at FHWien of WKW?	Open question + no answer	

Source: Author.

The follow up surveys (2021) contained mainly the same questions as the previous surveys except for the fact that the 2021 surveys include more questions about e-assessment. However, these questions are not relevant for the purpose of this paper and, therefore, in this paper, they will not be taken into account.

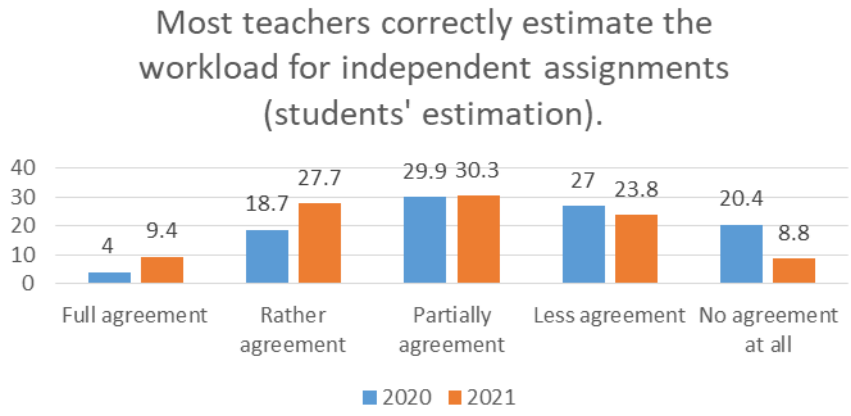
Results

This section presents a selection of results from the FHW surveys that are pertinent to the research question. These are structured according to the selected categories from Arndt et al. (2020): (a) workload, (b) life situation, (h) media-technical and didactical competences, (j) technical infrastructure and tools, and (k) virtual teaching and learning scenarios.

Workload

As shown in Figure 2, below, students of the FHW der WKW University of Applied Sciences for Management and Communication were asked whether they think most teachers correctly estimate the workload for independent assignments. A comparison between the years 2020 and 2021 shows that student evaluations have become more positive over time. In 2020, a lower percentage of students expressed "full agreement" or "rather agreement" that lecturers correctly estimate student workloads, with a greater percentage opining "less agreement" or "no agreement at all". Thus, an overall improvement over time could be noted, even though almost one third of students still disagree (less agreement or no agreement at all) that lecturers estimate workloads correctly in 2021.

Figure 2. *Student Evaluations of Teachers' Correct Estimation of Workload/ Comparison 2020 and 2021*



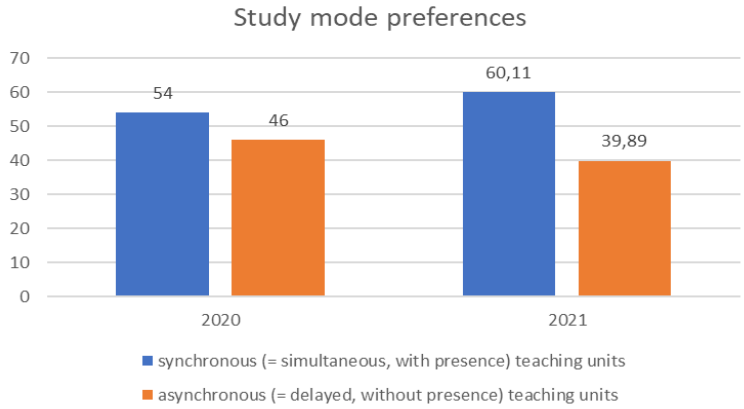
Source: Author

Life Situation

Both students and lecturers were asked about their study mode preferences, where the synchronous study mode refers to simultaneous Distance Learning, while the asynchronous study mode involved delayed Distance Learning and without presence. This information seems relevant not only to how students prefer to organize their studies, but more broadly to organizing their study-work balance/ study-life balance.

The data is presented in Figures 3 and 4, below, where Figure 3 shows a longitudinal comparison of study mode preferences by students between 2020 and 2021, and Figure 4 shows a cross-sectional comparison of study mode preferences between students and lecturers in the year 2021.

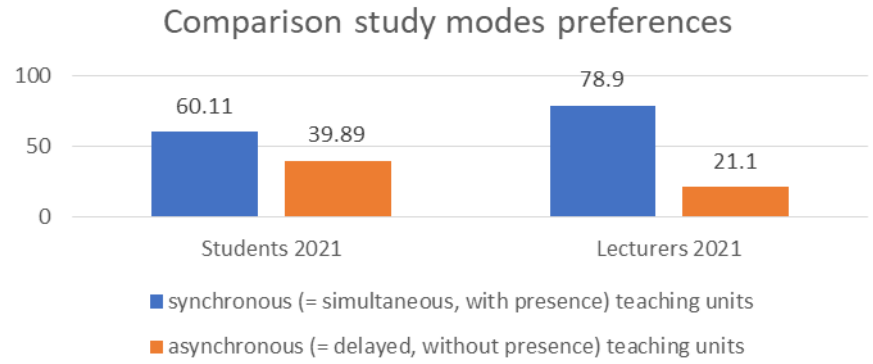
Figure 3. *Comparison of Students' Study Mode Preferences between 2020 and 2021*



Source: Author

Interestingly, Figure 3 shows that students have a stronger tendency towards the synchronous study mode in 2021 compared to 2020. After one year of distance education, students increasingly prefer to be simultaneously online when engaged in Distance Learning.

Figure 4. *Comparison of Study Mode Preferences between Students and Lecturers*

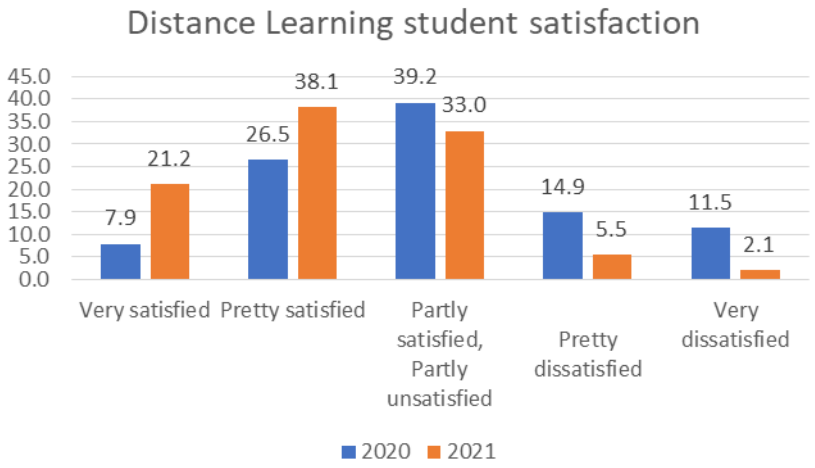


Source: Author

The increasing preference of students for synchronous instruction is also reflected among lecturers. Figure 4 shows that approximately 80% of lecturers prefer a synchronous study mode in 2021, exceeding the approximately 60% of students who prefer the synchronous study mode. It is clear that both target groups prefer synchronous study modes to asynchronous study modes, and that this tendency has increased over the course of the study period.

The FHW surveys further asked students about their level of satisfaction with Distance Learning, both in 2020 and again in 2021. The data presented in Figure 5 show a comparison of student evaluations across these years.

Figure 5. *Student Satisfaction with Distance Learning in 2020 and 2021*



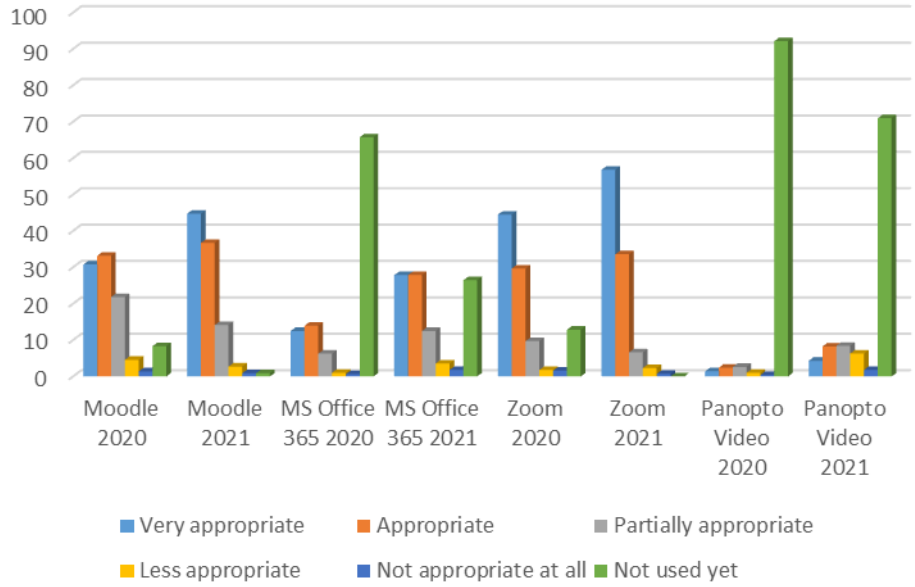
Source: Author

Interestingly, after one year of the COVID-19 pandemic, students expressed higher levels of contentment ("very satisfied" or "pretty satisfied") with Distance Learning, while the percentage who are "partly satisfied, partly unsatisfied", "pretty dissatisfied", or "very dissatisfied" decreased in comparison to 2020. This shows that students are generally more satisfied with Distance Learning now than they were when commencing this experience.

Media-technical and Didactical Competences, Technical Infrastructure and Tools, and Virtual Teaching and Learning

As shown in Figure 6, students were also asked about the appropriate deployment of technical infrastructure and tools used for Distance Teaching. For the purposes of Distance Teaching at the FHW, the four tools Moodle, Microsoft Office 365, Zoom, and Panopto were employed. In Figure 6, student evaluations are compared between 2020 and 2021.

Figure 6. *Tools for Distance Learning (2020 and 2021)*

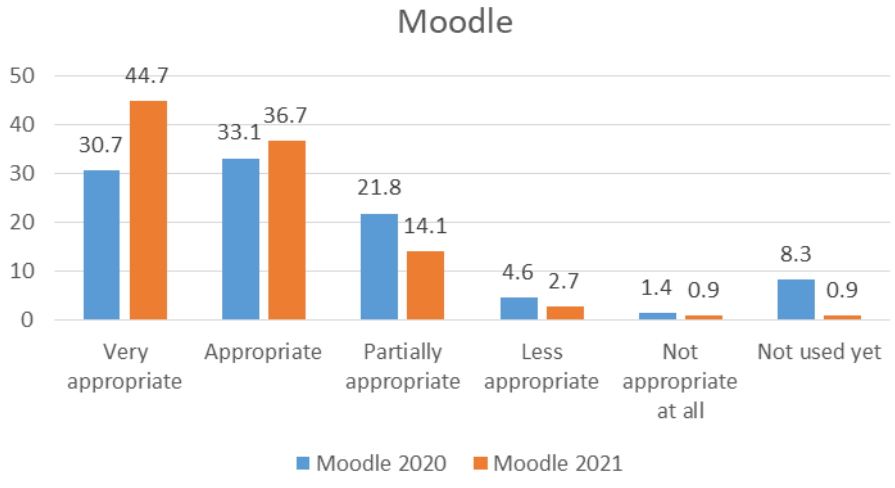


Source: Author

As shown in Figure 7, students found Moodle to be even more appropriate for their studies in 2021 than in 2020. The graph also reveals that the proportion of students in the "not used yet" category declined over the course of the year.

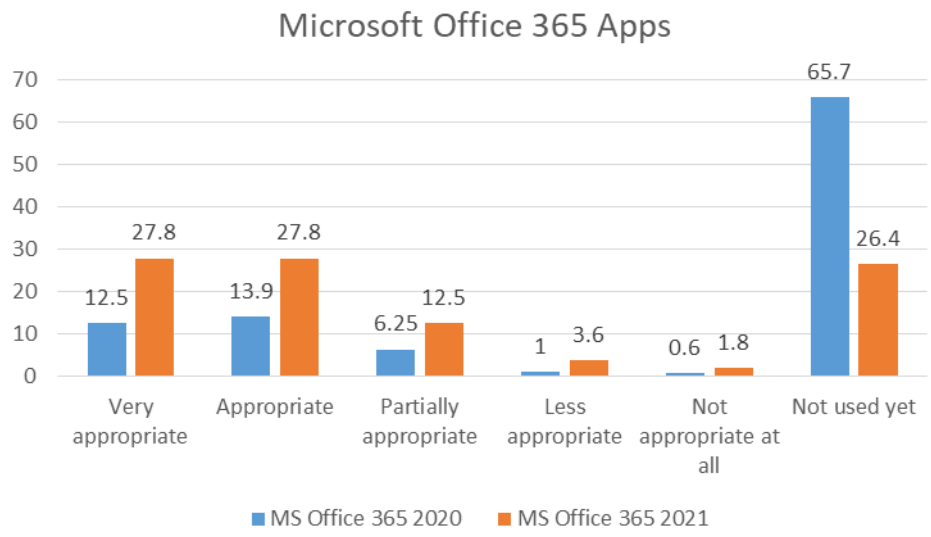
Figure 8 shows that more students consider the online tool Microsoft Office 365 as "appropriate" to "very appropriate" in 2021 than in 2020. As with Moodle, the percentage of students who claimed not to have used the tool also declined from 2020 to 2021.

Figure 7. *Moodle for Distance Learning (2020 and 2021)*



Source: Author

Figure 8. *Microsoft Office 365 Apps for Distance Learning (2020 and 2021)*

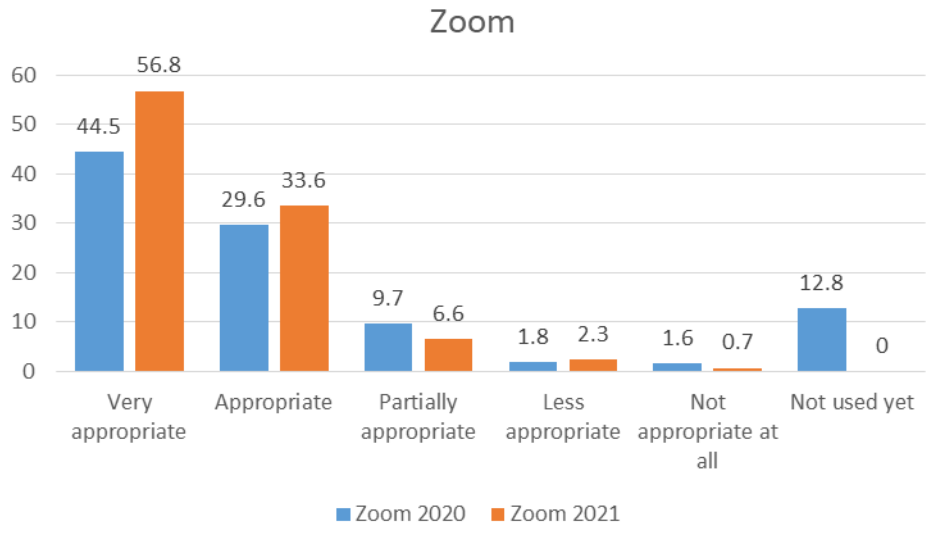


Source: Author

Contentment with the online tool Zoom also increased between 2020 and 2021, as shown in Figure 9. In 2021, students are more likely to find Zoom "very appropriate" to "appropriate", as the proportion of students declaring that they had "not used (Zoom) yet" dropped to near zero in 2021.

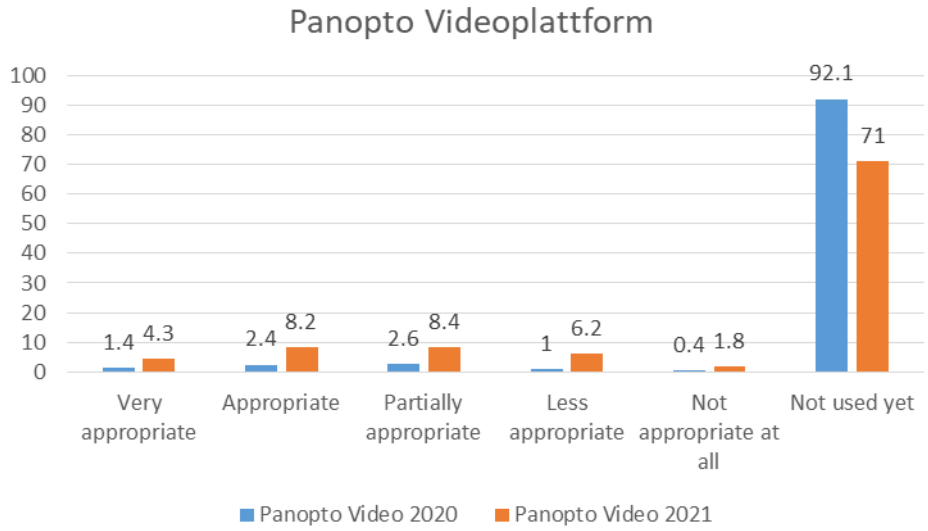
As Figure 10 demonstrates, even though students find the online video platform Panopto slightly more appropriate in 2021 than 2020, most participants had still not used the video platform.

Figure 9. *Zoom for Distance Learning (2020 and 2021)*



Source: Author

Figure 10. *Panopto for Distance Learning (2020 and 2021)*



Source: Author

Furthermore, the outcome of this study shows that full-time and part-time students have different needs and acceptance levels regarding distance learning and digital tools. Shifts in these needs and requests are observed after one year of being forced to work with digital tools, with both students' and teaching staff's attitudes generally becoming more accepting.

Discussion and Conclusions

The results of the FHW student and lecturer surveys offer valuable insights regarding questions about the acceptance of digital education by students and educators. Since the surveys were conducted at the beginning and at the end of the first year of COVID-19 restrictions in Austria, they enable identification of shifts in attitudes towards digital education.

Compared to the related studies cited in the literature review section of this paper, the FHW results correlate well with their results. Hence, while student satisfaction correlates with their perceived usefulness towards digital education in the Ilgaz and Aşkar (2013) study and therefore has the tendency to increase as more students get used to digital education, the FHW results shows that one year into the pandemic 59.3% of students are "very satisfied" or "pretty satisfied" with distance learning, compared with only 34.4% the year before. On the other side of the equation, the percentage of "pretty unsatisfied" to "very dissatisfied" students declined from 2020 (26.4%) to 2021 (7.6%), which also indicates the positive overall trend.

Related to the (a) *workload*, which according to Arndt et al.'s (2020) BRIDGING study became higher compared to face-to-face-semesters, the following results were observed in the FHW surveys. Student (full or rather) agreement with the proposition that lecturers correctly estimate workloads rose from 22.7% in

2020 to 37.1% in 2021, while disagreement (less or no agreement) with this statement fell from 47.4% in 2020 to 32.6% in 2021. Although the FHW surveys do not facilitate a direct comparison of students' workload perceptions between traditional teaching model and distance learning models, the improvement in student evaluations of the accuracy of lecturers' workload estimations from 2020 to 2021 nevertheless indicates issues of increased workloads when switching to distance learning. Although this issue seems to have somewhat mitigated over time, the approximately one third of students who continue to express issues with workloads in 2021 suggests value in further research on this point.

Another area of relevance for digitalization within universities identified by Arndt et al. (2020) was that of (b) *life situation*. Related to this element, the FHW survey results show that students and lecturers have certain preferences when it comes to study modes. Even though it could be assumed that students and lecturers actually prefer an asynchronous study mode, meaning that teaching and learning happen independently of time and place, results from one year after the outbreak of the pandemic surprise with a different outcome. While 54% of students preferred a synchronous teaching mode in 2020, a slight increase to 60.11% was noted in 2021. Interestingly, the comparison of students' and lecturers' study mode preferences in 2021 shows that lecturers prefer synchronous study modes even more strongly, with 78.9% favoring this option and only 21.1% preferring asynchronous teaching. This development shows that after one year of the pandemic, both parties prefer synchronous study modes involving more interactive and engaging teaching. This effect also supports the findings from the FHW surveys regarding lecturer's preferences for Zoom, which is a helpful tool for synchronous classes. Therefore, in contrast to the BRIDGING studies, the preference for Zoom in the category (j) *technical infrastructure and tools* can not only be attributed to its good performance, but also because this tool satisfies lecturers' and students' needs.

As for the area of relevance (h) *media-technical and didactical competences*, the surveys point to a considerable increase in students' competencies as the use of the software tools has progressed. Comparing 2020 to 2021, students increasingly perceive the digital tools as appropriate for teaching. The acceptance of Moodle as a learning platform and of MS Office365, for example, has increased by 17.6 % resp. 29.2 % in this period ("very appropriate" and "appropriate" were counted as positive responses). At the FHW, students and the teaching staff can also rely on the Competence Centre for E-Learning to enhance their digital competencies. Adapted to the situation, the FHW provides a COVID-19-specific Moodle Help Course, a weekly Distance Learning Q&A session, co-moderation for live online teaching, early roll-out of the Panopto video system, and guides for online teaching. Thus, the results of the FHW surveys in this area are very similar to the results of the BRIDGING study.

The BRIDGING study also pointed out the students' and lecturers' desire for synchronous lectures over abundant self-learning materials (area of relevance: (k) *virtual teaching and learning scenarios*). This preference was confirmed by the surveys at the FHW.

The insights gained from the surveys and from academic papers such as those by Pausits et al. (2021) opened up opportunities to implement measures to support digital learning and teaching at the FHW. As mentioned before, the Competence Centre for E-Learning offers courses and support for teachers and students, facilitating the deployment of digital teaching skills. Yet, these four FHW surveys focused primarily on the impact of the use of digital tools and their features related to educational purposes. Therefore, not all key challenges mentioned in the Pausits et al. (2021) study were discussed here. However, the surveys did investigate the challenge "*high workloads in distance learnin*g", and the results agree with the findings of the Pausits study:

Most students (2020: 77.3%, 2021: 62.9%) did not or only partially agree with the statement "Most teachers correctly estimate the workload for independent assignments." Even though there is a year-over-year improvement, teachers' estimates of the workload still could be improved, at least in the students' opinion. Other key challenges mentioned by Pausits et al. (2021) (e.g., less enjoyment of studies conducted through individual learning, increased difficulties in communication with individual teachers) need further follow-up studies at the FHW.

The FHW surveys provide hints that with the passage of time in which universities are forced to adapt to distance learning, their technical competence increases. Hence, "perceived ease of use" - a determinant of acceptance according to TAM - enhances as well. Overall, there is a clear positive development in levels of satisfaction with distance learning at the FHW.

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Using Digital Humanities for Understanding COVID-19: Lessons from Digital History about Earlier Coronavirus Pandemic

By Tado Jurić[*]

At the time of the COVID-19 epidemic, it is useful to look at what lessons (digital) history can give us about the past pandemics and dealing with them. We show that the Google Ngram Viewer (GNV) can discover hidden patterns in history (of pandemics). Our study is searching for evidence that the COVID-19 is not a unique phenomenon in human history. By using the approach of Digital Humanities, we are testing the hypothesis that the flu-like illness that caused loss of taste and smell in the late 19th century (Russian flu) was caused by a coronavirus. This approach could give hints on how the COVID-19 might develop in the following years. The objective was to calculate the ratio of increasing to decreasing trends in the changes in frequencies of the selected words representing symptoms of the Russian flu and COVID-19. The primary methodological concept of our approach is to analyse the ratio of increasing to decreasing trends in the changes in frequencies of the selected words representing symptoms of the Russian flu and COVID-19 with the Google NGram analytical tool. Initially, keywords were chosen that are specific and common for the Russian flu and COVID-19. We show the graphic display on the Y-axis what percentage of words in the selected corpus of books (collective memory) over the years (X-axis) make up the word. To standardise the data, we requested the data from 1800 to 2019 in English, German and Russian (to 2012) book corpora and focused on the ten years before, during and after the outbreak of the Russian flu. We compared this frequency index with "non-epidemic periods" to test the model's analytical potential and prove the significance of the results. The limitation of this study is that it is difficult to formulate a hypothesis for a microbiological aetiology of a pandemic that occurred 133 years ago based on symptoms. There are indications that COVID-19 is not unique because the Russian flu (1889-1891) might be a coronavirus infection. The most crucial observation of similarities between the Russian flu pandemic and COVID-19 is the loss of smell and taste (anosmia and ageusia). Results show that all the three analysed book corpora (including newspapers and magazines) show the increase in the mention of the symptoms "loss of smell" and "loss of taste" during the Russian flu (1889-1891), which are today undoubtedly proven to be key symptoms of COVID-19. The mention of symptoms and the pandemic-related words fell sharply after the pandemic stopped. According to our analysis of historical records with the approach of GNV, 1) the 'natural' length of a pandemic is two to five years; 2) the pandemic stops on its own; 3) the viruses weaken over time; 4) the so-called "herd immunity" is not necessary to stop the pandemic; 5) Our approach has shown that a significant crisis does not need to occur after the COVID-19 pandemic. According to our study, GNV clearly shows the influence that social changes have on word frequency. The results of this study open a discussion on the

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usefulness of the Google Ngram insights possibilities into past socio-cultural development, i.e. epidemics and pandemics that can serve as lessons for today. However, this method has severe limitations and can be useful only under cautious handling and testing. Despite the numerous indications, we are aware that this thesis still cannot be confirmed and that it requires further historical and medical research.

Keywords: *Google Ngram, big data, epidemic, COVID-19, Russian flu, digital Humanities*

Introduction[1]

An answer to the future development of the COVID-19 pandemic is of high importance for all societies and countries worldwide. By messages from the media and official reports, we know that they are unreliable and that epidemiological predictions are uncertain. Because medical evidence and epidemiological estimates cannot answer this question, looking at history's lessons can be helpful.

Studying past pandemics shows that elements relevant to the COVID-19 pandemic are repeated and that the measures that we undertake today are precisely the same as what they did in Spanish flu and partially in Russian flu – social distancing, wearing masks, quarantining, travel restrictions (King 2021). But just as individuals forget the past, so do societies (Halbwachs 1992). This paper shows that Digital Humanities approaches might be used to track historical epidemics and renew knowledge from the past.

According to Brüssow (2021) and Van Ranst (King 2021), the Russian flu might have been a coronavirus infection. Due to the limitations, it is impossible to have medical evidence for this thesis. Therefore, we set the hypothesis that the tools of Digital Humanities, especially Google Books Ngram Viewer (GNV), can help find the clinical data from the historical reports.

Our goal in this paper is to analyse the epidemiological literature on the development of the Russian flu pandemic (1889) for hints on how the COVID-19 might develop in the following years and compare the similarities. The historical record of past pandemics might thus provide us with the so-called "retrodictions" (Brüssow 2021) on possible future scenarios for the COVID-19 pandemic.

According to Van Ranst, the first coronavirus was transmitted from bovines to humans. According to this thesis, what we are experiencing today has already been experienced in the late 19th century (King 2021). To find evidence, we have analysed the indices by the clinical data from the historical reports from the Google corpus of digitised books that includes 15 million books (12% of all books ever published). We asked ourselves, especially if the COVID-19 pandemic is a unique occurrence in humanity, whether it will disappear or become endemic, and the future consequences.

[1]The study was released as a pre-print version on 6 February 2022 during the peak of the pandemic: Jurić T (2022) *Using digital humanities for understanding COVID-19: lessons from digital history about earlier coronavirus pandemic*. MedRxiv, https://www.medrxiv.org/content/10.1101/2022.02.02.22270333v1.full-text. DOI: https://doi.org/10.1101/2022.02.02.22270333.

According to our study, the GNV clearly shows the influence that social changes have on word frequency. The relationship between values fostered in a society and its language is close (Brüssow and Brüssow 2021). Our basic assumption is that when culture and language are linked, one should impact the other. Furthermore, it has been recently shown that during seasonal influenza epidemics, users of Google are more likely to engage in influenza-related searches and that this signature of influenza epidemics corresponds well with the results of CDC surveillance (Jurić 2021b). We, therefore, reasoned that the Big Data and Digital Humanities approaches might be used to track historical epidemics and give us answers to some questions that would otherwise remain unanswered.

Big Data in Digital Humanities

The expression "Big Data" has been spreading since 2011. The term is used in academia, industry and the media, but it is not even today precisely clear what it means. Is it an object of study, a method, a group of technologies or a discipline (Rojas Castro 2017)? The definitions combine two essential ideas: storing a large volume of data and analysing this data quantitatively and visually to find patterns, establish laws, and predict conduct (Ward and Barker 2013). The classic definition of "Big Data" is a formula - the three "Vs": Volume, Velocity (data that is constantly generated) and Variety (texts, images, sounds) (Ward and Barker 2013).

According to Oza, Digital Humanities is "a broad field of research and scholarly activity covering the use of digital methods by arts and humanities researchers and how the arts and humanities offer distinctive insights into the major social and cultural issues raised by the development of digital technologies" (Oza 2020). Work in this field is methodological and interdisciplinary in scope, involving multiple skills, disciplines, and areas of expertise with the investigation, analysis, synthesis and presentation of data electronically (Oza 2020). According to Burdick et al. (2012) "Digital Humanities is less a unified field than an array of convergent practices exploring a universe in which print is no longer the primary medium in which knowledge is produced and disseminated" (Burdick et al. 2012).

Big Data is widely used today in digital culture as a promising method for deriving new understanding from massive aggregations of information. The ability to collect a vast amount of data from text, images, and media and to analyse it using computerised algorithms creates endless opportunities in many areas (Ophir 2016). "Big data" methodologies bring new potential not just for medicine and business analytics but also for humanities research and social sciences. Latour believes that big data can resolve the gap between the micro and the macro in sociology, the unexplained relations between macro-social phenomena and the individuals taking part in that phenomena (Latour 2014).

In the humanities, one can only speak of Big Data in connection with the technologies associated with this phenomenon, such as data mining, stylometry or natural language processing (Rojas Castro 2017). It is crucial to differentiate between "data", "raw material", and "information". According to Castro, more than the finished product, what matters in the Digital Humanities is the creative

process when a phenomenon is "modelled". The aim is to gain new knowledge and meanings by generating an external object that represents it (Rojas Castro 2017). Humanistic disciplines such as history, philosophy, and philology are characterised by a specific object of study and a method that seeks to understand particular, unusual and even unique cases through text commentary. According to Castro, Big Data in humanities will unquestionably affect certain clichés about the Humanities and their classic objects of study (Rojas Castro 2017). Although the tool may help develop specific theories concerning socio-cultural phenomena, many researchers claim that the data obtained with Google Books Ngram Viewer is not reliable enough to confirm these theories (Zięba 2018) (see Limitations).

Google NGram Viewer

Reading small collections of carefully chosen works enables scholars to make robust inferences about trends in human thought. However, this approach rarely allows precise measurement of the underlying phenomena. According to Michel et al. (2011a), computational analysis of the digitalised corpus of books enables us to observe cultural trends and subject them to quantitative investigation. This new field, *Culturomics*, extends the boundaries of scientific inquiry to a wide array of new phenomena (Lieberson and Horwich 2008).

One of the tools that serve Digital Humanities is GNV.[2] This tool has been created on top of Google Books, the largest digitised collection of books. GNV is creating a graphical representation of the frequency of occurrence of search terms over the years in a selected corpus of digitised books (Michel et al. 2011a). It contains a corpus of over 15 million digitised books and over 600 billion words in 2022. It is actually the world's largest archive - which is also available online and for free. Google states that its team, together with Cultural Observatory, Harvard University, Encyclopaedia Britannica and the American Heritage Dictionary, have digitised over 15% of all books that have ever been published from over 40 university libraries (such as the University of Michigan and the New York Public Library) and individual publishers.[3] In 2004, Google began by scanning books (OCR). The first version in 2009 had six million books; in 2012, the second version incorporated eight million books (Lin et al. 2012), and the 2019 version had over 15 million books. Due to the wide scale of digitally archived texts, these corpora are not limited to specific genres. It includes all sorts of literature, ranging from academic publications to biographies and novels (Chumtong and Kaldewey 2017). The collection contains books dating back to as early as 1473 and texts in 478 languages (Michel et al. 2011b). Of the 15 million books scanned, the country of publication is known for 91.5%, authors for 92.1%, publication dates for 95.1%, and the language for 98.6%. The OCR quality is generally higher for the languages that use a Latin alphabet (English, French, Spanish, and German), and more books are available (Michel et al. 2011b).

The new version of GNV from 2019 is characterised by improved optical character recognition (OCR) and better underlying library and publisher metadata

[2]Google NGram View: https://books.google.com/ngrams.
[3]Ibid.

(Younes and Reips 2019). Google estimates that over 98% of words are correctly digitised for modern English books (Michel et al. 2011a). The GNV does offer differentiation by language. Subcorpora exist for eight languages, with the English corpus being the biggest, containing more than 350 billion words. The corpus covers a period from 1500 until 2008. However, Michel et al. (2011b) point out that search inquiries between 1800 and 2000 will deliver the highest data density and quality. The problem is that smaller language communities are not included.

Compared to other big data sets, the GNV enables fast and easy access to this pool of information (Chumtong and Kaldewey 2017). Next to a regular search field for the term or phrase of interest, the online tool offers filtering options for the period, the language, the degree of smoothing that affects how the graphs of the search result are displayed, and a case insensitive option. It is also possible to search for more than one term or phrase for direct comparison (Chumtong and Kaldewey 2017). Next to avoid overwhelming the diagram in any given year, the graph will only show books with the term(s) if there are more than 40 occurrences. To deal with the problem presented by the increase in published books over time, the results are normalised by the number published each year (University of London n.d.).

Without a normalisation, it would be impossible to compare the frequency of a specific n-gram over time, as the number of books published in 1500 is not equal to the number of books published in 2010.[4] The viewer, therefore, displays a percentage of the number of occurrences, where the percentage is calculated out of the total number of books published in a given year. Clicking on a point in the plotted graph shows the rate of occurrences for that year (Ophir 2016). The data generated by specific inquiries can then be exported as a list and processed with alternative software packages (for example, "R"), particularly with spreadsheet applications (Chumtong and Kaldewey 2017).

GNV can be used as a tool for discovering hidden patterns of conceptual trends, trends in knowledge, the relative importance of concepts etc. (Kratzer 2019). The main challenge for Digital Humanities will be to take patterns discovered by digital analysis and discern correlations to historical events, to explain patterns by historical forces, causes and relations (Ophir 2016).

How to Use Google NGram Viewer in Digital Humanities

The GNV calculates how often a certain n-gram appears in the selected corpus of a given year relative to the total number of n-grams (Michel et al. 2011a). In computational linguistics, an Ngram is a contiguous sequence of *n* items from a given sequence of text[5], and the items can be phonemes, syllables, letters or words. The GNV database supports n-gram sequences of up to five elements (Ophir 2016). For example, "I" is a 1-gram and "I am" is a 2-grams - this means that if the researcher searches for one word (unigram), he will get the percentage of this word to all the other words found in the corpus of books for a specific year (Kratzer 2019). If the researcher entered more than one word or phrase, each one is

[4]Ibid.
[5]Google NGram View: https://books.google.com/ngrams.

represented by a colour-coded line to contrast with the other search terms. This is similar to Google Trends (see Jurić 2021a), except the search covers a longer period (Karch 2021).

The researcher can modify searches by time frame, degree of detail and corpus type, including several different languages as mentioned. As well as verbs and nouns, scholars can also search for adjectives, adverbs, pronouns, determiners, prepositions and more, using the tags listed on this helpful page of tips. Google estimates the accuracy of this tagging at 95% (Kratzer 2019).

A few features of the GNV may appeal to users who want to dig a little deeper into phrase usage: *wildcard search*, *inflexion search*, *case insensitive search*, *part-of-speech tags* and *n-gram compositions* (Kratzer 2019). For comparisons of several n-grams, it is possible to combine or separate two expressions and divide or multiply expressions to compare n-grams of different frequencies or to isolate frequencies of one n-gram in relation to another. Adding a "+" operator between n-grams allows the researcher to combine multiple frequencies into one. Adding the operator "-" between n-grams allows the subtraction of frequencies from the right from the frequencies from the left and thus enables the measurement of frequency connectivity (Michel et al. 2011a).

Adding the "/" operator between n-grams allows isolating the movement of one frequency to another. Adding the operator "*" between n-grams multiplies the frequency on the left by the frequency with the selected value, that is, by the given number. It allows a comparison of two distinctly different frequencies. Adding the ":" operator between n-grams uses the n-gram on the left and the corpus on the right, and compares n-grams in different corpora (Michel et al. 2011a).

Representation of words in multiple grammatical categories can be achieved by adding the code "_INF" as a suffix to the word's root. Example: "book_INF" generates the appearance of words such as "books", "booking", "booked" for viewing in a single graphical display.[6] GNV offers the option to tag words in search, such as "_NOUN_" (noun), "_VERB_" (verb), "_ADJ_" (adjective), "_ADV_" (adverb). These labels can serve as part of a word or make up the word itself. By entering the operator "=>," it is possible to show the relationship between words and their connection in a sentence.

There is also a case-insensitive option - displaying words written in lowercase, uppercase only, or a combination of words. If smoothing factor "1" is selected as the smoothing level, it means that the data are shown for - for example, 1990 will be the average of the raw data for 1990 summed with one value on each side (previous and future years) and divided by the number year (data for 1989 + data for 1990 + data for 1991) (Kardaš 2020). GNV does not make the search result available for further processing. Even though it is possible to download the raw data, this option only addresses extensive scale analyses that require technical resources and advanced know-how in computer science.[7] However, there is a pragmatic way of extracting data from the HTML source code shown by Chumtong and Kaldewey (2018).

[6]Google NGram View: https://books.google.com/ngrams.

[7]Google Apis: http://storage.googleapis.com/books/ngrams/books/datasetsv2.html. [Accessed 23 December 2021]

The primary method used by GNgram is text mining. It is a method for gathering structured information from unstructured text and discovering meaningful relationships (Berry 2012). Text mining has significant potential for academic application (Berry 2012) to 1) develop new hypotheses, 2) systematic reviewing of literature, and 3) testing of hypotheses. Documents can be mined to confirm or deny an existing hypothesis. In many cases, this might be the first opportunity to test an established belief about something (Berry 2012).

Text mining enables the identification of patterns and relationships within a large body of texts that would otherwise be extremely difficult or time-consuming to discover. Therefore, it is a method that can speed up research and allow us to pose new questions or test the old ones. One of the merits of this tool is that it enables the socio-cultural researcher to spend more time analysing data than on their collection, which is usually very time-consuming (Zięba 2018).

According to Zięba (2018), since the lexical changes are gradual and relatively stable, the fluctuations in word frequency are relevant, and their study will improve our comprehension of the social changes and their consequences (Zięba 2018). However, this method comes with severe limitations and can be useful only under the condition of cautious handling and testing. Otherwise, there is a high potential to gather garbled or false results due to badly formed questions being asked of data or the nature of the text(s) under study (Berry 2012). It is important to stress that no result from text mining should be taken at face value by historians. Results must be checked and confirmed, and this often involves manually delving into the text under study (see section Limitations and Methodology).

Literature Review

Since its introduction in 2010, GNV has been widely described and applied both in the social and natural sciences (Zięba 2018). Berry (2012) describes it as an example of "the way in which code and software become the conditions of possibility for human knowledge". Rutten et al. treat it as a tool to overcome a "chronological distance, or time lag, between books and their subject matter in studies of memory" (Rutten et al. 2013). Michalski et al. (2012) suggest the GNV could be used "as a fast prototyping method for examining time-based properties over a rich sample of literary prose".

Linguists used it to investigate biomedical domain literature in respect of terminology changes. In social studies, it was used to prove that moral ideals and virtues decreased significantly in the American public conversation, to analyse the concepts of happiness across time and cultures, to trace the roots of industrial ecology education to the 1960s and 1970s, to study the relations of science and capitalism, to trace the history of marketing and to introduce the concept of information overload (Zięba 2018).

As already mentioned, Michel et al. (2011a) showed that the corpus enables investigators to study cultural trends quantitatively. The authors inquire into collective memory, compare the rise and fall of fame of the most well-known people, and uncover censorship in Nazi Germany. Michel et al. showed that this

approach could provide insights into fields as diverse as lexicography, the evolution of grammar, collective memory, the adoption of technology, the pursuit of fame, censorship, and historical epidemiology. The authors examined timelines for four diseases: influenza, cholera, HIV and poliomyelitis. In the case of flu, peaks in cultural interest showed excellent correspondence with known historical epidemics (the Russian flu of 1890, the Spanish flu of 1918 and the Asian flu of 1957) (Michel et al. 2011b).

Newberry et al. (2017) use Google Ngram Viewer to analyse changes in the English language from the 12th to the 21st century. Greenfield (2013) tested with GNV her theory on the influence of individualism on the individual's values, behaviour, and psychology.

Acerbi et al. (2013) explored the presentation of emotions in books through the twentieth century using GNV. The authors conclude that stressful and violent historical events leave traces in the expression of emotions in books, so it is possible to detect "happy" and "sad" periods of history, depending on the representation and use of words for certain emotions through books (Acerbi et al. 2013). Overall, GNV has allowed scholars to shed further light on various topics such as gender differences (Twenge et al. 2012), emotions (Mohammad 2012), personality (Roivainen 2015), cognition (Virues-Ortega and Pear 2015), psychotherapy (Rossi at al. 2013), moral values (Mooijman et al. 2018), education (Roivainen 2014), nature (Kesebir and Kesebir 2017) and the development of individualism and collectivism (Grossmann and Varnum 2015).

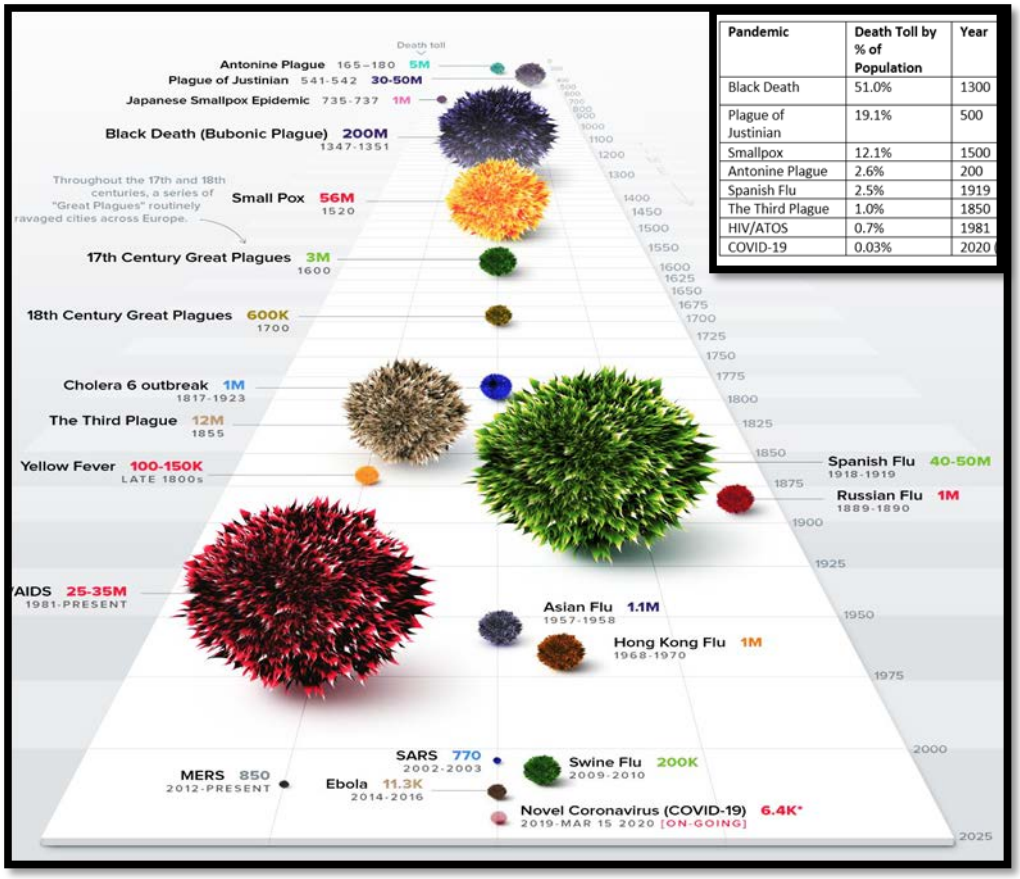
Epidemics through History

Epidemics and pandemics have always been a part of human life. Since the existence of man, there have been infectious diseases. According to Harari (2014), infectious diseases start when a person begins living sedentary; stops collecting and hunting. The First Agrarian Revolution cost man various diseases and contagions. The man no longer moved; he began to breed, keep animals and live in one place, which became an excellent prerequisite for developing diseases (Harari 2014). The spread of trade and the interaction of a growing number of people has led to epidemics, and in those times, it was not even known what humanity was facing. As humanity became more civilised, with the emergence of larger cities and population growth, exotic trade routes, and increased contact with different people, animals and ecosystems, the emergence of pandemics became greater.[8]

The infographic below (Figure 1) outlines some of the deadliest pandemics in human history, from the Antonine Plague that struck the Roman Empire from 165 to 180 to today's current events and coronaviruses.

[8]Lider.hr: https://lider.media/poslovna-scena/svijet/infografika-sve-pandemije-kroz-povijest-130435. [Accessed 23 October 2021]

Figure 1. *Timeline of Historical Pandemics*



Pandemic	Death Toll by % of Population	Year
Black Death	51.0%	1300
Plague of Justinian	19.1%	500
Smallpox	12.1%	1500
Antonine Plague	2.6%	200
Spanish Flu	2.5%	1919
The Third Plague	1.0%	1850
HIV/ATOS	0.7%	1981
COVID-19	0.03%	2020

Source: Visual capitalist, CDC, WHO, BBC, Encyclopedia Britannica (https://lider.media/poslovna-scena/svijet/infografika-sve-pandemije-kroz-povijest-130435), edited by author

By the end of the 16th century, influenza was likely beginning to become understood as a specific, recognisable disease with epidemic and endemic forms. Since pandemic 1781–1782, starting in China, influenza became associated with sudden outbreaks of febrile illness (Potter 2001). Around the world, during the pandemics of 1889 (Russian flu) and 1918/1919 (Spanish flu), between 50 and 100 million people are estimated to have died (Spinney 2018; see: Kucharski 2020). A direct comparison between the pre-pandemic and the coronavirus cannot be made. The world at the time did not know what made people die, and viruses as the cause of the disease were discovered only in 1933. But these pandemics still have something in common: they have thrown humanity into a deep crisis. That is why we wonder if the experiences from historical records about pandemics can help us prepare for the actual pandemic and the time after the pandemic.

The problem also arises in differentiation between Flu and COVID-19. Flu and COVID-19 are contagious respiratory illnesses, but different viruses cause them. COVID-19 is caused by infection with a coronavirus first identified in 2019, and flu is caused by infection with influenza viruses (CDC n.d.). Similarities are that both COVID-19 and flu can have varying signs and symptoms, ranging from no symptoms (asymptomatic) to severe symptoms. Common symptoms that COVID-19 and flu share include: fever or feeling feverish/having chills; cough;

shortness of breath or difficulty breathing; fatigue (tiredness); sore throat; runny or stuffy nose; muscle pain or body aches; headache; vomiting and diarrhoea (CDC n.d.).

Russian Flu - An Earlier Coronavirus Pandemic?

According to Van Ranst, a flu-like illness that caused loss of taste and smell in the late 19th century was probably caused by a coronavirus that still causes the "common cold" in people today (King 2021). Van Ranst states that the COVID-19 virus will follow a similar pattern and become a continuously circulating, or "endemic" virus, joining four other human coronaviruses that infect people with common cold symptoms. "The virus OC43 is still around. It is now responsible for common colds (…). And probably in some elderly people, it can lead to severe illnesses (…). COVID-19 is now the most intensely studied virus ever. These other viruses received far less attention" (King 2021).

Vijgen et al. (2005) showed that at the same time, historical records showed a highly infectious respiratory disease with a high mortality rate affecting cattle herds around the world (see: Crookshank 1897). Today, the same similar disease is known as contagious bovine pleuropneumonia (Vijgen et al. 2005). In the XIX century, the clinical symptoms of CBPP would have been difficult to distinguish from those of BCoV pneumonia. Most industrialised countries mounted massive culling operations between 1870 and 1890 and were able to eradicate the disease by the beginning of the XX century (Storz et al. 1996). According to Vijgen et al. (2005), during the slaughtering of CBPP-affected herds, there was ample opportunity for the culling personnel to come into contact with bovine respiratory secretions. Around the period in which the BCoV interspecies transmission would probably have taken place, a human epidemic ascribed to influenza was spreading worldwide.

The 1889-1890 pandemic probably originated in Central Asia and was characterised by malaise, fever, and pronounced central nervous system symptoms (Vijgen et al. 2005). Indisputable evidence that an influenza virus was the causative agent of this epidemic was never obtained due to the lack of tissue samples from that period (Vijgen et al. 2005). However, post epidemic analysis in 1957 of the influenza antibody pattern in sera of 50 to 100 years old indicated that H2N2 influenza antibodies might have originated from the 1889-1890 pandemic (Mulder and Masurel 1958). According to Vijgen et al. (2005), dating the most recent common ancestor of BCoV and HCoV-OC43 to around 1890 is one argument. Another argument is that central nervous system symptoms were more pronounced during the 1889-1890 epidemic than in other influenza outbreaks (Anonymous 1958). It has been shown that HCoV-OC43 can be neuroinvasive (Arbour et al. 2000).

The work of Brüssow and Brüssow (2021) reported that medical reports from Britain and Germany on patients suffering from the Russian flu share several characteristics with COVID-19. Most notable are multisystem affections comprising respiratory, gastrointestinal and neurological symptoms, including loss of taste and smell perception. In COVID-19 and unlike in influenza, mortality was seen in

elderly subjects, while children were only weakly affected (Brüssow and Brüssow 2021).

The Russian flu pandemic claimed the lives of an estimated 1 million humans from a world population of 1.5 billion people and represented thus one of the great epidemics of the 19th century (Valleron et al. 2010). The pandemic spread was extremely rapid, with a starting point at St Petersburg in December 1889 (Valleron et al. 2010id). The UK and Scottish cities were hit only six weeks later. The mean basic reproduction rate was 2.15, and the highest reproduction rates were observed at Stuttgart, St Petersburg, and Amsterdam (Valleron et al. 2010).

The Russian flu was described as influenza because viruses were still unknown at the time. Since the oldest influenza viruses were isolated and kept as laboratory stocks only since the 1930s, direct evidence for linking influenza viruses with the Russian flu is lacking (Brüssow and Brüssow 2021). In contrast, direct virological proof for the attribution of the Spanish flu from 1918 to 1919 to an influenza virus has been achieved by finding pathological samples and corpses of pandemic victims buried in permafrost soils, followed by reviving this pandemic influenza virus in the laboratory (Brüssow and Brüssow 2021).

To address the question of whether the clinical symptoms reported for the Russian flu patients better fit "an influenza virus infection or a trans-species infection h a bovine coronavirus or another infectious agent," Brüssow and Brüssow (2021) used two comprehensive contemporary reports on the Russian flu pandemic from Britain and Germany. According to Parsons (1890), Brüssow and Brüssow (2021) concluded that many observations described in the Parsons report resemble more characteristics of COVID-19 than those of influenza. Notable are light affection in adolescents and age as a risk factor for mortality: "Influenza was a disease especially fatal to elderly persons" (Parsons 1890). "Pulmonary inflammation was the most frequent cause of death and affected the very old and the previously diseased" (Parsons 1890).

Kousoulis and Tsoucalas (2021) also concluded that some characteristics of the 1889 pandemic resemble more coronavirus affection than classical influenza. Further insight is provided by an Encyclopaedia Britannica entry on "Influenza" published in 1911 (Encyclopædia Britannica 1911). According to Encyclopaedia Britannica from 1911, "influenza melancholia is twice as frequent as all other forms of insanity put together. Other common after-effects are weakness or "loss of the special senses, particularly taste and smell" (The German "Verein für Innere Medizin") Report issued in 1892 at Berlin[9] also lists loss of smell and taste.

According to Van Ranst, "incidences like COVID-19 happened all the time, but we did not notice them" - medicine detects viruses more frequently (King 2021). "If some of these outbreaks, like SARS in 2003, happened one hundred years ago, then it would not have been noticed, and it would be a local outbreak" (King 2021). In the context of the current pandemic, it is surprising that the COVID-19 virus was sequenced so quickly, especially when considering that one of the most common cold viruses, OC43, had not even been sequenced until 2003 by Mark Van Ranst et al. (King 2021).

[9]Leyden and Guttmann, 1892: https://collections.nlm.nih.gov/catalog/ nlm:nlmuid-64820270R-bk.

It is, of course, difficult to formulate a hypothesis for a microbiological aetiology of a pandemic that occurred 133 years ago, at an epoch when viruses were still unknown. But differentiating an influenza virus infection from a COVID-19 patient purely on the clinical ground is a problematic task for a physician today (Brüssow and Brüssow 2021) because the symptoms overlap. As we have already stated, the most important observations of the loss of smell and taste (anosmia and ageusia) were made during the Russian flu pandemic and with COVID-19. Since anosmia and ageusia are now used as relatively reliable clinical diagnostic markers for COVID-19 (Bénézit et al. 2020), one is tempted to attribute this specific symptom seen in the Russian flu pandemic patients more to a coronavirus than to an influenza virus infection.

According to a thesis from Van Ranst (King 2021) and a reformulated hypothesis by Telenti et al. (2021), the world faced 1890 a coronavirus pandemic. Due to the mentioned limitations, it is impossible to have medical evidence. Therefore, we have looked for evidence in history using the method of Digital Humanities and GNV below.

Methods

In our work, we have used the new updated English corpora (2019) to exploit the advantages of improved OCR and better underlying library and publisher metadata. We chose to work on an English (both British and American) corpus, as it is the most extensive database available so far. We have also used both the German (2019) and Russian corpora (2012) for comparison and verification of results.

Our approach is based on analysing the so-called pandemic-related words during history. The objective was to calculate the ratio of increasing to decreasing trends in the changes in frequencies of the words representing the Russian flu symptoms and compare similarities between the development of the Russian flu and COVID-19. If the desired term or set of words is entered in the search engine, for example, the word “epidemic”, the graphic display on the Y-axis shows what percentage of words in the selected corpus over the years (X-axis) make up the word.

It is important to emphasise that the smoothing factor “3” we use in the paper shows the average for each year, considering the three previous and three upcoming years. The validity of the data obtained is guaranteed by normalising the data with the number of published books each year (Michel et al. 2011a). As previously mentioned, GNV provides five operators that the researcher can use to combine n-grams: “+, -, /, *, :” With the “wild card”, a searcher can ask for information that is not pre-defined by other search keywords. That can lead to an exploration of hidden patterns (Ophir 2016). The wild card can be applied to the next adjacent word and different patterns. When the researcher puts a “*” in place of a word, the Ngram Viewer display the top ten substitutions. For instance, to find the most popular words following “University of”, the researcher should search for

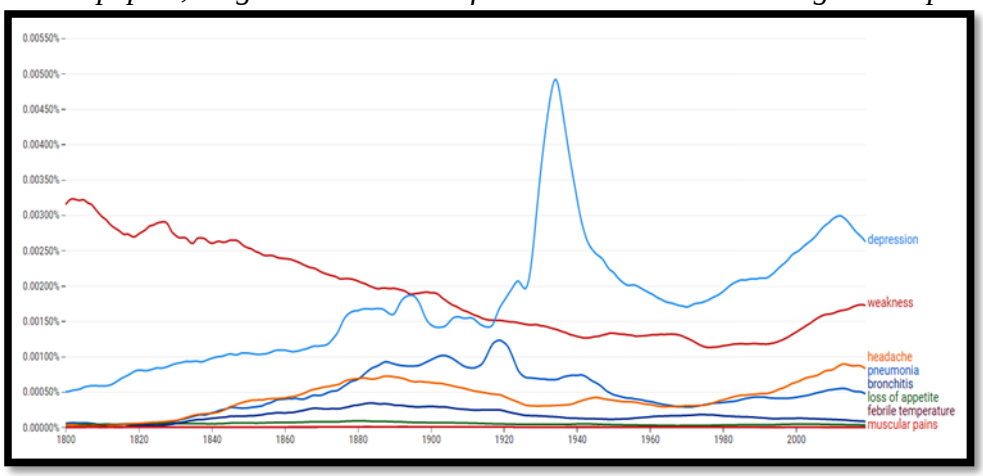
"University of *".[10] For our study, this operator is helpful because it shows that the term "loss of smell" is most often mentioned in combination with the term "loss of taste". In addition, we see that both terms are used frequently during the Russian flu.

Results and Discussion

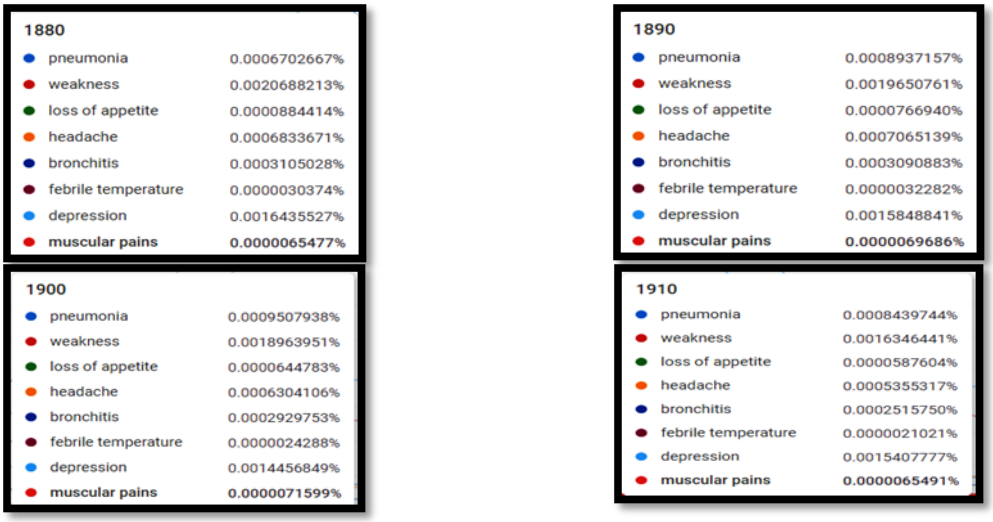
In the section Literature review, we have listed some of the sources we discovered using GNV to confirm the thesis that the Russian flu was a coronavirus infection, i.e., that COVID-19 is not a unique phenomenon. In the following, we show how to use NGram concerning pandemics throughout history and lessons for today. The first example (Figure 2) relates to the above symptoms that GNV correctly records, which is the first evidence of the reliability of this approach.

Figure 2 shows the increase in the mention of symptoms "pneumonia; weakness; loss of appetite; headache; bronchitis; febrile temperature; depression and muscular pain" in the English book corpora at the time of the outbreak of the Russian flu (1889-1891). We chose the years 1880, 1890, 1900 and 1910 to show the frequencies of mentioning symptoms in the period before the outbreak of the Russian flu and in the period after. Figure 2 indicates that NGram is a reliable tool for monitoring social trends in the past.

Figure 2. *Frequencies for the Symptoms "Pneumonia; Weakness; Loss of Appetite; Headache; Bronchitis; Febrile Temperature; Depression and Muscular Pain" Mentioned in Newspapers, Magazines and Books from 1800 to 2019 in the English Corpus*



[10]Google NGram View: https://books.google.com/ngrams.



Source: author's creation based on Google Ngram (http://books.google.com/ngrams)

Figure 3. *Frequencies for the Words "Anosmia" and "Ageusia" from 1800 to 2019 in the English Corpus*

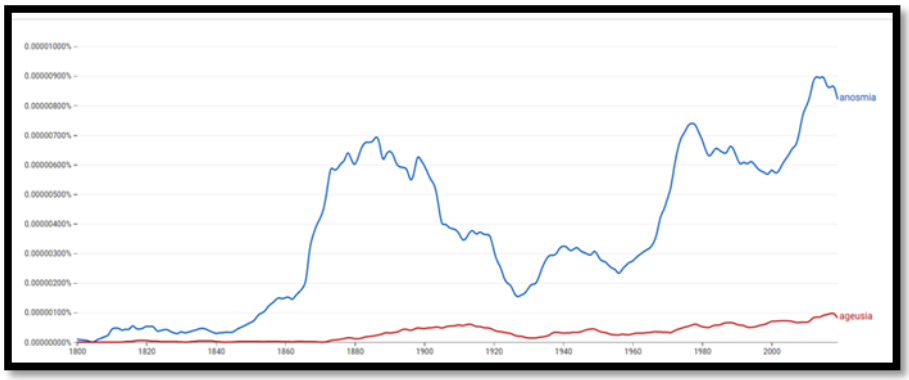


Figure 3 shows the rapid increase in the mention of the term "anosmia" (loss of smell) and "ageusia" (loss of taste) in English book corpora at the time of the outbreak of the Russian flu and immediately after it (1889-1891).

Figure 4. *Frequencies for the Words "Loss of Smell" and "Loss of Taste" from 1700 to 2019 in the English Corpus*

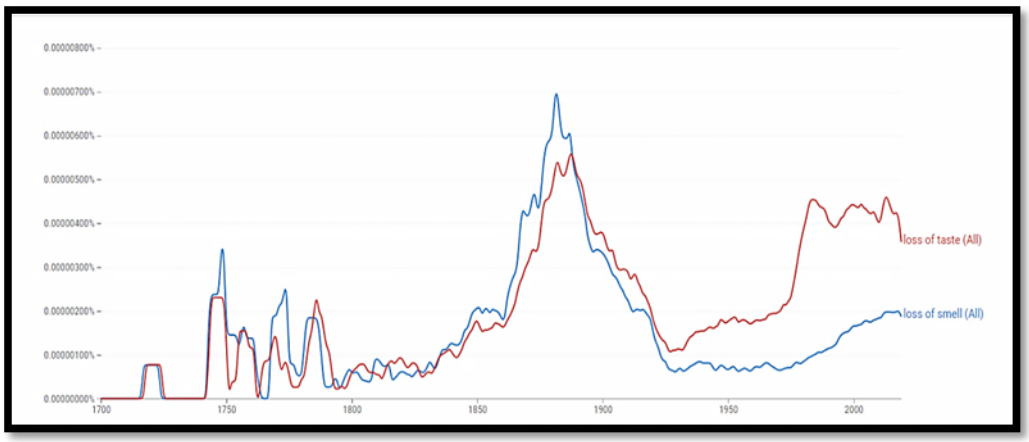
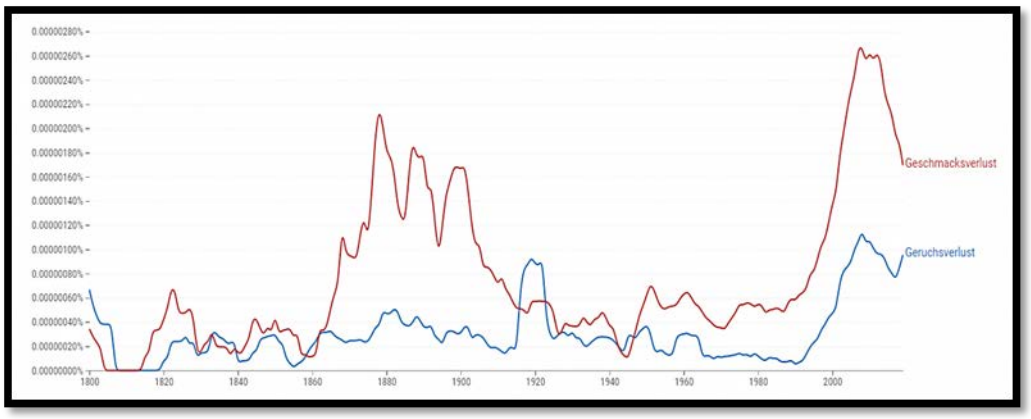


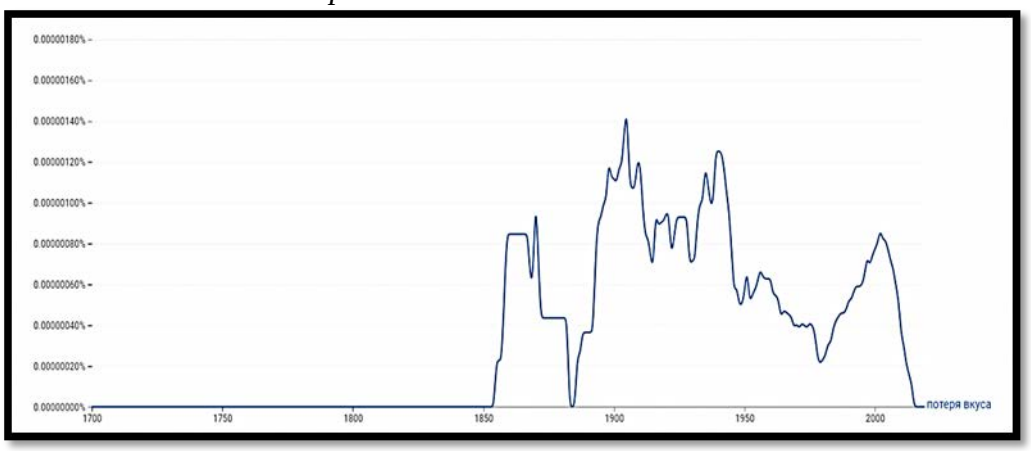
Figure 4 shows the increase in the mention of the term "loss of smell" and "loss of taste" in English book corpora (including newspapers and magazines) at the time of the outbreak of the Russian flu and immediately after it (1889-1891). We can see the same development in German and Russian book corpora (Figures 5 and 6).

Figure 5. *Frequencies for the Words "Geruchsverlust" (Loss of Smell) and "Geschmackverlust" (Loss of Taste) from 1700 to 2019 in the German Corpus*



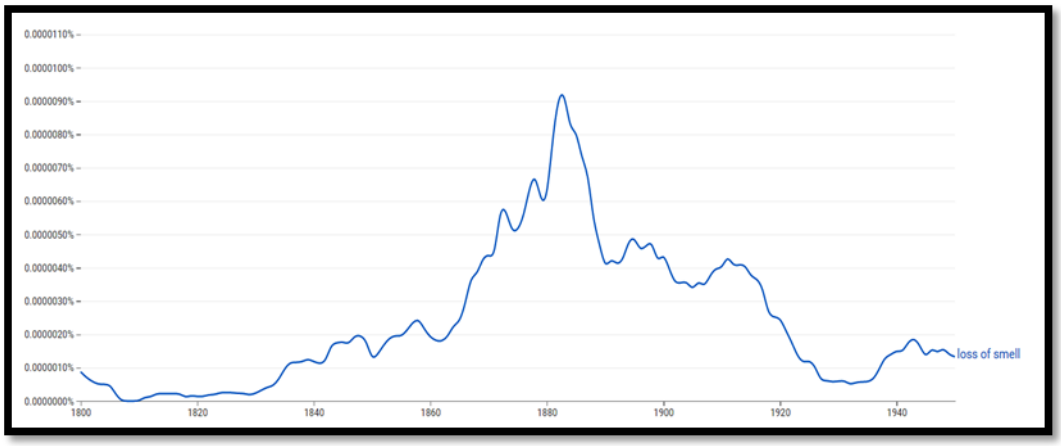
In contrast to the German and English one, the Russian corpus (Figure 6) indicates censorship because the terms quickly disappear from the public space after their sudden appearance, i.e., it is no longer mentioned in newspapers or books. The possibility of censorship is also mentioned in the work of Brüssow (2021).

Figure 6. *Frequencies for the Words "Потеря Вкуса (Loss of Taste) "from 1700 to 2019 in the Russian Corpus*



The English One Million option allows searches that limit books to 6,000 in any given year. Google has made attempts to select books randomly, but at the same time to maintain the subject distributions for each year (University of London n.d.). Figure 7 also shows, in this case, an apparent increase in the use of the term "loss of smell" in books during the Russian flu.

Figure 7. *Frequencies for the Term "Loss of Smell" from 1800 to 2019 in the Corpus English One Million*



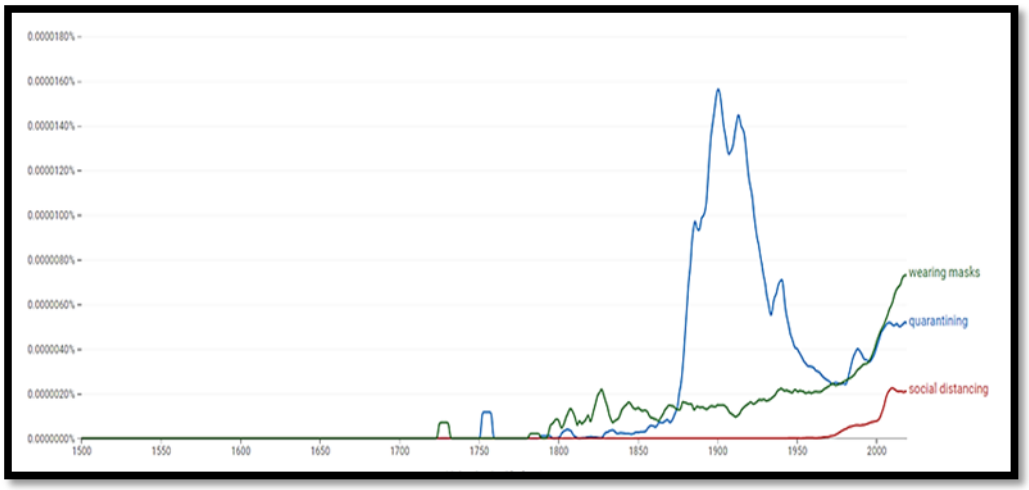
Further similarities between Russian flu and COVID-19 are that COVID-19 has, as mentioned, its main fatality in the elderly; this was also noted for the Russian flu pandemic (Rozen 2020). While the peak mortality in the Russian flu pandemic was among the elderly, substantial mortality was also seen in adults with comorbidity, but children suffered only mild symptoms similar to the current COVID-19 pandemic (Rozen 2020).

In our study, by applying NGram, we also evaluated historical reports from newspapers and scientific and medical journals. GNV recorded more than 600 news articles about the Russian flu from 42 newspapers (Paris - Le Temps, Le Matin, Berlin - Vossische Zeitung, London - The Times, and many Austrian newspapers and medical journals such as The Lancet). The high attack rate of Russian flu can be read in the newspapers that reported the closure of schools, universities and factories because a large part of the staff fell ill. Reports quoted by the newspapers noted that mortality rates had increased by 30% compared to the same period of the pre-pandemic year.

The past pandemic has elements relevant to the COVID-19 pandemic, showing the measures that we undertake today and the same as they did in 1918 – social distancing, wearing masks, quarantining, and travel restrictions (King 2021). But just as individuals forget about the past, so do societies (Halbwachs 1992). Studying past pandemics shows that the pandemic stops on its own. According to mentioned historical records, a pandemic's 'natural' length is two to five years (Spinney 2018). In the absence of treatments and a vaccine, both the Russian and the Spanish flu ran and stopped after two to three years. The wearing of masks was during the Spanish flu understood to be of significant importance in preventing infection (Martin et al. 2007). However, "herd immunity" was not necessary to stop the pandemic (Brian 2021).

Despite the similarities, several differences distinguish the COVID-19 situation from the Russian flu. In contrast to its widespread use during the Spanish flu pandemic of 1918, face masks were not used during the Russian flu pandemic (Spinney 2018).

Figure 8. *Frequencies for the Terms "Quarantining", "Social Distancing", and "Wearing Masks" from 1500 to 2019 in the English Corpus*



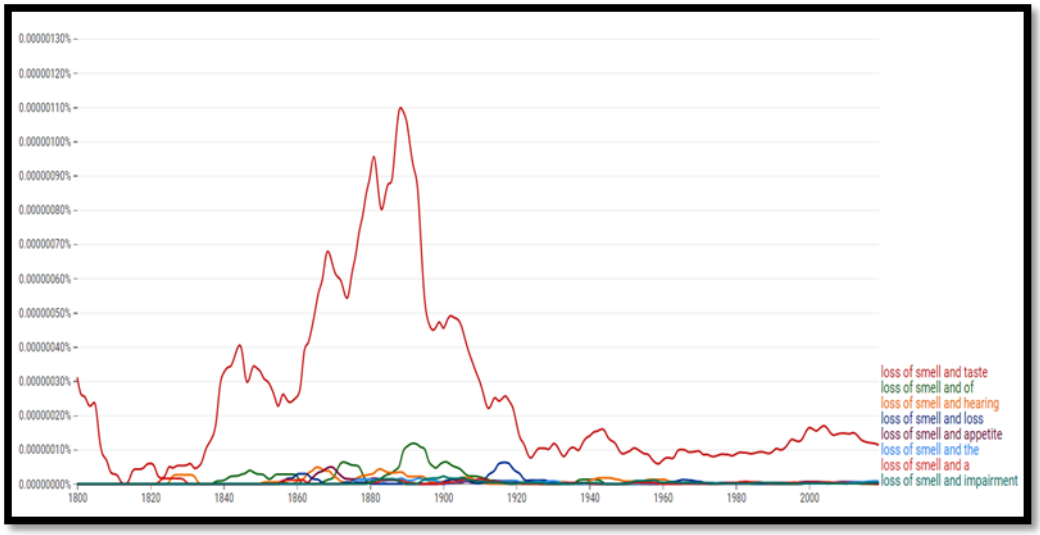
NGram (Figure 8) shows us evidence that during the Russian flu wearing masks was less used than during the period of Spanish flu. This is another proof that NGram correctly records social trends. The term "social distancing" is a newer word coin, so it is not surprising that it was not mentioned in the 19th century, while in the case of the term "quarantining", we see that this term was intensive mentioned in the middle of the XVIII century (bubonic plague between 1738 and 1740) and that it is intensively mentioned during both the Russian and the Spanish flu. Croatia first introduced quarantine, i.e., Dubrovnik, in the middle of the 14th century.[11] However, since the printing press was invented in the middle of the 15th century, such a record cannot be registered by the NGram (this should be borne in mind in the case of many other discoveries and historical events).

Public health measures during the 1889 pandemic consisted mainly of school closures and hygiene advice (handwashing) that GNV also records. Intensive care medicine was 1889 practically non-existent, and the best medical advice of the time was early bedrest and antipyretics (Brüssow 2021).

Figure 9 below shows the benefit of the operator "*" application that enables function: most often mentioned followed words. We can see that the most frequently followed words for the phrase "loss of smell" is "loss of taste", which indicates similarities between the Russian flu and COVID-19.

[11] *Opća i nacionalna enciklopedija*, Zagreb 2006.

Figure 9. *Frequencies for the Words "Loss of Smell and *" from 1800 to 2019 in the English Corpus Showing Most Often Mentioned Followed Words Using the Operator "*"*



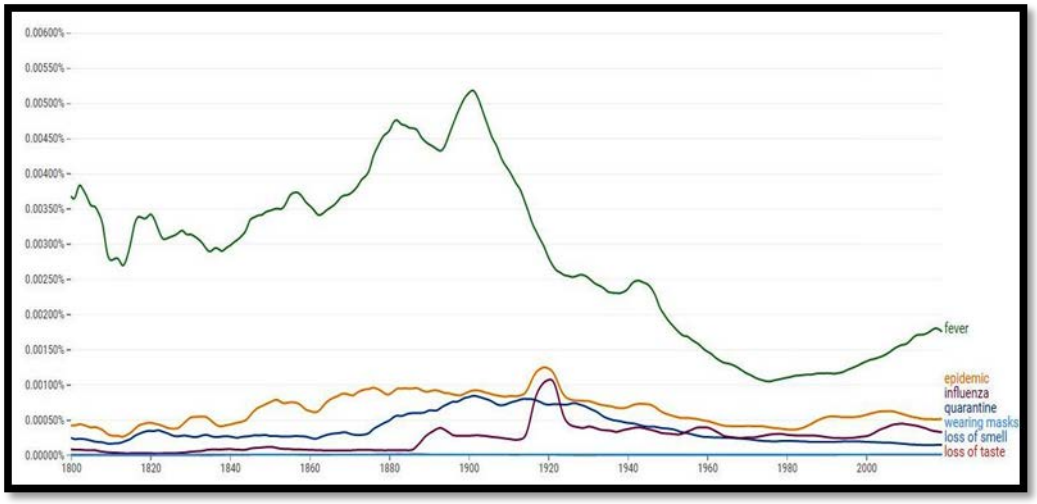
Note: Below the graph, GNV shows year ranges for query terms, and by clicking on those, the query is directly submitted to Google Books. It is important to note here that one can choose between newspapers, magazines and books

Table 1 in the following presents numeric frequencies for the pandemic-related words "fever", "epidemic", "influenza", "quarantine", "wearing masks", "loss of smell", "loss of taste" from 1800 to 2019 in the English corpus (in %) and the Figure 10 shows GNV display for the frequencies.

Table 1. *Numeric Frequencies for the Words "Fever", "Epidemic", "Influenza", "Quarantine", "Wearing Masks", "Loss of Smell", "Loss of Taste" from 1800 to 2019 in the English Corpus (in %)*

Russian flu	**1880**	**1889**	**1890**	**1891**	**1900**
loss of smell	0.0000049357	0.0000043904	0.0000042023	0.0000040161	0.0000028211
loss of taste	0.0000040433	0.0000047123	0.0000044648	0.0000043490	0.0000033861
fever	0.0045785303	0.0044563019	0.0044123274	0.0043885018	0.0051403633
epidemic	0.0008526997	0.0008944025	0.0008965982	0.0009177670	0.0008983375
quarantine	0.0004794893	0.0005985671	0.0006383930	0.0006295467	0.0008166632
influenza	0.0000663529	0.0002639855	0.0002983151	0.0003359815	0.0002702021
wearing masks	0.0000015962	0.0000013616	0.0000013950	0.0000013922	0.0000015227

Figure 10. *GNV display - Frequencies for the Words "Fever", "Epidemic", "Influenza", "Quarantine", "Wearing Masks", "Loss of Smell", "Loss of Taste" from 1800 to 2019 in the English Corpus*



We can see that the frequency of the words "loss of smell" and "loss of taste" rapidly increased during the Russian flu and that the mention of this symptom fell sharply after the pandemic stopped.

Figure 11 shows that in the case of symptom "loss of taste," the frequency rose from 0.0000040433 % in 1880 to 0.0000047123 % in 1889 and the mention of this symptom fell sharply after the pandemic stopped in 1900 (0.0000033861%). In the case of symptom "loss of smell," the frequency decreased from 0.0000043904% in 1889 to 0.0000028211% in 1900.

Figure 11. *Frequencies for the Words "Fever", "Epidemic", "Influenza", "Quarantine", "Wearing Masks", "Loss of Smell", "Loss of Taste" in 1880, 1889, 1890, 1891 and 1900 in the English Corpus*

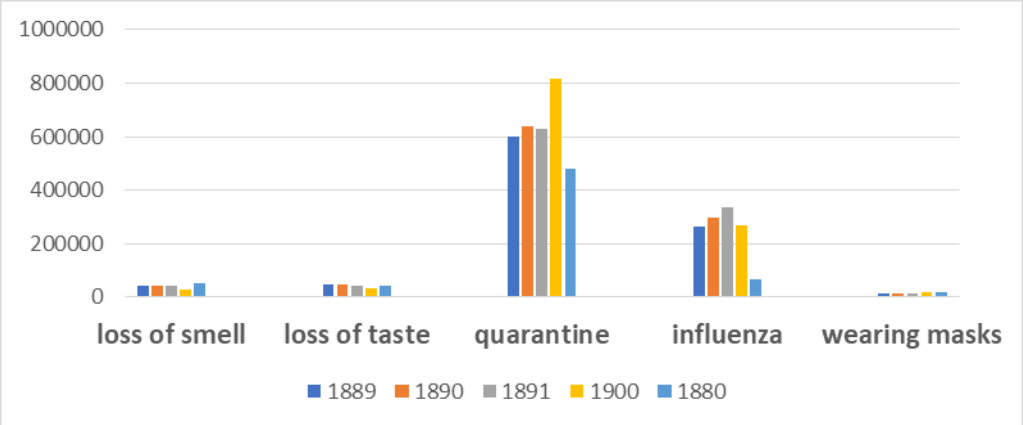
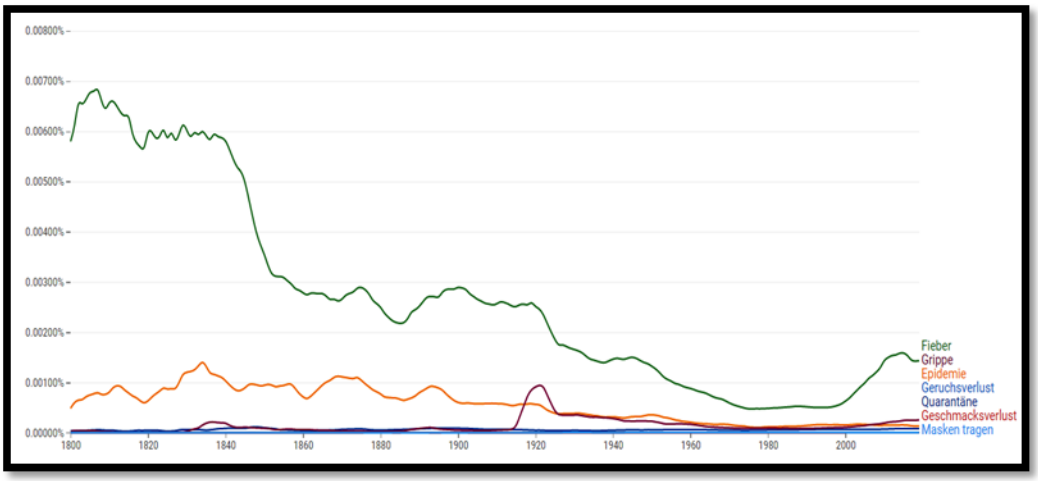


Table 2 presents numeric frequencies for the pandemic-related words from 1800 to 2019 in the German corpus (in %) and the Figure 12 shows GNV display for the frequencies.

Table 2. *Frequencies for the Words "Fieber (Fever)", "Epidemie (Epidemic)", "Grippe (Influenza)", "Quarantäne (Quarantine)", "Masken tragen" (Wearing Masks), "Geruchsverlust (Loss of Smell)", "Geschmacksverlust (Loss of Taste)" from 1800 to 2019 in the German Corpus (in %)*

Russische Grippe	**1889**	**1890**	**1891**	**1900**	**1880**
Geruchsverlust	0.0000004145	0.0000003559	0.0000003501	0.0000003071	0.0000003501
Geschmacksverlust	0.0000017517	0.0000018015	0.0000014463	0.0000016600	0.0000014463
Fieber	0.0024394190	0.0025105012	0.0026102443	0.0029010263	0.0026102443
Epidemie	0.0007245716	0.0008011005	0.0008347561	0.0005970067	0.0008347561
Quarantäne	0.0000705233	0.0000763311	0.0000766396	0.0000863325	0.0000766396
Grippe	0.0000711845	0.0000807742	0.0000877451	0.0000481621	0.0000877451
Masken tragen	0.0000006314	0.0000004534	0.0000003115	0.0000012416	0.0000003115

Figure 12. *Frequencies for the Words "Fieber (Fever)", "Epidemie (Epidemic)", "Grippe (Influenza)", "Quarantäne (Quarantine)", "Masken tragen" (Wearing Masks), "Geruchsverlust (Loss of Smell)", "Geschmacksverlust (Loss of Taste)" from 1800 to 2019 in the German Corpus*



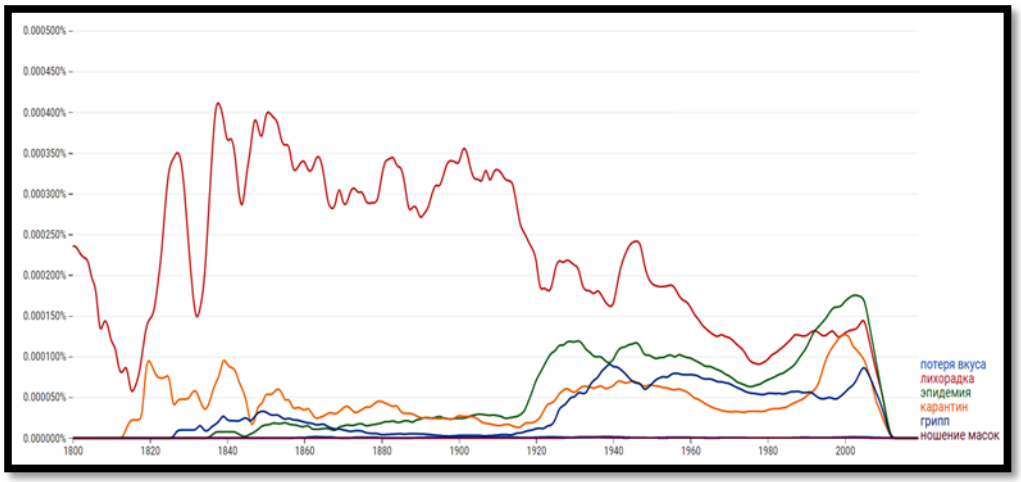
In the German corpus the frequency for "Geschmacksverlust" (loss of taste) rose from 0.0000014463% in 1880 to 0.0000018015% in 1889 and decreased rapidly after the pandemic (1900 = 0.0000016600%). The most rapid change in the German corpus between the years 1890 and 1900 can be noted at the term "Epidemie" (epidemic) (1890 = 0.0008011005%; 1900 = 0.0005970067%).

Table 3 presents numeric frequencies for the pandemic-related words from 1800 to 2012 in the Russian corpus (in %) and the Figure 13 shows GNV display for the frequencies.

Table 3. *Frequencies for the Words "лихорадка" (Fiver), "эпидемия" (Epidemic), "грипп" (Influenza), "карантин" (Quarantine), "ношение масок" (Wearing Masks), "Потеря обоняния" (Loss of Smell), "потеря вкуса" (Loss of Taste) from 1800 to 2012 in the Russian Corpus (in %)*

Russian flu	1889	1890	1891	1900	1880
Потеря обоняния	0.0000005041	0.0000005041	0.0000005041	0.0000001579	0.000000000
потеря вкуса	0.0000004682	0.0000004682	0.0000006787	0.0000011834	0.000000000
лихорадка	0.003102872	0.003102872	0.0002993711	0.0003607911	0.0003471586
эпидемия	0.0000247684	0.0000247684	0.0000278790	0.0000251270	0.0000191910
карантин	0.0000277171	0.0000277171	0.0000254140	0.0000297613	0.0000473150
грипп	0.0000065101	0.0000065101	0.0000057692	0.0000044993	0.000052766
ношение масок	0.0000000000	0.0000000000	0.0000000000	0.0000000000	0.0000000000

Figure 13. *Frequencies for the words "лихорадка" (fiver), "эпидемия" (Epidemic), "грипп" (Influenza), "карантин" (Quarantine), "ношение масок" (Wearing Masks), "Потеря обоняния" (Loss of Smell), "потеря вкуса" (Loss of Taste) from 1800 to 2012 in the Russian Corpus*



In the Russian corpus the frequency for "loss of taste" rose from 0% in 1880 to 0.0000004682% in 1889 and decreased rapidly after the pandemic (1900 = 0.0000011834%). The frequency for "loss of smell" rose from 0.000000000% in 1880 to 0.0000005041% in 1889 and decreased rapidly after the pandemic (1900 = 0.0000001579%).

Table 4. *Comparison of the Symptom "Loss of Taste" in the English, German and Russian Book Corpus (in %)*

loss of taste	1880 (decrease)	1889 (increase)	1890 (increase)	1891 (increase)	1900 (decrease)
English corpus	0.0000040433 %	0.0000047123	0.0000044648	0.0000043490	0.0000033861
German corpus	0.0000014463	0.0000017517	0.0000018015	0.0000014463	0.0000016600
Russian corpus	0.000000000	0.0000004682	0.0000004682	0.0000006787	0.0000011834

The comparison presented in Table 4. clearly shows that all the three corpora (English, German and Russian corpus) we used for the analysis show that the symptoms of "loss of taste" before and after the outbreak of the Russian flu pandemic were mentioned in the literature, newspapers and magazines to a much lesser extent then it was during the pandemic. The same is noticeable in almost all other symptoms and social trends.

The frequency of the words "fever", "epidemic", "influenza", "quarantine", "wearing masks", "loss of smell", "loss of taste" increased rapidly during the Russian flu from 1899 to 1891, which is especially noticeable in the German and Russian book corpus. In the case of symptom "loss of taste" in the English corpus, the frequency rose from 0.0000040433% in 1880 to 0.0000047123% in 1889. One cannot but notice that the mention of this symptom fell sharply after the pandemic stopped in 1900 (0.0000033861%).

In the Russian corpus, the frequency rose from 0.000000000% in 1880 to 0.0000004682% in 1889 and decreased rapidly after the pandemic (1900 = 0.0000011834%). In the German corpus the frequency rose from 0.0000014463% in 1880 to 0.0000018015 % in 1889 and decreased rapidly after the pandemic (1900 = 0.0000016600%). These results prove our thesis that GNV is a reliable tool for monitoring social trends during pandemics and a very useful window into history.

Of the other social trends we have analysed using GNV, we would highlight the terms: "economic crisis", "unemployment", and "hunger". None of these terms shows a significant frequency deviation compared to the period immediately before and after the epidemic. From the historical point of view (GNV as the window of history), we conclude that a significant crisis does not need to occur after the COVID-19 pandemic. Judging by the collective memory of humanity and the insights we have gained using GNV, the virus will undoubtedly weaken over time. The results of GNV show that the pandemic in this decade will turn into an endemic or common cold and will stay with us like other types of flu.

Limitations

The possibilities and limitations of using the GNV for research have been controversially discussed (Younes and Reips 2019). Although many Google Ngram studies indicate scientific recognition, several papers address methodological issues (Gooding 2012). The data set from GNV has been criticised for its reliance on inaccurate OCR, an overabundance of scientific literature, and large numbers of incorrectly dated and categorised texts (Pechenick 2015). Because of these errors, and because it is uncontrolled for bias, according to Zhang (2017), it is risky to use this corpus to study language or test theories. Since the data set does not include metadata, it may not reflect the general linguistic or cultural change and can only hint at its effect (Younes and Reips 2019).

The main points of criticism relate to insufficient OCR, particularly concerning semantic scanning errors (which can affect words such as fail and sail due to similarities in the letters "f" and "s") (Pechenick et al. 2015) and messy

metadata that may lead to the display of word frequencies in the wrong or unrelated time intervals (Gooding 2012). The last criticism is that the percentage considers published manuscripts regardless of their importance (Kratzer 2019).

Hilpert and Gries (2009) warn that a statistical measure that would help determine if the observed frequencies differ from the mean more than expected should be incorporated in more complex studies. Mayer-Schönberger and Cukier express concern about machines replacing human activities and decision-making (see: Younes and Reips 2019). Boyd and Crawford also raise critical questions about big data: "Will large-scale search data help us create better tools, services, and public goods? Or will it usher in a new wave of privacy incursions and invasive marketing? (…) The era of Big Data has only just begun, but it is already important that we start questioning the assumptions, values, and biases of this new wave of research" (Boyd and Crawford 2012).

Several authors have problematised the GNV corpus and raised doubts about its representation of natural language and its development over time (Pechenick 2015). Chumtong and Kaldewey (2017) highlight that what makes the GNV a valuable research tool is not primarily its accuracy but rather its potential for "quick-and-dirty heuristic analysis". Davis (2014) recognised the dataset as remarkable but perceived the interface too simplistic. He claimed it did not allow for collocations in searches, searching by wildcards and meaningful use of parts of speech.

It also appears that GNV does not consider the different contexts in which the analysed words are set in, and contexts carry the meaning the cause of which we are unable to determine. The fact that the frequency of a word rises does not necessarily mean that the concept is valued more but that it is discussed extensively (Zięba 2018). The GNV enables viewing the excerpts from which the analysed words come; however, as collecting such data has not been automated yet, and would have to be done manually for all words in millions of contexts, it seems implausible to incorporate such information into the study, even if for reasons of time and space (Zięba 2018). Needless to say, either an individual or a larger team cannot study any of the corps manually.

According to Zięba (2018), the usage of GNV should be limited to uncomplicated studies related to word frequency. It cannot be treated as the only tool in researching complex socio-cultural transformations. However, with careful analysis of the results, the GNV does potentially improve our understanding of cultural and linguistic trends over time. With Google making its datasets available, more complex text mining tools can study the ever-growing corpus (University of London n.d.). Compared to the 2009 versions, the 2012 and 2019 versions have more books, improved OCR, improved library and publisher metadata.[12] According to Zięba (2018), even if we consider the imperfections of OCR, GNV still seems to put socio-cultural research in a context whose significance is hard to question, especially if carried out cautiously and conscientiously.

Lakoff agrees that even though the presence of most words and the changes in their frequency does not tell much about the values ascribed to certain phenomena, it may be a sign of recognition of a problem (Lakoff 2013). Younes and Reips

[12]Google NGram View: https://books.google.com/ngrams.

(2019) propose how to address these concerns by introducing several methodological procedures such as cross-validations via the examination of different language corpora, the use of word inflexions and synonyms, as well as the use of a newly-developed standardisation procedure that all aim at increasing the reliability of GNV studies.

According to Solovyev et al. (2020), there are several ways to make the GBN corpus results more reliable. On the one hand, it is impossible to correct all its errors, and on the other, perfectionism should be avoided in this field since no one knows what an ideal corpus would be like (Solovyev et al. 2020). The first one is to use all possible support data extracted from the corpus and use synonyms (Younes and Reips 2019). Younes recommends studying each word and its three synonyms selected from the relevant dictionaries of synonyms (Younes and Reips 2019). Sometimes it is pertinent to perform comparative studies and see how the same or close meaning terms are used in different corpora presented in GNV (Solovyev et al. 2020). The second way to enhance the results is to pre-process the GNV raw data. Solovyev et al. show that the GNV corpus can be regarded as representative for the following reasons. It is the most extensive corpus ever existed, including texts of various types and genres written by people of different ages, sex and diverse backgrounds. Such diverse texts, their length and size, serve as a solid empirical foundation for linguistic and related studies (Solovyev et al. 2020).

Conclusions

This paper showed that the Google Ngram (GNV) can give us useful insights into the history of pandemics and that the tools of Digital Humanities can discover hidden patterns in history. With the help of GNV, we have analysed the epidemiological literature on the Russian flu pandemic development for hints on how the COVID-19 might develop in the following years. We showed indications that the COVID-19 is not a unique phenomenon because the Russian flu might be a coronavirus infection. This thesis still cannot be confirmed, requiring further historical and medical research.

According to our study, the GNV clearly shows the influence that social changes have on word frequency. The most important observation of similarities between the Russian flu pandemic and COVID-19 is the loss of smell and taste (anosmia and ageusia). The frequency of the words “fever”, “epidemic”, “influenza”, “quarantine”, “wearing masks”, “loss of smell”, “loss of taste” increased rapidly during the Russian flu from 1899 to 1891, which is especially noticeable in the German and Russian book corpus. The mention of symptoms and the pandemic-related words fell sharply after the pandemic stopped.

Other social trends we have analysed using GNV “economic crisis”, “unemployment”, and “hunger” do not show a significant deviation in frequencies compared to the period immediately before and after the epidemic. We conclude that a historical perspective shows that a substantial crisis does not need to occur after the COVID-19 pandemic. Judging by the collective memory of humanity and

the insights we have gained using GNV, the virus will undoubtedly weaken over time. The results of GNV show that the pandemic in this decade will turn into an endemic or common cold and will stay with us like other types of flu.

These results prove our thesis that GNV is a reliable tool for monitoring social trends during pandemics and a very useful window into history. This study has also shown how to overcome the binderies between the social sciences and the humanities. The results of this study open a discussion on the usefulness of the GNV insights possibilities into past socio-cultural development, i.e., epidemics and pandemics that can serve as lessons for today. We have shown hidden patterns of conceptual trends in history and their relationships with current development in the case of the pandemic COVID-19. Despite the numerous indications we have demonstrated, we are aware that the hypothesis still cannot be confirmed and that it is necessary to require further historical and medical research. The main challenge was to correctly interpret patterns discovered by digital analysis and discern correlations, causes and relations between historical events and current development.

The benefit of this method could help complement historical medical records, which are often woefully incomplete. However, this method has serious limitations and can be useful only under cautious handling and testing. Despite its limitations, the GNV research based on an over 500 billion word corpus is prone to produce valuable results when approached with great care and consideration according to the restrictions brought by this method and will certainly find application in many research areas in humanities and social sciences in future.

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Management Strategies for Engineering Faculties under Consideration of Current Developments in the Higher Education Sector

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Faculty management organizes the effective operation of a faculty and is responsible for all occurring problems. As the work will be done mainly behind the scenes, faculty management's influence on performance and development of a faculty often is underestimated. The challenge for faculty managers lies in balancing the conflict between governing and supporting faculty members while being in an uncomfortable sandwich position – between the central university administration and the faculty members. The big ambition of administration should be to appear "invisible" for university staff, to work efficiently and to avoid a waste of faculty resources. Nevertheless, administration has a strong positon in a higher education institution. Its decisions about resources and facilities are able to influence teaching and research to advantage or disadvantage of a faculty. The paper explains typical tasks of faculty management and shows in which way it influences engineering teaching and research by using examples from the daily working practice. Additionally, author gives advices how to improve faculty administration at engineering faculties. Efficient faculty management can contribute to teaching and research immensely, and, as a result, decide about success or failure of faculty performance.

Keywords: *faculty management, administration, engineering education and research*

Introduction

Elementary for the success of a higher education institution is good management. But, concepts of good management and how to achieve it differ. These differences might arise from variations in culture and traditions, historic experiences or from levels of development, to name just a few reasons (Fedrowitz et al. 2011).

Since the invention of New Public Management (NPM) at German Universities around 20 years ago, management methods and instruments are used to optimize and to measure universities' academic and financial outcome. Behind the idea of NPM stands a comprehensive reform concept for the modernization of public administration in order to manage it in a similar way like enterprises (Knopp 2012). The objective is to increase efficiency and effectiveness in public service (see also Bleiklie 2018). The success of NPM methods may be controlled by target

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agreements between the granting public authority and the financed universities. Targets often include the quantity of enrolled students, external funding received, number of outgoing or incoming foreign students, gender equality, dropout rates and cooperation with enterprises. If universities do not sign the target agreements, they risk to receive much less money from the state and to lose staff (Quapp and Holschemacher 2019). As a consequence, the central university management concludes target agreements with faculties. These agreements, normally, form the basis for universities' internal resource allocation. The better the faculties perform the more resources they will receive from the university administration.

This adjustment in public administration management over the last years is the reason why qualified management is of high importance for faculties. The paper gives an overview about basic methods in faculty management under consideration of relevant literature. Furthermore, the authors focus on faculty management at engineering faculties followed by recommendations for improving management quality. The paper will close with conclusions.

Literature Review

There is a huge amount of literature how to manage an enterprise or how to lead teams in economy and the open market. However, managing structural units or leading a team at higher education institutions is a completely different issue. Some literature exists about how to manage universities or faculties (see for example, Hagerer 2020, McGaffery 2019, Scholz and Stein 2014) and NPM (e.g., Bleiklie 2018, Broucker and De Wit 2015, Wan et al. 2021), but only less information about the specific management of the several faculties (see as an example, Mahajan et al. 2021). As the authors experienced, there is nearly no literature which deals with managing an engineering faculty or department.

Basics of Faculty Management

Managing structural units or leading a team at higher education institutions significantly differs from managing a company or an enterprise. Reason for that is, for example, the different funding situation. In Germany, and many other parts of the world, the state or the public hand mainly funds higher education institutions. Thus, university staff normally must not be feared of an insolvency of their employer. Nevertheless, there may be exceptions for private financed higher education institutions.

In Germany, university staff works in public service with special legal provisions, e.g., regarding labor law. Normally, professors receive a permanent engagement inclusive their professor title for life. For academic and administrative staff, public higher education institutions offer high employment security, especially in cases of economic downturn or crisis situations (such as for example in the current COVID-19 pandemic). However, due to the absence of a hire and fire policy, sometimes motivating university staff may be a challenging issue.

Faculty management, not exclusively in Germany, normally consists of dean, vice-deans, deans for study affairs and faculty manager. In Germany, there is the special situation that most of the faculty managers are non-academic staff working in civil service who has open-ended employment contracts with a fixed salary. There are no strategic options, such as performance based funding or other possibilities (e.g., bonus-malus-systems), to reward or penalize their work.

Official authorities, e.g., ministries for higher education, are charged with administrative, functional and/or legal control over universities, depending on the countries' legislation. That means less flexibility for higher education institutions in strategic development and strict requirements resulting from higher education legislation. Furthermore, in Germany, the salary and the number of state financed staff is restricted and universities are unable to adapt their human resources to their current needs.

Due to the above-mentioned specialties of universities compared to companies and enterprises, rules, principles and experiences from the economy and the open market can only be adapted to management of higher education institutions to a very limited extent. Of course, some of the common management principles can be used to run a faculty successfully. Office management tools, such as documentation, deadline management, and absence management for staff are appropriate instruments for facilitating the functioning of a dean's office.

However, the authors experienced a significant difference between organizing engineering faculties and other higher education institution units (e.g., faculties of law) due to partially different targets, performance indicators and culture of the academic disciplines. The specifics of the various subjects may have a significant effect on the management of the respective faculties. Understanding the culture of an academic discipline enables the responsible persons in the faculty's administration to lead the staff, to come to decisions and to find solutions, which will be accepted by all or at least the majority of the academics who work at the structural unit. That is why this paper only focuses on management of engineering faculties.

Faculty Management at Engineering Faculties

Faculty management organizes and supports teaching as well as research. Additionally, it is responsible for self-administration (including strategy, preparation and conduct of meetings of the faculty's councils and boards), finances, human resources, quality management, internationalization and many things more. The following part of the paper will focus only on the most important responsibilities of faculty management.

Organization of Teaching

Teaching is one of the basic tasks of all universities. Depending on the special type of higher education institution and the country in which it is located, professors and lecturers have more or less hours of teaching load. Faculty

administration is obliged to organize teaching and examinations at the faculty and to support the scientists as much as possible in the education of students.

The organization of teaching by faculty management starts with accompanying the process of creating study programs. According to German Law, professors are responsible for the courses of degree programs, especially they may define content and method of their courses, such as topic, form (lectures, seminars, practical and non-practical exercises), structure and duration (Fehling 2021). All professors in a degree course have the same fundamental rights of free teaching. However, in the case that all professors would enforce their rights, efficient course planning would not be possible. Thus, to enable conception of study plans, there must be a balance in practicing lecturers' fundamental rights. Faculty management has to provide assistance to put the subject specific decisions in an administrative and legal frame. Because of that, the faculty's Academic Commission is responsible for proposals for new degree programs or changes to existing curricula. The Academic Commission usually includes both professors and students and discusses the subjects in the curriculum, their duration, the amount of working hours and many other details (Quapp and Holschemacher 2019). However, the final decision about a curriculum takes the Faculty Council, which represents all faculty member groups such as professors, scientific and administrative staff members as well as students.

Furthermore, the organization of teaching includes providing teaching facilities such as lecture rooms and technical equipment, to prepare course planning and to create timetables for students and staff. At the end of the study year, faculty administration may support the professors and lecturers in the documentation processes of their lectures.

Human Resources

The true treasure of a higher education institution is its human resources. The faculty's success in teaching and research is significantly dependent on high qualified and motivated staff. Thus, for example, with many specialized research and teaching assistants, professors are able to apply for a higher number of research projects, to gain third party funds for the faculty and to deliver teaching of high quality.

Nevertheless, currently, hiring qualified staff for engineering faculties in Germany is a huge problem. Most of the German Universities are state universities and the salary is lower than in industry. Furthermore, sometimes only temporary employment for third party funded research and/or teaching assistants can be offered. That is why working at higher education institutions is not quite attractive for excellent educated engineers. Additionally, the lack of qualified engineers makes the situation more demanding for universities.

Faculty administration is responsible for organizing all human resources processes at the faculty, starting with developing and posting a position, to organizing the application process and the job interviews. This should always be done in compliance with the legal requirements as well as university's gender and diversity strategy.

Furthermore, the dean's office manages the provision of an appropriate working environment including office space, necessary technical equipment and all useful information. It is responsible for all occurring questions and problems, should give feedback, and motivate the faculty staff. This can be realized by regular staff meetings and interviews.

Successful human resources management at higher education institutions in Germany is challenging because the ways to motivate or to discipline are limited. Furthermore, many different staff groups are working at a university, such as professors, lecturers, scientific and administrative staff who are paid by the state or by external funding. All of them have different educational backgrounds, needs, intentions and problems. To form them to a team is the main challenge of faculty management.

Budget

Key tasks of faculty management are financing and budget of the faculty. Around 72 per cent of German universities (Statistisches Bundesamt 2020) are state institutions and therefore funded by the German Federal States. Once a year, higher education institutions receive their operating budget from the state and distribute a part of it by a fund allocation system over the faculties.

The administration of the faculty may distribute all or a part of its operating budget among the faculty members for their own use. Another system is to allocate the money based on applications of faculty members to the faculty management.

At Faculty of Civil Engineering at HTWK Leipzig, the operating budget is distributed to the professors or institutes by using a two-pillar-model. One part of the budget is distributed non-performance based, e.g., on the basis of the number of professors and state employees. The second part of the budget is distributed performance-based using performance indicators, such as individual teaching load, successful supervised degree theses, acquired third party funds, international activities, publications, conference organizations, memberships in scientific organizations, awards and much more. This system allows rewarding faculty members' activities in various fields of strategic importance.

Quality Management

Faculty management is responsible for quality assurance in teaching and research. Methods can be for example course evaluation, study program accreditation or process evaluation. There is no doubt that evaluation and accreditation of programs and courses done by students and external organizations are an outstanding opportunity for testing the competitiveness of universities, detecting existing problems and providing a stimulus for revisions in programs and faculty strategy. Nevertheless, a clever faculty management knows that quality assurance measures should not be used without any critical reflection. In Germany, study program accreditation and course evaluation by students has been discussed controversially since years (Quapp 2020, Quapp and Holschemacher 2020) because these quality assurance measures affect the constitutionally guaranteed freedom of science to a

considerable extent. That is why faculty management should adapt quality assurance methods to the individual needs of the faculty in order to achieve the best possible results. Additionally, faculty management must secure that quality assurance does not lead to such a high workload for the scientific and administrative staff that main tasks will be neglected.

Internationalization

Internationalization has become a central issue at universities in the last years, with the aim to participate intellectually and financially in the global academic resources. Due to the reduced numbers of local first-year students resulting from the decreasing population in European countries, German universities' survival depends on foreign students. Furthermore, European universities' internationalization efforts are driven by the desire to get larger share of the academic cake that the major countries of academic mobility, namely the United States and Great Britain, divide among themselves.

Internationalization often is a part of target agreements. However, this should not be the only reason for creating an international atmosphere at the faculty. Successful internationalization includes students' and staff mobility, welcoming international guest scientists and their inclusion in the faculty daily working process. Participation of faculty members in international conferences and committees as well as visits at partner universities should be part of the academic routine.

Support of Research

Universities in Germany must foster sciences, culture and education by teaching, research and degree programs (e.g., Federal State of Saxony 2021). Due to their research activities, higher education institutions contribute to development and improvement of the society. Especially in the fields of medicine and engineering, innovations as a result of research are especially tangible for the people.

Mainly in engineering faculties, third party funded research and development plays a major role. Faculty management is able to support scientist to increase research activities by reducing the administrative efforts, e.g., for hiring staff, purchasing research equipment and spending research overheads. Furthermore, it should provide appropriate research facilities such as technical equipment and labs. Nevertheless, administration should also coordinate the faculty's active research projects if there is a need to use the same facilities. This avoids conflicts among the researchers. Furthermore, faculty management has the task to monitor the application of health and safety regulations in offices, labs and while all research activities.

Making research understandable and relevant for society – the so called Third Mission – is one of the current topics in German universities' daily life. The politics urges the sciences to leave their "academic ivory tower" and to increase lifelong learning offers as well as the knowledge and technology transfer to practice (Tauch 2012). To manage that task, faculty administration will be the ideal

contact point between science and society.

Alumni contacts and fundraising have become more and more important in the competition for industry funded research projects or external financial support for student excursions or student competitions. And for the amount of third party funds from the industry, faculty management's activities and the quality of contacts to the industry are important as well.

University Self Administration

For the university leadership, faculty management is partner on the one side and counterweight on the other side. Faculty management has to execute the rectorate's top down decisions and is responsible for negotiating and signing target agreements with the rectorate. In close contact to the president of the university, the deans should do their best to influence the university strategy to the benefit of their faculty.

On faculty level, faculty management is responsible for strategy development, which substantially must correspond to the university strategy. Furthermore, it has to prepare and lead all meetings of the councils and boards of the faculty and to execute their decisions. The dean has to criticize decisions of the Faculty Council as well as of other boards, which do not comply with the legal regulations.

Safety and Hazard Management

An efficient safety and hazard management is the basis for successful teaching and research. It avoids accidents, protects staff from injury, secures the functional capability of technical equipment, and therefore prevents cancellation of courses or delays in research projects.

Safety and hazard management benefits from fixed check-up deadlines, lists with (mobile) phones numbers of contact persons and clear instructions for the case of emergency. Faculty staff should be familiar with this information.

Particular attention must be paid to people with special needs. For pregnant students/faculty members or other high-risk groups, individual solutions have to be developed, especially in using toxic materials and dangerous (lab or experimental) works. In case of emergency, disabled people can be limited to protect and/or to help themselves, for example if they are not able to use elevators in case of fire. Thus, faculties shall develop individual emergency strategy for these special persons.

<u>Safe Occupational Environment</u>

Safe and ergonomic working places contribute to the health and working ability of faculty members. That is why periodical check-ups of offices, labs teaching rooms and other facilities are required. To guarantee a high quality evaluation of the occupational safety, it is recommendable to appoint a staff member as safety officer and to provide him/her regular further training.

Especially in labs or experimental halls, a detailed safety concept is required due to sensible technical equipment and toxic substances or harmful materials. Lab and hall safety first of all benefits from access restriction and access

documentation. Each person working there, whether staff or students, must be instructed how to behave and how to ensure a safe working environment. Elaborating lab or experimental hall users' guidelines can be helpful. Toxic or harmful substances must be inventoried and stored under lock and key.

General Safety at Faculty

A general safety concept provides a feeling of security to staff and students. This includes, if not already forbidden by law of the respective country, the prohibition of weapons on the campus. In addition, access regulations for outside persons to the campus and its documentation may contribute to a feeling of security to all university members. Especially facilities where toxic materials, expensive technical equipment or other relevant resources are stored must be under lock and key. However, in doing so, faculty management shall balance the safety interests of the structural unit with the access needs of students, especially to PC-pools in the evening, at night and at the weekend. For realizing the students' access outside office hours, a flexible key card access system and a video monitoring system as theft protection may be installed.

Preparation for Unforeseen Occurrences

As currently experienced by the COVID-19 pandemic, unforeseen occurrences may affect universities and their structural units to a greater extent. Economic troubles, natural disasters, pandemics, civil unrest, war or terrorism are likely to influence the regular functioning of a faculty.

Due to the COVID-19 pandemic, universities all over the world were forced to reorganize teaching and research to protect staff and students from an infection. First problem was to change the high share of presence teaching in university rooms by online teaching without any personal contact. Faculties had not only to identify suitable online teaching tools, but also to purchase necessary hard and software. Furthermore, face-to-face interactions and oral examinations became impossible which had to be replaced by alternative examination forms without any personal contact.

In Germany, the type of teaching and examination must be fixed in the study and examination regulations for each study program. The faculty council had to adopt and the university's rectorate shall authorize the faculty's study and examination regulations. In the Corona crisis, faculties were not allowed to simply modify teaching and examination types what required a change of the respective regulations. Elaborating new study and examinations regulations for each of the programs and ensuring the relevant decisions in the boards and councils was a time consuming work. A further challenge was to deliver complete and early information to students and staff. Universities and responsible state authorities currently discuss how to deal with the summer term regarding state financial promotion of students or the recognition of the semester as regular semester within the study time.

In addition, conducting research projects in times of the COVID-19 pandemic posed a huge challenge to universities' structural units. Although some research funding organization announced a prolongation of project duration and/or funding,

faculty management had to develop ideas how to enable a continuation of the projects in compliance with all the new hygienic guidelines.

Regarding the health protection of human resources, many faculties organized home office for staff. Essential for effective working in home office is to provide the staff with the necessary hard and software to enable a work result similar to them gained in the offices on the campus.

Universities have learned from the COVID-19 pandemic that staying calm, keeping the overview and having fast and defined decision finding procedures may support an efficient and clever reaction on such a crisis. The future will show, if higher education institutions will use the pandemic as a chance to rethink teaching, research and working area. Unforeseen occurrences, also if they are unpleasant, force management to evaluate the status quo and, by this, create a new approach to faculty management.

Of course, faculty management is not able to prepare for all potential situations but faculty leaders should use the experience from former occurrences and document the found decisions and used measures. Ideally, next generations in faculty management will use these information to learn from the situation and, if necessary, to improve the hazard management.

Improvement of Faculty Management

Faculty management is in an uncomfortable sandwich position between the central university administration and the faculty members. It must enforce faculty interests towards the university management and, on the other side, implement the university strategy on faculty level.

Essential to have is qualified administration staff, which does not take itself too seriously. Faculty management must be considered as a service unit with the aim to support the faculty members in performing at their best. Administration is not an end in itself.

If all administration processes are working efficiently, the scientific faculty staff is able to concentrate on their actual job and to deliver high quality outcomes, to improve teaching and to increase research activities. That is why administration must be as less as possible but as much as required.

Human Resources

For universities it is not easy to apply methods of NPM because they are not compatible with an education and science oriented institution. Attempts of managing universities in a way like enterprises cannot be successful due to the different preconditions in tasks, funding, image and especially intentions of the staff (Turner 2015). Normally, staff in enterprises has an interest to achieve optimal results by increasing production or shareholder value. This will secure existing jobs and generate new ones. For scientific staff at universities, success achieved by the home university is only of secondary importance. Primary, they are interested in their own scientific reputation among other researchers and the

acceptance among students (Turner 2015). One reason may be that university staff does not participate directly and financially in the success or failure of their institution.

Using the few performance-oriented instruments, which are available at universities, faculty management must be careful with the consequences a competitive situation among faculty staff could have. It may encourage motivation but also often can create feelings like envy and jealousy.

Furthermore, modern management instruments are working only in conjunction with a modern human resources management. Some of the big problems for faculties in human resources management are low salaries for researchers, less flexibility and only average working conditions in comparison to other (foreign) performance oriented university systems or the industry.

Organizing and controlling the work performance at a faculty while, at the same time, giving the staff a feeling of respect and support, represents one of the biggest challenges for faculty management. It is important to prevent mobbing or unethical behavior, to support competition without causing jealousy and distrust and to illustrate a common goal to all faculty members. If faculty staff enjoys working at the institution, they will be more productive which increases the success of the faculty. That is why, providing a common goal to work for is one of the secrets for successfully running a university's structural unit.

Less Bureaucracy

The big ambition of administration should be to appear "invisible" for the scientific faculty or university staff. Moreover, faculty management must be very efficient and should avoid wasting faculty resources.

Additionally, it is expected that management will take serious all concerns of the faculty members and try to assist them as good as possible.

In the last years, staff surveys and other quality management measures increased rapidly. Of course, these feedback tools are necessary to be informed about problems or needs of faculty members but their use is time intensive for both administration and staff. It will be more efficient to use the old school techniques of informal direct feedback to the faculty management.

Support for Teaching and Research

The best way for supporting teaching by administration is to give lecturers time to prepare high quality courses, to offer consultations to students, to extend their knowledge and to go abroad to broad their horizon – that means, at the end, to prevent them from too much administrative work.

The same applies for the aim to increase research activities at the faculty. The better variety of possibilities in obtaining third party funds from industry for research and development seems to give an advantage to civil and structural engineering faculties in contrast to social sciences and humanities.

By the means of a performance based fund allocation model, faculty management may encourage researchers to increase efforts in application for research funds and

to publish their research results. Young researchers could be motivated with a start-up funding for development of their own research ideas.

However, rigorous output orientation in teaching and research will have its price. Faculty management must protect its researchers from exaggerated expectations regarding the research outcomes of a faculty. Otherwise, that will have an effect on the research and paper quality. Furthermore, basic research that needs more time will be less attractive. Science is based on a slow, steady, methodical process, and should not be expected to provide fast and easy answers to society's problems. Scientists need time to think, to read and to fail (Slow Science Academy 2010).

Conclusion

The authors conclude that efficient faculty management can contribute to teaching and research immensely, for example by enabling high quality in teaching and by guaranteeing the efficient and successful conducting of research projects. Quality and motivation of administrative staff is of particular importance.

Exactly as an orchestra, a higher education institution's structural unit consists of many heterogeneous people. Faculty management must act like a conductor and should understand, respect and support the staff's diverse intentions, responsibilities, wishes and needs. That is why, communication is an essential tool in modern faculty management, but time consuming as well. All faculty members are high-qualified specialists and play their "instrument" in a very masterly way. Only the conductor can bring them into a perfect harmony and motivate them to show their best performance. Encouraging scientific staff by the administration is an excellent way to bring lecturers and scientist to maximum performance. However, in doing so, faculty managements' challenge lies in balancing the conflict between governing and supporting faculty members.

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