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COVID-19 Lockdown Education: The Importance of Structure in a Suddenly Changed Learning Environment

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Abstract: In early 2020, the COVID-19 pandemic emerged, which resulted in global lockdowns. As a result, education could no longer be provided in its current form and was therefore provided online. This study discusses the consequences of online instruction in secondary education and how students perceived this new way of learning. Specifically, this research focuses on how online education was facilitated, how this differs from regular education and how students and teachers experienced these practices. In this study, qualitative and quantitative data were collected from teachers and students. Our findings revealed that the students were missing a proper structure in the lessons. There was a decline in the understanding and enjoyment by students in all courses. This study also shows that the variety of instructional strategies that the teachers used increased during the lockdown period. However, teachers were lacking in other aspects that define good instruction. Moreover, teacher data demonstrate that the teachers needed guidance from the schoolboard. It is remarkable that the schoolboard plays a key role in improving this situation. This research suggests that if the schoolboard provides guidelines on planning education, teachers could focus more on other aspects of a good instruction.

Keywords: COVID-19 lockdown education; structure in education; online education; secondary education; teacher knowledge

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1. Introduction

The evolution towards distance education practice started 170 years ago when distance education was an individual pursuit defined by geographical disadvantages between student and teacher [1–3]. Since the last half of the twentieth century, the developments were accelerated by the emergence of three additional generations, supported by: (a) the mass media of television and radio, (b) the synchronous tools of audio and video conferencing, and (c) computer conferencing [1]. In the past two decades specifically, online learning has become an increasingly important component of secondary education [4].

Even though, full online instruction has not been a common practice in secondary schools until recently, many higher education institutions already have been practising online education [3,5,6]. Reference [6] (p. 682) stated that "*online learning offers some significant advantages over learning through traditional, classroom-based courses.*" Students look more objectively at collaborative dialogue and their participation in it. This participation results in more equalized roles, where written exchange of messages leads to more effective communication [7]. Reference [8] distinguished two incentives for universities to engage in online learning: to provide learning to new audiences and to transform learning delivery in a competitive landscape. Reference [3] used these incentives to define four categories for universities to embrace online education [9]:

1. "*Expanding access*" to accommodate for the mismatch in programme calendars, work, and family responsibilities.
2. "*Alleviating capacity constraints*" to provide education to more students than the physical housing of universities allows.

3. "*Capitalising on emerging market opportunities*" to meet the market's demand for higher education outside the traditional 18–24 age range.
4. "*Serving as a catalyst for institutional transformation*" to adapt to the increasingly competitive environment due to a decrease in public funding.

Although online education has been implemented and promoted at higher education before early 2020, it was not common for secondary schools to facilitate education online. The standard setting was in-class education, where all students were physically present. However, when COVID-19 emerged in early 2020, which was declared as a pandemic by WHO, measures such as lockdown and social distancing were introduced in many countries all around the world [10]. Consequently, students were forced to follow their education from home. All countries in the European Union required their secondary schools to provide online instructions to all of the students [11]. This sudden and unexpected change in society required teachers to adapt their teaching practice (i.e., adopting instruction and assessment strategies) for this new way of teaching without any preparation.

Despite the fact that several researchers have studied the impact of the COVID-19 virus on education [12–15], most of these studies focus on medical education or university education. To our knowledge, there are limited studies that examine practices of teachers and perceptions of students about online education during the COVID-19 pandemic in the secondary school education context. The present study aims to explore the perceptions and experiences of both students and teachers with respect to educational practices in the context of the COVID-19 pandemic. More specifically, this research focuses on how online education was facilitated, how this differs from regular education, and how students and teachers experienced these practices. The findings of this study have the potential for improving education outside the context of a pandemic.

1.1. Context of Research

In Europe, COVID-19 emerged in late February 2020. As a result, schools were fully closed in March for several months due to contemporary COVID-19 countermeasures in various European countries [11]. In this period, referred to as the *lockdown period*, all students had to follow education from home. This implied that not only higher education, but also primary and secondary schools, were obliged to facilitate online education to their students.

The present study was conducted at a public secondary school in the Netherlands, which has approximately 1200 students, aged between 10 and 19 years old. This school is renowned for its excellence in education and prepares the students for university education. Furthermore, the school encourages students to become responsible for their own learning process rather than being engaged in a cooperative learning process with other students.

The school obtained a licence of an online learning environment and video-conferencing software a few weeks after the beginning of the lockdown period. Furthermore, the school had been using an online administration platform that was already in place for administration of grades, attendance of students and class schedule. The administrative platform was mainly used for registering homework, while the online learning environment was used for deliverables and lecturing. During the lockdown period, no summative assessment took place; only formative assessment was allowed by the schoolboard. This implied that no additional grades could be given to the students.

1.2. The Study

Due to the sudden changes in society, the teaching practices had to be adapted quickly to new situations. Specifically, this meant that teachers had to provide their students with education while the students were absent in the classroom. In most cases, online education was provided by the teachers. This new way of teaching should, like teaching in regular scenarios, be of proper quality. Therefore, it is interesting to investigate the teaching practices used during the lockdown and investigate the experiences of the students. The hypothesis of this research is that when teachers were able to apply all their knowledge

during online lessons, in the same way as they did in in-class teaching, the lessons would be of the highest quality.

This study aims to explore perceptions of students and knowledge domains that teachers used regarding education in the context of COVID-19. More specifically, we are interested in exploring needs and positive experiences regarding non-physical education during the pandemic and how these insights could be useful for improving education.

In order to gain better insight into how regular education can be improved with the newly gained insights from COVID-19-related scenarios, the following question needs to be answered: How did teachers' use of knowledge domains during lockdowns influence the students' perception of the courses? In order to answer this question, one first needs to answer the following sub-questions:

- *What are the differences regarding the characteristics of good teaching in regular in-class learning compared to lockdown learning?*
- *How does the use of teachers' knowledge domains influence the students' perception on the subject matter?*

Answering these questions helps in establishing a relationship between teacher knowledge domains, related pedagogical approaches, and the quality of instructions. Ultimately, the answers to these questions enable the establishment of grounded recommendations for pedagogical approaches in regular situations.

2. Theoretical Background

2.1. Aspects of a Good Instruction

Summarizing the work of [16], there are eight main aspects of good instruction to be distinguished:

- The *goals* of the instruction should be properly formulated [17,18]. The main achievements are typically provided by a curriculum that defines what students should know at the end of every year.
- There should be a "*safe learning environment*" [16]. This environment is built out of both motivational and pedagogical aspects [17,19–22].
- *The instruction should be given in a constructive manner* [18,23]. The instructions could, for instance, be supported by a whiteboard on which the teacher can write notes for the class. This point is about the materials available to support instructions.
- The teacher should be able to *provide proper guidance and coaching* to support a safe learning environment [17,18].
- *The instruction should contain meaningful contexts* [18].
- The student should be *encouraged towards individual learning* [16,24].
- Students should be *encouraged to work together* on exercises [18,25].
- Finally, the learning needs to be *assessed in both a formative and summative manner* [16,26].

All of these aspects are embedded in the Dutch teacher education, i.e., all Dutch teachers should be able to provide the above-mentioned aspects in their lessons [16].

The characteristics of good instruction, as given above, also apply in online education, as enforced by the COVID-19 pandemic. However, the implementation of these characteristics can be different in online education compared to regular education. Reference [27] makes suggestions on how to modify the regular course set-up to meet the requirements set by online education. Reference [27] stated that dividing content into smaller pieces and emphasizing the teacher's voice is beneficial for providing online education. Additionally, Reference [28] stated that teachers should be flexible towards students and their delivery of materials due to possible unstable internet connections. All of these suggestions are aimed at properly adapting to the new, online learning environments rather than redefining *good* instruction.

The International Association of Universities (IAU) launched a global survey on the impact of COVID-19 on higher education around the world. The results show that although almost all Higher Education Institutions (HEIs) reported having infrastructure

to communicate with students and staff, they also reported that it is a challenge to ensure clear communication. Teaching and learning are affected by COVID-19 at almost all HEIs. They reported challenges such as technical infrastructure, competences, and pedagogy for distance education and specific requirements of a particular field of study. On the other hand, it was also reported that online education offers remarkable opportunities for more flexible learning, exploring blended or hybrid learning and combining synchronous and asynchronous learning [10].

2.2. Teacher Knowledge

Besides the aspects of good instruction, described above, teacher knowledge domains influence the quality of instructions as well [29]. Reference [30] described five general domains of teacher knowledge:

- Knowledge about the general educational context.
- Knowledge about the specific educational context.
- General pedagogical knowledge.
- Subject matter knowledge.
- Pedagogical content knowledge (PCK).

These domains are subsets of each other, i.e., general pedagogical knowledge and subject matter knowledge are subsets of PCK, which are all subsets of specific educational context, which in turn is a subset of the general educational context [30].

Each teacher knowledge domain is characterized by a set of aspects. First of all, general pedagogical knowledge consists of knowledge about the learners and learning, classroom management, and knowledge about the general curriculum and instruction [30–34]. Secondly, subject matter knowledge is defined by the knowledge of syntactic structures of the discipline and substantive structures of the discipline [30–32]. PCK is defined by blending general pedagogical knowledge and subject matter knowledge. Aspects defining PCK include knowledge about common misconceptions, topic-specific instructional strategies, and purposes for teaching the topic [30]. All of the three above mentioned domains are included in the domain about the specific educational context. Knowledge about specific contexts includes knowledge about the classroom (e.g., the layout of the physical classroom) and knowledge about the students. Lastly, the domain of the general educational context extends the domain about the specific educational context by including knowledge about the state and nation, the community, the school, and former students [30]. Due to the generality of these domains, we argue that these knowledge domains are also applicable for online teaching [29].

According to Shulman's conceptualization of PCK, it includes using appropriate technology to represent concepts to students [32]. However, the authors of [35] argue that it is necessary to add domain of technology knowledge (TK) considering important role of technology in society and in education. TK is defined by [36] (p. 63) as "*knowledge of how to use emerging technologies*". According to this definition, emerging technologies refer to technologies that are not yet often used in a particular context such as education. In addition, TK is also described as procedural knowledge regarding using technology and technological tools, which includes abilities to tackle with problems while using technologies [37]. Furthermore, TK involves knowledge of understanding technologies, being aware of opportunities that technology and technological tools offer for education for a particular concept and level, recognizing how and when various technology and technological tools can support or hinder students' learning, and pursuing learning and using new technologies [38].

2.3. Theoretical Framework: Characteristics of Good Teaching

The theoretical framework considered throughout this research is based on the theory presented in Sections 2.1 and 2.2. Both characterizations of a good instruction and teacher knowledge are acknowledged by this research, and therefore both concepts are being

considered. This framework for characteristics of good teaching is divided into seven different categories.

The first category is *assessment (AS)*, which allows a teacher to gain an overview of how well the subject matter is understood by the students. Assessment includes both summative and formative assessment, in which the teacher will be able to closely monitor the progress of the students throughout the learning process. The second category is *goals* (*GO*). This category includes all aspects that teachers use to establish learning goals. Goals are defined for the current topic considering the previously acquired goals. The next category, *context* (*CO*), considers how well a teacher can provide meaningful context to students. The fourth category is *cooperation* (*CP*), which indicates how well students are encouraged to work together. The fifth category is called *individual learning responsibility (IV)*. This category gives insight into how well teachers can guide students towards taking their own responsibility on their learning process. The sixth category is *instructional strategies* (*IS*) which includes strategies and tools that teachers use throughout their lessons (e.g., topic-specific instructional strategies). The seventh category is *pedagogical guidance* (*PE*), which monitors how well teachers guide their students. Aspects include knowledge about the students and the ability to create a safe learning environment. The final category is *technological knowledge* (*TK*), which describes how skilled teachers are in handling technological tools for instruction purposes.

The eight categories described above cover all aspects of a good instruction and different domains of teacher knowledge. Therefore, these categories provide a well-suited framework for investigating experiences with respect to educational practices in the context of the COVID-19 pandemic.

3. Materials and Methods

3.1. Research Design

In this mixed-methods study, qualitative and quantitative data were collected from teachers and their students in two rounds as illustrated in Figure 1. The first round of the research was designed for a small group of students and teachers. In this round, the data collection method was optimised such that in round 2, this method could be applied to a larger set of participants.

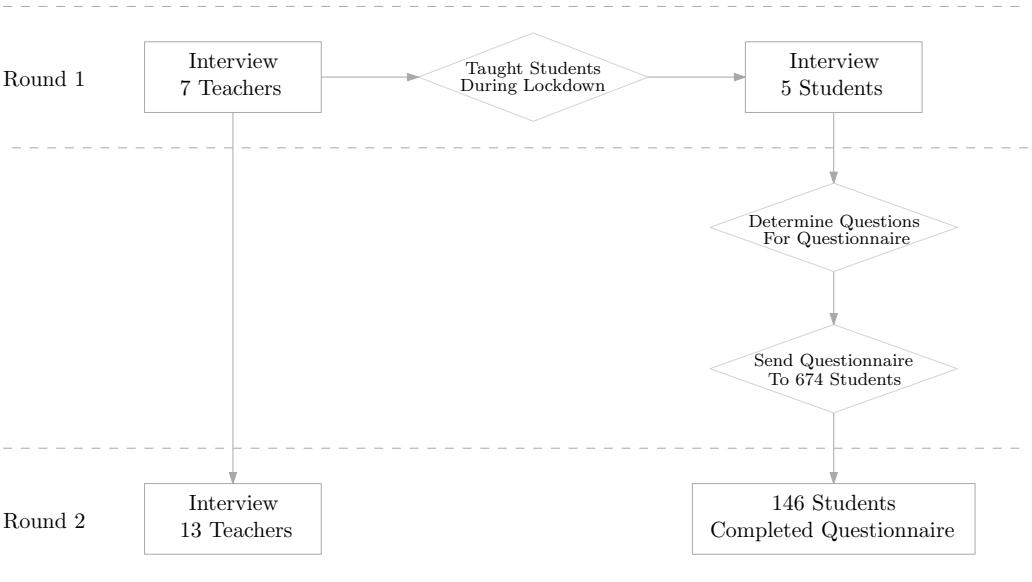

Figure 1. Schematic overview of the research design, including the number of participants.

For teachers, the first round of data collection consisted of semi-structured interviews where the teachers could add comments outside the provided interview protocol. The design was such that there was a possibility for adjustment for the second round. Fortunately,

no adaptions had to be performed, and therefore the same interview protocol was used in the second round of the interviews with the teachers.

For students, the first round of data collection consisted of structured interviews. Therefore, students were not able to add comments. The structured interviews were chosen to ensure that students would not deviate from the guidelines provided by the interview protocol. The students' answers led to the design of the questionnaire for the second round. This questionnaire was sent to 674 students, 288 responded to it, and 146 of those 288 students fully completed it.

3.2. Participant Teachers and Students Recruitment

The teachers and students were recruited in two rounds. In the first round, seven teachers were selected that were willing to participate in the research. Secondly, five students were selected who were taught by the selected teachers during the lockdown period and were known to be critical and able to provide very elaborate opinions. In this way the most reliable results could be achieved, and links between the answers of the students and teachers could easily be identified.

For the second round, an additional 13 teachers from different departments were selected, indirectly, by the schoolboard. All 13 teachers participated in a group responsible for the development of the pedagogical strategies used by their respective department. Therefore, these teachers were well aware of all developments that were taking place inside their department. This made these teachers appropriate participants. A summary of all participating teachers, their courses and the round in which they interviewed is given in Table 1. References [39–41] state that a group of fifteen participants is the smallest acceptable sample size for qualitative research. Therefore, the number of participants included in this study is sufficient to reach reliable outcomes.

Table 1. Overview of the interviewed teachers.

Teacher	Course	Round	Teacher	Course	Round
Teacher-1	Geography	1	Teacher-11	Physics	2
Teacher-2	German	1	Teacher-12	Physics	2
Teacher-3	Latin and Greek	1	Teacher-13	Information theory	2
Teacher-4	Physics	1	Teacher-14	Economics	2
Teacher-5	Dutch	1	Teacher-15	English	2
Teacher-6	Arts	1	Teacher-16	Mathematics	2
Teacher-7	Mathematics	1	Teacher-17	Geography	2
Teacher-8	Dutch	2	Teacher-18	Biology	2
Teacher-9	Chemistry	2	Teacher-19	Music	2
Teacher-10	Arts	2	Teacher-20	Latin and Greek	2

Students in the second round were approached based on the study year. Only students that were in the first three years of secondary education were approached because their schedules were planned according to the study year. In the last three years of secondary education in the Netherlands, all students have personalized schedules, which makes it difficult to design an automated questionnaire and thus makes it difficult to reach a large set of participants simultaneously. Therefore, only the 674 students that were in the first three years of their secondary education during the lockdown period were approached. From the approached 674 students, 288 students responded to the questionnaire, and 146 of them fully completed the questionnaire. Table 2 provides an overview of the participant students. Reference [42] states that, achieving a 90% chance of observing the desired behavior of 3 different themes with the lowest prevalence requires at least 105 participants. Therefore, the number of participants in this research is in line with the guidelines provided by [42].

Table 2. Overview of the number of students that responded to the questionnaire.

Year	Age (Range)	Level	Percentile [1]	Participants
1	11–13	N/A	65th and up	106
2	12–14	Havo	65th and up	36
2	12–14	Vwo	82nd and up	45
3	13–15	Havo	65th and up	42
3	13–15	Vwo	82nd and up	59
Total				288

[1] Reference [43]

3.3. Data Collection Process and Sources

3.3.1. Teacher Interviews

The data were collected through semi-structured interviews with the teachers. In both the first and the second rounds, the interviews were designed to collect data about teacher knowledge regarding their teaching pedagogies during the lockdown period. The interview protocol was first discussed with other teachers and researchers to make sure that the interview protocol was complete and the questions were clear for the teachers. The final interview protocol, used in both rounds 1 and 2, consisted of 27 questions.

The first four questions aimed to get a good overview of how the goals of the teachers have been adjusted in the lockdown period. The next five questions were used to gather an overview of the pedagogical approaches that were used in the course. The next four questions were for assessing prior knowledge of the students, i.e., how the teacher was able to monitor the progress of the students' learning so far. The following three questions were specifically designed to see how well the teachers were able to detect which students were having troubles with the material. Additionally, these questions indicate what approaches the teacher used to make sure struggling students could understand the material better. Finally, nine questions about the assessment in class were asked of the teachers. Note that this section is different from assessing the prior knowledge of the students, since these final questions ask specifically about assessment moments. Of this last section, the first four questions were mainly about the summative assessment methods. The last five questions were mainly about the formative assessment methods.

The interviews in the first round took one hour on average, where the interviews in the second round lasted 40 min on average. The interviews were audio-recorded and transcribed verbatim.

3.3.2. Student Interviews in Round 1

The student interviews were mainly focused on how they experienced online education during the lockdown period. The interview protocol consisted of five general questions and nine questions per course. Seven courses were considered during the interviews, bringing the total number of questions to 68.

First, the students were asked to state their general opinion about the education in the lockdown period. The next question was about whether the student lacks at a specific course due to the lockdown period. The next two questions were about what the students did and did not like about the lockdown period in general. The fifth question asked if the student's motivation towards school changed during the lockdown period.

After the general questions, the student was asked to answer eight or nine course-specific questions depending on whether or not the same teacher was still teaching the student. The questions in these course-specific parts were the same for each course. The first four questions were about the change in student motivation and how the students liked the course before and during the lockdown period. The next two questions were about what the students liked the most and least about how the specific course during the lockdown period. The next question was about if the teacher used different approaches in explaining the material. Next, the students were asked about their concentration during

the specific course. Finally, the student was asked to list any differences in the teacher's way of teaching if the student still had the same teacher for the same course.

The student interviews in the first round took 10 to 15 min per student. The interviews were audio-recorded and transcribed verbatim.

3.3.3. Student Questionnaire in Round 2

The questions presented in the questionnaire for the students were similar to the questions used in the interview. However, in the questionnaire, the questions were formulated in a closed manner; i.e., the student could choose from a limited set of answers. The options to choose from were generated based on the answers given by the students who were interviewed. Since the answers are now finite, analysis can be performed more efficiently compared to the open questions asked during the interviews, since all questions for each course are exactly the same.

For administration of the questionnaire, the survey tool VOspiegel (https://onderwijsspiegel.nl/spiegel/vospiegel/, accessed on 29 April 2021) was used. This tool was able to distribute the designed questionnaire to all considered students with only the questions applicable to them. Furthermore, VOspiegel was able to provide an elaborate summary of the results from the questionnaire with the basic analysis already performed.

The questionnaire itself was constructed in such a way that students only had to answer questions that were applicable to them. In the Netherlands, it is the case that after the first year of secondary education, students get two new courses: German and physics. After the second year, they get two other courses: chemistry and economics. VOspiegel was able to take into account all of these changes in courses. However, students not only get new courses, but they also drop some in the third year: biology and music. Unfortunately, it was not possible to remove courses if they were not being taught any more. Therefore, it was decided not to ask students questions about these courses to maintain the high efficiency of the questionnaire.

3.4. Data Analysis

In this study, two different methods of data collection were used: interviews and a questionnaire, which provided qualitative and quantitative data, respectively. These two data types also require different approaches in analysis. This section will discuss the two methods separately.

3.4.1. Qualitative Analysis

For the interviews conducted, the analysis was based on coding principles of qualitative data. The coding was executed in iterative cycles where the code list, new codes, and coding strategies were checked, refined and confirmed [44]. Each interview gave approximately 4 pages of data that needed to be analysed. In order to code the data according to the principles of [45], a concept-driven coding approach was used [46], based on the aspects discussed in Section 2. The categories were defined by the aspects noted in Section 2.3, where the characteristics of good teaching are mentioned. The main categories are assessment (AS), goals (GO), context (CO), cooperation (CP), individual learning responsibility (IV), instructional strategies (IS), pedagogical guidance (PE), and technological knowledge (TK). Besides these categories, there are two categories called *course* (CR) and *time* (TM) that, respectively, indicate the course that the interviewed teacher teaches and the time in which the teaching took place. The CR group enables the analysis to distinguish between the approaches used by different courses such that they can be linked to the outcomes of the students. The obtained data were coded using Atlas.ti (https://atlasti.com/, accessed on 29 April 2021) qualitative data analysis software. Before coding all the data, firstly, a coding exercise was performed in which the two researchers coded the transcripts of the same teachers with the same a priori code list. When the disagreements were discussed, the two researchers reached a consensus with an interrater agreement of 81% [47]. After this coding exercise,

the a priori code list was updated with new codes that appeared to be significant and frequently emerged from the data.

After the first round of coding, the code list was revised by merging the codes that indicate the same aspect. In the second round, all teacher data from the 7 teachers (first round) were coded again together with the other 13 teachers (second round) by using the final code list (see Table 3). The focus of coding lay on the teacher's experience rather than the interconnection with the students. This analysis extends the analysis in the first round by means of increasing the sample size to draw more reliable conclusions [41]. The results of the analysis in the second iteration eventually were compared to the results of the questionnaire of the students in order to match the effects of certain decisions that were made by the teachers. The comparison is based on the course that the teacher taught.

Table 3. Coding scheme for instruction characteristics.

Category	Codes
Assessment (AS)	Formative assessment: • Formative assessment of work • Formative oral examination • Formative, summative written examinations (i.e., exams that were originally made for summative assessment, are now examined, but not graded) • Formative written exercises • Making self-made exam questions Summative assessment: • Presentations • Summative oral examination • Summative practical assignment • Summative written examination
Context (CO)	Provide another dimension to the study material: • Illustrative examples • Practical examples
Instructional strategies (IS)	Ways of presenting material to students: • Notes on whiteboard • Using presentation software • Notes on presentations • Separate document with notes distributed • Notes with tablet • Video instructions • Demonstrations • Personalised explanation Distributing study materials: • Electronic learning environment • E-mail Other factors that influence the instructions: • Practical-specific material • Lack of materials • Less instruction possibilities • Providing a static structure

Table 3. *Cont.*

Category	Codes
Cooperation (CP)	Stimulation for students to work together: • Work together on exercises
Goals (GO)	Planning related characteristics: • Modifications according to situation • Shortened planning • Unmodified planning • Explicit formulation of goals Checking prior knowledge: • Checking achieved goals Check if material is understood by students: • Check intermediate goals • Goals have been achieved • Goals have not been achieved • Unclear if goals have been achieved
Pedagogical guidance (PE)	Teacher initiatives to help students: • Additional instructions • Personal guidance • Share work online Observations made in the (physical) absence of the teacher: • Difficult to provide the students with proper instructions • Less guidance possible when the students are at home • Less motivations when the students are at home • Unable to reach everybody during online classes • Students are properly motivated to work
Individual learning responsibility (IV)	Helping students improve their own responsibility: • Student logs own progress • Students need to take their responsibility • Making exercises in class • Applying scaffolding techniques • Mandatory participation of students Observations made in the (physical) absence of the teacher: • Students do not take their responsibility • Students do not actively participate in the learning process • Students do not know how to learn properly • Students only learn for their grades
Technological Knowledge (TK)	Ability to handle technological instruction tools: • Inability to use technological tools • Knowledge about technological tools • Ability to use technological tools • Disliking of having to use technological tools

The student interviews were coded with a code list that consists of answer choices for the questions in a questionnaire. Therefore, in the end, the code list provided useful guidelines for setting up the questionnaire for the students.

3.4.2. Quantitative Analysis

The questionnaire mainly comprised closed-ended questions with an extra option to provide comments. The statistical results were summarized by the same tool that

acquired the results in the first place: VOspiegel. This tool is able to summarize the responses/choices of the students and provide relative and absolute results.

The results provided by VOspiegel are accompanied by the raw data on which the provided summary is based. Even though the summary might be sufficient to draw conclusions, some references to the original data are used to link certain questions to their respective course. In this way, it is possible to link the effect of certain strategies implemented by a course to the perception of the students. For other, more elaborate analysis, MATLAB (https://www.mathworks.com/products/matlab.html, accessed on 29 April 2021) was used with the provided raw data from the questionnaire. With MATLAB, the significance of certain results could also be computed.

4. Results

In this section, first, the results regarding teacher knowledge domains and teachers' experiences are presented. Then, the results with respect to students' perceptions are provided.

4.1. Teacher Interviews

This section provides the reader with the results provided by the conducted interviews with the teachers. First of all, all domains of teacher knowledge are discussed together, and later these aspects will be discussed one-by-one.

4.1.1. Teacher Knowledge

The analysis of the teachers' knowledge showed that teachers faced a lot of difficulties during the first lockdown period. Most teachers indicated that there was a lack of structure and steering from the school board about what was expected of them. "It was not clear in the first few weeks what needed to be done", indicated Teacher 3 (Latin and Greek), who ultimately was unable to teach due to this confusing environment. This new environment caused teachers to face significant difficulties in their teaching approaches at first. Later, when teachers understood what was expected of them, the teachers indicated that they felt more at ease and were able to teach properly.

Table 4 shows, for each of the domains of teacher knowledge, how many aspects teachers used. These aspects only include those factors that teachers can influence; i.e., all opinion and observation codes are left out. Table 4 reveals that each aspect, except IS, is used less during the lockdown than it was before the lockdown. Furthermore, Table 4 shows that the CP characteristic is used significantly less than all other aspects among the interviewed teachers.

Table 4. Teacher-dependent aspects present per teacher knowledge category before and during the lockdown period.

Category	Before the Lockdown	During the Lockdown	Relative Difference [%]
AS	65	37	−43.09
GO	19	9	−52.63
CO	30	19	−36.67
CP	2	0	−100.00
IV	23	10	−56.52
IS	49	65	+32.65
PE	31	20	−35.48

4.1.2. Assessment

Teachers indicated that assessment was the most challenging aspect during the lockdown period. The schoolboard announced early in the lockdown that there would be no examinations anymore for the rest of the year, with an exemption being made for practical and oral examinations. For teachers, this meant that no summative assessment was allowed anymore, even though a significant part of the learning material was to be

discussed. Usually, every course has at least two exams during the last period of the year. Most teachers switched to using formative assessment strategies by providing the students with the exam that was meant for the course, without grading it afterwards. Teacher 4 (physics) indicated that this was not the right way of conducting formative assessment.

4.1.3. Goals

During the lockdown period, teachers had to adapt their teaching to the new environment. Therefore, some teachers adapted their planning and learning goals to better suit the new situation. Half of the teachers indicated having changed their goals according to the situation. Of the other half that indicated not to have modified their planning, again, half indicated to discussing less material; e.g., Teacher 1 (geography) said that the goals "...were not modified, but all material was provided on a lower speed."

Even though in 70% of the cases the goals were not achieved, some of them additionally indicated being satisfied with the result. One of those teachers, Teacher 8 (Dutch), indicated that he was "...unsure if this could have been prevented" "...we got the best results, considering these circumstances", Teacher 14 (economics) added. The remaining teachers stated that they were unable to tell if goals were achieved in the first place "...no summative examination took place...", Teacher 18 (biology) mentioned.

Besides being able to tell the level of understanding after giving a course, this teacher knowledge aspect also tells how well the teacher can estimate the level of prior knowledge of the students. During the lockdown period, there was approximately 58% less checking of the goals by the teachers. Teachers 10 (arts), 12 (physics), 15 (English), 16 (mathematics), and 17 (geography) even indicated not having checked the level of understanding at all during the lockdown. Teachers had the opportunity to grade themselves on their ability to guess the level of prior knowledge of their students. Whereas teachers before the lockdown gave themselves a 7.7 on average for diagnosing the level of understanding, during the lockdown, this was only a 3.9.

4.1.4. Pedagogical Guidance

One of the most obstructing aspects of online instruction is the fact that teachers are faced with a physical barrier. This barrier prevented teachers from providing guidance to the students. All of the teachers indicated that, before the lockdown period, they would walk through the class to see where students were struggling with the material. When teachers found a student struggling with the material, they would give this student one-on-one explanation about the material. Unfortunately, during the lockdown, this was no longer possible; there was no possibility of physical contact with the students. Teachers 12 (physics), 15 (English), and 20 (Latin and Greek) found themselves unable to provide the students with any form of (individual) guidance during the lockdown. Of the remaining 17 teachers, 15 relied on the students for personal guidance; i.e., only if the student asked for help was it provided to them (e.g., planning a video call for additional explanation). Whereas, before the lockdown, the teacher decided who got individual guidance, during the lockdown, students had to decide for themselves.

Other observations about the pedagogical guidance during the lockdown that teachers made was the fact that the guidance at home was lacking. Teachers indicated that students were not properly motivated any more to do anything for school. Teacher 2 (German) said that "students were not interested in the material anymore, because there would be no 'real grade' given in the end." Since only formative assessment was allowed, teachers indicated that the motivation of students was significantly lacking.

4.1.5. Individual Learning Responsibility

Not only the pedagogical guidance suffered from the online barrier but also the individual learning responsibility was subject to it. At the school, the students were encouraged to take their own responsibility for their learning process. Therefore, the teachers decided to give more responsibility to the students during the lockdown period.

Teacher 8 (Dutch) even said that "...we [the teachers] will provide the material, but the students are responsible for asking what they want." Fifty percent of the teachers clearly observed a significant lack in students' ability to take their own responsibility, "...the motivation of the students was missing...", Teacher 9 (chemistry) said.

The teacher interviews revealed that there was a 73% reduction in guidance in the process towards taking responsibility of one's own. Even though there was the possibility for students to participate in individual instruction sessions, this already assumed that students were able to take their own responsibility. In the end, most teachers agreed that most students were not yet able to take their own responsibility in their own learning process.

4.1.6. Instructional Strategies

The only teacher knowledge component that was applied more in the lockdown period than before was the instructional strategies component (see Table 4). Before the lockdown period, teachers were using either a whiteboard or PowerPoints. However, using a whiteboard was no longer possible during the lockdown, and therefore other methods were to be investigated. Teacher 7 (mathematics), who was using a whiteboard before, was forced to "...explore other possibilities of providing notes to the students." Furthermore, Teacher 19 (music) was using pilot versions of online-based teaching methods to see what could be used further on.

However, some classes were highly dependent on materials present in the classroom that were not (always) present at the students' homes, for example, arts classes, which are dependent on practical materials that can be found in class (e.g., special drawing ink). It is interesting to see that even these courses, music and arts, were able to adapt their goals and instructional strategies to meet the available materials at students' homes. Teacher 6 (arts) decided to "...divide bigger assignments in smaller ones, doable at home", where she considered the materials that all students have available at home.

One obvious shift in the instructional strategies is the shift in the distribution of study materials. The material originally handed out in class, was to be distributed in another way. Most of the teachers decided to distribute their materials via some sort of electronic learning environment. A few other teachers used emails to communicate material with their students.

4.1.7. Context

Providing context to the students is divided into two aspects: practical and illustrative examples. Practical examples refer to demonstrations of how to directly implement knowledge into a context. Think for instance of some drawing technique being demonstrated by the arts teacher. Illustrative examples show how the theory would be applied in practice but do not directly link theory to the application. For instance, economic examples in mathematics exercises do not always present students how to handle those situations in real life, and therefore, these are only illustrative.

Before the lockdown period, 15 of the 20 teachers used practical examples. However, during the lockdown, only Teachers 5 (Dutch), 13 (Information Theory), and 15 (English) were able to still implement practical examples in their lessons. Teachers 5 and 15 used videos to show how language was to be used in a practical way. Teacher 5 used writing examples and exercises, and Teacher 15 made videos with pronunciations explained. Teacher 13 was an information theory teacher who did not suffer that much from moving to online education: "...information theory was in that sense a privileged course." The students were supposed to work on their computers during regular classes as well, and Teacher 13 thinks that this made online education "...relatively easy ..." compared to other courses.

Illustrative examples, however, did not suffer that much. Whereas before, 15 teachers used illustrative examples, only Teacher 17 (geography), was unable to present illustrative examples during the lockdown. This is due to the fact that Teacher 17 switched fully to the usage of the book and pointed out the students' own responsibility; no additional

instruction was provided any more. Teachers 6 (Arts) and 10 (Arts), however, had to switch from using only practical examples to using only illustrative examples.

4.1.8. Technological Knowledge

In contrast to all other aspects discussed before, technological knowledge was not measured before and after the lockdown period; this aspect was analyzed over both periods at once. Some courses never needed to use any technological tools in their classes, such as mathematics, but that does not mean that the teacher had no knowledge about technology. In the lockdown period, however, all teachers had to use their technological knowledge. In this period it became clear which teachers had TK and was able to use it in their teaching.

From all 20 interviewed teachers, 15 were perfectly capable of adapting to the new online environment. These teachers were directly able to provide their students with some form of online education. Secondly, 3 teachers were able to implement the technological tools, but did not use them to the full potential. This includes, e.g., Teacher 19 being unable to properly show their notes to the students online while being able to start video conferences. Lastly, only two teachers were completely unable to use any form of technology during the lockdown period.

4.1.9. School Organisation

Most teachers made additional comments on the lack of steering from the schoolboard. Mail traffic shows that the board sent teachers an email about education strategies, two weeks after the lockdown started. Before that, teachers had to figure out themselves how to teach in this unusual situation. Teacher 3 (Latin and Greek) found this very inconvenient: "*I am not a hero in technology . . . and now we had to figure out ourselves how to teach online.*" It should be noted that this does not mean that teachers are unaware of the procedures in their school; the board failed to (properly) communicate policies to their employees on time.

4.2. Student Questionnaire

For the students, it is important to get an insight into their understanding and liking of the courses they participated in during the lockdown. Unfortunately, due to privacy issues, it was not possible to ask for the students' grades. However, since there was no examination any more after the start of the lockdown period, there would have been no added value to that information. Therefore, the students were asked about their perception of their understanding and liking of all their courses; these results are summarised in Tables 5 and 6, respectively. Tables 5 and 6 show that for every course, the students' understanding and liking decayed during the lockdown period, and the results have proven to be significant with Pearson's correlation coefficient being up to 10^{-7}. Note that the number of responses in Tables 5 and 6 varies because not all students took all courses in the Dutch education system.

Students also expressed their opinion about the best and the worst aspects for each course. Tables 7 and 8 show the best and worst aspects for each course according to students, respectively. It is interesting to see that for every course, except English and mathematics, the worst aspect was the missing structure during the instructions. English and Mathematics had as the worst aspect, respectively, the inability to talk to fellow students and that too much homework was assigned. It should be noted that for almost every course, the second worst aspect was the fact that students were unable to talk to each other. This shows that students need to communicate with each other.

For the best aspects, it is interesting to see that the most common aspect is a good structure in the classes. Where English and mathematics were the only courses that did not have as worst aspect a lacking structure, their best aspect according to the students is that they had proper structure during the online classes. Note that for Geography, the worst part was a lack of structure, and the best aspect was a proper structure. This contradiction is explained by the fact that only 20% of the students voted for a lacking structure as worst

aspect, apparently from the remaining 80%, some students voted for a proper structure as being the best aspect, resulting in 14% of the all students.

Table 5. Average of students' opinion of the understanding of their courses in regular situations and during the lockdown on a scale from 1 to 5.

Course	Regular	Lockdown	Δ [%]	Total Responses
Chemistry	3.6	2.7	−25	96
Economics	3.6	3.1	−14	62
German	3.9	3.3	−15	125
Physics	3.1	2.6	−16	95
Mathematics	3.8	3.1	−18	203
Dutch	3.7	3.3	−10	172
English	3.9	3.6	−8	157
Art	4.0	3.5	−13	151
Geography	3.8	3.4	−11	149
Latin and Greek	3.4	2.8	−18	51

Table 6. Average of students' opinion of the liking of their courses in regular situations and during the lockdown on a scale from 1 to 5.

Course	Regular	Lockdown	Δ [%]	Total Responses
Chemistry	3.3	2.8	−15	96
Economics	3.2	2.8	−13	62
German	3.3	2.9	−12	125
Physics	2.7	2.5	−7	95
Mathematics	3.2	2.8	−13	203
Dutch	3.0	2.8	−7	172
English	3.6	3.2	−11	157
Art	3.5	2.8	−20	151
Geography	3.3	3.1	−6	149
Latin and Greek	3.5	3.0	−14	51

Table 7. Worst aspect of a course during the lockdown period according to students.

Course	Worst Aspect	Percentage [%]
Chemistry	Lack of structure	26
Economics	Lack of structure	23
German	Lack of structure	21
Physics	Lack of structure	19
Mathematics	Too much homework	23
Dutch	Lack of structure	23
English	Unable to talk to your classmates	17
Art	Lack of structure	29
Geography	Lack of structure	20
Latin and Greek	Lack of structure	39

Table 8. Best aspect of a course during the lockdown period according to students.

Course	Best Aspect	Percentage [%]
Chemistry	Teacher shared notes	23
Economics	Usage and sharing of presentation slides	28
German	Usage of online learning environments	15
Physics	Teacher shared notes	17
Mathematics	Good structure	13
Dutch	A similar approach was used as before the lockdown	15
English	Good structure	15
Art	Usage of online learning environments	17
Geography	Good structure	14
Latin and Greek	A similar approach was used as before the lockdown	19

Qualitative Analysis of Student Questionnaire

Besides the given, closed questions, the students were also able to provide additional comments on the courses. Below, the most important findings of these comments are provided.

The most important finding from the students' comments is the fact that they value structure. This became clear already from the results given in Tables 7 and 8; however a *clear structure* does not exclusively mean that the teacher is able to give clear instructions to the students. From the comments of the students, it became clear that even though a teacher was able to provide clear instructions to the students, the overall structure was still lacking. For German courses, for instance, students indicated that there were "proper instructions" and that "…it was clear what was expected of …" the students. However, the German teacher was sometimes unable to turn on the camera, "…making it inconvenient to ask questions." Furthermore, for economics, students indicated that there were "…clear instructions, however it was still difficult to follow online." Therefore, these courses still had as the worst aspect that the structure was missing.

One course that had proper structure was mathematics. Students indicated that it was very clear what had to be done and where to find all the material such as instruction videos: "almost everything was properly arranged." For mathematics, the whole electronic environment was used in an orderly fashion, making it clear to students where everything could be found. Even though there was "…no opportunity to ask questions during instructions …", students still valued the structure present in the mathematics department.

In addition to structure, the students also indicated that it is important for a teacher to be familiar with the digital environments and tools. One of the main complaints towards teachers was the fact that they were unable to properly work with the provided video conferencing software. A geography teacher, for instance, was able to start video conferences, but was unable to properly share their notes with the class. The teacher "…wrote everything on the whiteboard behind them …" which was "…not readable." Students indicated that the quality was "…really bad." The inability to properly sharing notes was, unfortunately, not the only thing that teachers failed to accomplish: some teachers failed to attend the online classes at all. Students indicated that one of the Dutch teachers "…did not know how to work with computers …" which resulted in absence during online classes. An English teacher also "…was sometimes not present …" during online classes. Students also indicated that the teacher of Latin and Greek "…failed to attend the online classes." However, during the teacher interviews, it became clear that the teacher Latin and Greek (Teacher 3) was absent on a personal note and failed to communicate this with their students.

The third aspect that was mentioned by students were practical examples. Some courses, such as chemistry and physics, rely on their practical examples to demonstrate students the real-world implications of certain theories. Students indicated that for chemistry, "…the material might have been more clear if there were any practical examples. Maybe something that could be done with things you have at home." Of course, there are

limitations on practical examples with chemistry due to the lack of materials that students have at home. However, physics teachers managed to provide the students with practical examples executable at home. According to students, "... these practical examples made sure ..." the students "... understood the material better." Even the videos of experiments shared by the physics teachers were considered to be "... very helpful."

The last aspect that students noted became present in the comments given on the Dutch courses. Here it was appreciated by students that "... the teacher started with asking the class how they were doing ... before discussion of the material ..." Students indicated that this personal aspect was something that "... was missing in other courses." Students valued the opportunity of sharing their experiences of the lockdown with the class.

5. Discussion

Prior work has documented the effects that competent teachers have on students' understanding of subject matter [48]. One of the main characteristics of a good teacher is a profound knowledge of tasks and instructional strategies that aid students' understanding [49,50]. Both the teacher knowledge domains and the aspects of good instruction are based on what is possible inside the physical classroom [16,30]. Unfortunately, due to the COVID-19 pandemic, teachers for secondary education were forced to move towards online education quickly [51]. Even though there are some studies on teacher competences in online education [27,52], these studies are focused on higher education, i.e., tertiary education. In particular, there is little known about what happens if education shifts from in-class to online at secondary school education [53].

The main aim of this study was to explore how the pedagogical strategies used during the lockdown period influence students' perception of the courses. The aspects of good instruction and domains of teacher knowledge before and during the lockdown have been investigated. Knowing about the perceptions of teachers and their students, together with the aspects of the lessons that are appreciated or not appreciated by the students, provide insights into the improvement of online and in-class education practices.

All student comments pointed out the aspects of the online lessons that deviated from the lessons before the lockdown period. These comments suggest that students relate structure to in-class lesson structure. If the teacher used different teaching practices in online lessons, students perceived this as a structural change. Therefore, it could be argued that students value a smooth transition from in-class to online education.

These findings are in line with previous research focused on the influences on a student when enrolment is changed [54]. Reference [54] showed that when pedagogical approaches change, this has a negative influence on the students' academic achievements. Even though the social ties are intact during a lockdown situation, the pedagogical approaches that teachers use are different, similar to when a student gets a new teacher. This suggests that any disruptive change in pedagogical approaches has a negative effect on the students' motivation, understanding, and hence achievement.

Additionally, this study shows that the number and variety of instructional strategies that teachers used increased during the lockdown period. This indicates that the teachers were trying to adapt to the sudden change to an online teaching environment. Our findings revealed that the teachers spent most of their time adapting to online teaching environment, while all other aspects of good instruction were lacking in this process. However, previous research suggests that teachers should not only focus on how to present their material but also on how to properly guide students in the learning process [55–57]. It is argued that teachers should also think of how to pedagogically guide their students when a sudden change in environment occurs.

This finding is in line with the comments that students gave on specific courses. Students valued the fact that a teacher was asking them personally how they were doing, for example, as it was done during the Dutch language course. Furthermore, students indicated that they disliked the fact that there was no possibility for interaction with the

teacher during mathematics courses. This suggests that students value the pedagogical guidance capabilities of their teachers.

On the other hand, students also made clear that they appreciated the quality of the instructions during the lessons. When something was not properly arranged, such as the readability of the presented material or the ability of the teacher to be online, this was found to be disturbing. This shows that students value the quality of the lesson's content as well. Therefore, it is beneficial for students when teachers are able to balance all aspects of good instruction properly.

One of the most important comments teachers made during the interviews was the reoccurring need for steering from the schoolboard. This indicates that not only do students require proper structure, but teachers also want to have some degree of structure and guidance for teaching. In the first days of the lockdown period, teachers were told to teach without any structure provided by the schoolboard. This most likely caused the increase in instructional strategies; teachers were searching for different ways of teaching.

This finding is in line with previous research indicating that the schoolboard influences the quality of education [58–60]. Therefore, this study suggests that teachers require proper guidance from the board on the basic guidelines about how to teach. When some degree of guidance is provided, teachers could spend less time in finding proper instructional strategies and more time on providing proper guidance to the students.

Especially with sudden transitions in education, it is important that guidelines are provided such that the teachers can focus on other aspects of good instruction such as pedagogical guidance. These guidelines include the available material and how to use them, e.g., the usage of a smartboard with specific software. This enhances the general educational context domain of teacher knowledge, which, due to the subset structure, enhances all other domains of teacher knowledge. In turn, this would result in better understanding on the students' side and, consequently, would provide a proper foundation for good achievement.

Most notably, this is the first study to our knowledge that investigates the effects of the sudden transition from in-class to only online education from teachers' and students' perceptions. The presented results provide compelling evidence indicating the importance of structure throughout all levels of the education system.

It is interesting to note that, even though there is no direct interaction between the board of a school and the students, the decisions of the board influence the students' perception on their level of understanding. It would be interesting to further investigate on the influences of board decisions.

This study also has some limitations that should be noted. First of all, this study was performed in only one school. Other secondary schools might have used other practices or strategies than the ones presented here. It would be interesting to investigate, in future research, how schools with different directions influence the perceptions of students.

Another limitation of this study is the fact that the individual approaches of teachers for their courses are not being considered. At every school, there are policies about how to teach specific courses, but the teachers mainly determine how this policy is translated into instruction. This means that almost every teacher uses their preferred style of teaching, which could also affect the liking of a course by students. Even though our study is only interested in the deviation of the score before and during the lockdown, it might still be interesting to link the individual teaching style of a teacher to the level of liking and understanding of the students.

Another limitation is that this research has been executed in only one country; similar to the previous limitation, it might have been that other countries applied different strategies in their secondary education. It is known that different countries have different educational systems. It would be interesting to see if guidelines provided by a nation's government also influence the perceptions of the students. This would extend this research by means of broadening the scope from school-wide to nation-wide.

6. Conclusions

The research hypothesis that teachers should apply all knowledge domains in online lessons for the best quality is supported by the reported findings. This research showed the relationship between the distribution of applied teacher knowledge domains and the perceived understanding from students and the importance of finding a balance between all of these domains. This research suggests that during online teaching, teachers should aim for implementation of all aspects of good instruction.

Furthermore, our findings demonstrated that students value structure when learning. This includes not only that the teacher provides proper instructions and makes clear what is expected from the students, but also provides stability to the students, e.g., using similar instructional tools throughout different courses. Students' difficulty in following what the teacher is doing contributes to the students' perception of a lacking structure in the particular course.

This research demonstrated the importance of a proper structure throughout the educational hierarchy, in particular during an unexpected, sudden change in learning environment. The board should provide their teachers with sufficient guidelines in using available materials. In this way, teachers can focus on implementing all aspects of good instruction and thus provide the students, in turn, with a properly structured instruction.

This research is not only applicable for instantaneous disruptions of the teaching environment such as the contemporary COVID-19 lockdown considered here, but also for education in general. We conclude that it is important to provide proper structure at all times. It is always important to establish structure throughout the whole school system, from the board to the teachers and from the teachers to the students.

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