

THE DEVELOPMENT OF INTERACTIVE QUALITY OF ONLINE TEACHING AND LEARNING DURING THE CORONA CRISIS

Francine Behnen*, Mariëlle Kuijper**

*Teacher Educator, NHL Stenden University of Applied Science, Rengerslaan 10, 8917 DD, Leeuwarden, The Netherlands, Francine.Behnen@nhlstenden.com,

**Teacher Educator, Windesheim University of Applied Science, Campus 2, 8017 CA Zwolle, m.kuijper@windesheim.nl

ABSTRACT

In March 2020 schools in The Netherlands closed to contain the spread of Covid-19 virus. Shortly after, schools took to online education.

The condensed setting of the Covid-19 situation provided a background to study which learning activities and tools teachers choose in online education and how they use them to promote interaction. Interaction is quintessential to learning but in online education it is not easy to provide room for interaction. Our central research question therefore is how interaction within online education activities change over time.

An online longitudinal survey amongst teachers was conducted. The first four rounds took place in the early stages of the lockdowns and shortly after. In total 179 different secondary school teachers participated of whom 16 responded three rounds or more.

Most teachers use tools in online education that can facilitate more interaction than necessary for the Instructional Design. This means that improving interaction in online education is more a pedagogical challenge than a technical one.

It was also found that teachers who deploy Instructional Designs that require more interaction use more and different tools. However, only few of these tools seem to facilitate the interactive quality the teachers pursued. Over time we saw the interactive quality of Instructional Design and tools converge. We are in awe of the artful way in which some teachers manage to combine the possibilities of different tools to establish high interactive quality in the online learning processes they conduct.



INTRODUCTION

On March 15th, 2020 the decision was taken in The Netherlands to close primary, secondary and vocational schools to limit the spread of Covid-19. Three days earlier, universities and college buildings were closed for students. Immediately schools collectively turned to online education. On March 18th, 2020, 88% of the schools reported to be technically ready to facilitate online education. After the technical possibilities had been put in place for online education, the next challenge was to carry out learning processes online.

In general, interaction is quintessential to learning (Chen et al., 2015; Tanner et al., 2005), highly valued by students (Baeten et al., 2010; Lear et al., 2010; M. Roblyer & Ekhaml, 2000; Smith et al., 2006) and appears to be a key factor in student success in online classes (Glazier, 2016). We perceive interaction as interpersonal communication (de Koster et al., 2012; Roblyer & Wiencke, 2003; Wagner, 1994) which can involve one or multiple people.

In online classes this interaction takes place by means of technology. The characteristics of the technology determine the way interaction can take place, i.e. one-way, two-way, multiple way and the number of people involved, i.e., interpersonal, intra groups, inter groups. Wagner (1994) summarizes these characteristics as the *interactivity* of the technology.

According to Roblyer and Ekhaml (2000) technologies allow high interactivity when they facilitate interactions in multiple directions within and between groups of people. Technologies with the lowest level of interactivity merely broadcast information which people can receive, but not react upon. In online situations “Technologies that allow high interactivity seem necessary to allow high person-to-person, person-to-group, and person-to-system interaction” (Roblyer & Ekhaml, 2000; Roblyer & Wiencke, 2004). Put in other words, the level of interactivity of technologies limits the interaction possible, but within this level the people involved determine the degree of interaction that actually takes place. The combination of the two determines the overall *Interactive quality*: the degree of interaction that takes place in distance learning courses (Roblyer & Wiencke, 2004)

Making use of the interactivity of technology to establish interaction is easier said than done. In regular face to face education, teachers make more use of digital tools for sharing information than using them to establish communication (Heitink et al., 2016). Research by Almås and Krumsvik (2008) and by Pareja Roblin, Tondeur, Voogt, Bruggeman, Mathieu, and van Braak (2018) shows that teachers have trouble in matching available digital tools with the learning activities that constitute a learning process as intended.

During the Covid-19 pandemic the only way to interact with students was through technology. This was to be done by teachers more familiar with the use of technology to share information (Heitink, Voogt, Verplanken, Van Braak & Fisser, 2016) than familiar with the possibilities of available tools to facilitate the desired interaction to establish sound learning processes.



During online education teachers need to combine both their pedagogical knowledge about the importance of interaction in learning processes as well as their technological knowledge about the interactivity the tools used can facilitate (Mishra & Koehler, 2006) in their Instructional Design (Dalziel, 2013). Within their instructional design teacher create, share and implement sequences of teaching and learning activities that include both content and collaboration (Dalziel, 2013). These learning activities consist of verbs that describe what students do to progress from the intended learning outcomes towards assessment (Laurillard, 2012 (pp 70).

A teacher well capable of conducting learning activities within an instructional design with high levels of interaction in a physical classroom, might not be able to do so online through lack of technological knowledge. Vice versa might also be possible, that teachers fail to exploit the interactivity of the technologies they deploy because of a limited pedagogical repertoire of learning activities that promote interaction.

Learning how to combine this knowledge and select and use tools that can facilitate or even promote interaction during online learning processes might be an important factor in student success during periods of lockdown. However, little knowledge is available on how to do so.

The purpose of this study therefore is to gain more insight in how teachers match tools and learning activities and which combinations of tools might, contribute to student success in online classes. This knowledge can be valuable for both apprentice and in-service teachers when designing technology enhanced learning processes in both distance and face to face settings

In this study we therefore focus on the matches teachers report between their instructional design and the tools they deployed. Following Roblyer and Ekhaml's line of thought, best matches between instructional design and tools are those that facilitate the way interactions take place between the number of people involved.

In order to identify matches we compare the interactions intended within the instructional design with the interactivity of the tools. Although Roblyer & Ekhaml's (2000) Rubric for Assessing the Interactive Quality of Distance Courses (RAIQ) still stands today, the tools mentioned are quite outdated. We slightly adapted the rubric and included pictograms to help understand the differences between their levels of interactive quality, see table 1.



Table 1

Interactive Quality of learning activities within Instructional Design and technologies

level	Interactive Quality	Ways of interaction	Example learning activity within Instructional Design	Example technology
1, very low	Broadcasting		Students gain information from a presentation	information on a website
2, low	Individual communication between two people or one person and a technology		Students respond to questions on a test or quiz	quiz software
3, intermediate	In addition to individual communication, small group work takes place with just the group members involved in the interaction		Students engage in dialogue with one or more peers synchronous/asynchronous	Chat
4, high	In addition to communication within small groups, the groups share their outcomes with the other groups and reflect and comment on each other's work		Students participate in or develop graphic organizers, semantic maps, etc.	Collective boards (padlet)
5, very high	In addition to small groups sharing their outcomes, outside experts are involved, harvesting information within and outside class and instant sharing of outcomes with all participants		Students discuss a concept or process with an external expert	Videoconferencing

This rubric portrays five different descriptions of instructional design with increasing interactions amongst students and gives examples of different technologies that can facilitate the interactions needed for the instructional design.

When instructional design and technologies match we can plot them in a graph, figure 1. On the x-axis the interactive quality of the instructional design is plotted which corresponds with the descriptions of Interactive Quality with the same name in table 1. On the y-axis technologies are plotted with the interactivity to facilitate the interactions needed for the level of interactive quality ascribed. At first glance this might seem obvious. However, if this were so in teaching practice there would be no reports on mismatches like those of Almås and Krumsvik (2008) and Pareja Roblin et al. (2018). Plotting the interactive qualities of the instructional design that teachers establish against the interactivity the technologies they use facilitate, can contribute to a deeper insight on how teachers match the two.



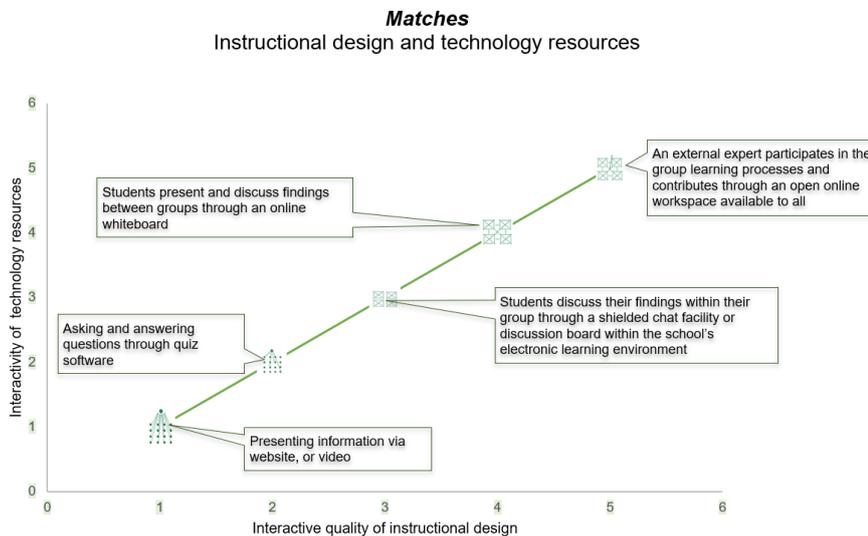


Figure 1. *Matches of instructional design and technology resources*

We presuppose mismatches to be deviations from the slanted line drawn in the graph. The distance from the line is an indication of the extent of the mismatch. The larger the deviation, the larger the mismatch.

Online education forces teachers to make use of tools to conduct the learning activities within the Instructional Design chosen. In physical settings teachers might be able to steer students to do whatever is intended, even when a tool might not support so. Online, this possibility is cut off and it follows that the interactivity of the tools chosen determine the highest level of interactive quality that can take place and hence influence the instructional design. In other words, when tools are chosen with an interactivity at level 2, the interactions that can take place between the people involved can be at interactive quality level 2 at the highest. When tools facilitate interactivity at level 5, then interactions between people can take place at interactive quality level 1, 2, 3, 4 and 5. When a higher level of interaction is needed for the instructional design than the tools chosen can facilitate, the learning activities intended for the instructional might be frustrated. Vice versa might be of a lesser problem. A tool then facilitates interaction that remains underused.

Our central research question therefore is

- How does interaction within online education activities change over time?

With the following sub questions



- How does the interactive quality of online education change during the Covid 19 period?
- What combinations of tools do teachers use at the different levels of interactive quality?

METHOD

To monitor a possible shift in interactive quality during the transition to online learning we used a longitudinal survey (Baarda, Bakker, Hulst, Julsing, Fisher, Vianen & Goede, 2012) and analysed the responses of teachers that participated multiple rounds. For the survey we used a questionnaire based on the Rubric for Assessing Interactive Qualities in Distance Learning Courses (RAIQ) (Roblyer & Ekhaml, 2000). Although technologies have significantly advanced since Roblyer and Ekhaml created the rubric in the year 2000, their levels of interactive quality are still valuable and used regularly (Banna et al., 2015; Bawa, 2016; Martin & Bolliger, 2018). The survey questions focus on two elements of the Rubric, namely

1. instructional designs, i.e. the learning activities
2. technology resources

For each of these elements, five different levels of interactive quality are described. The technology resources were based on the meticulous collection of over a hundred tools by www.Doedactiek.nl. This collection is maintained by teachers with broad practical knowledge of educational tools. Within the collection all tools are meta dated on several taxonomies, one of which is interactive quality. The meta dation of each tool is checked by at least one other teacher. Because the meta dation is very much at the heart of the work of Doedactiek, regular collective sessions are conducted to insure different tools are meta dated in the same way. To make the questionnaire manageable for the respondents, the tools in the questionnaire were grouped into 42 groups on similar functionality and equal interactive quality based on the meta data of Doedactiek. In the questionnaire respondents could tick the groups of tools used in the past two weeks.

Because we expected many changes to take place in the early stages of the transition to online education, the questionnaire was set out three times during the initial period of closure of schools. The questionnaire was set out another three times afterwards.

The questionnaire was conducted anonymously. Participants were invited to respond through the personal social media networks of teachers involved with Doedactiek and through the networks of the teacher training institutes of NHLStenden and Windesheim in The Netherlands. Participating teachers who wished to respond in subsequent rounds could leave their e-mail address. In total 179 secondary school teachers responded at least once. A group of 16 loyal teachers responded at least 3



rounds. This made it possible to follow changes they made in their instructional design and the tools they chose over time.

First we analysed the changes in matches in time of the responses on instructional design and technology resources. We plotted the highest interactive quality of the instructional design given and the highest interactivity the tools ticked could facilitate per teacher per round for all teachers.

We then calculated the average deviation from the line with matches as shown in figure 1. We calculated the difference between the highest interactive quality of the Instructional Design and the highest interactivity of the tool used and squared the result to eliminate positive and negative differences. We then determined the average chi square per round and plotted the changes in chi square over time.

Thirdly we portrayed the changes in interactive quality of instructional design and tools over time for the 16 teachers who responded three rounds or more and grouped them around patterns of changes that emerged.

With a different analysis of the same data, we grouped all respondents according to the highest level of interactive quality reported in the questionnaire. We then listed the tools they used and calculated the average number of tools per teachers per level of interactive quality.

FINDINGS

Changes in interactive quality of online lessons over time

In figure 2 we see the highest interactive quality of the instructional designs given and the highest interactive quality of the tools ticked per teacher per round. During the first analysis it stood out that during the months of full lockdown, April and May 2020, all the plots were above or on the slant line. During the other months small numbers of students were allowed to attend school. In these months we see plots both above and under the slanted line. When plots are above the slanted line it means that the interactivity of the tool facilitates more interaction than is needed for the Instructional Design chosen. When plots are underneath the slanted line, the tools cannot facilitate the interaction needed for the learning activities within the Instructional Design. In regular face-to-face education the latter is not problematic because the interaction needed for the Instructional Design can be conducted with face to face techniques. During online education however, the latter becomes impossible because all interaction is facilitated by the technology.

What shows up is that over time less dots appear at the lower levels of interactive quality of both instructional design and tools. This indicates that respondents made adaptations to their teaching during the Covid-19 period. In November 2020 we see more teachers deploying group work at interactive quality level 3, 4 and 5 during their online education than in the first three months of the first lockdown in March, April and May. The steady trend we see until November 2020 is not continued. In



February 2021 we see a slight relapse. At that time both teachers and students dearly yearned to come back to school physically. At this time concerns on the emotional and social wellbeing of students were being reported and political pressure increased to ease the measures in favour of children and students. The relapse we see might reflect the yearning.



Figure 2. Highest interactive quality of instructional design plotted against highest interactive quality of tools

The relapse shows up even more clearly figure 3. In the first weeks of the first lockdown between March 2020 and April 2020 we initially see larger differences in interactive qualities of the instructional design and the tools. It is a time when many teachers get acquainted with the communicative possibilities of technology. Between April and November 2020 an increasing percentage of the respondents better matched the interactive quality of their instructional design and tools. In February 2021 however we saw a strong relapse back to a level close to that a year earlier.

During the second lockdown from november 2020 till February 2021 many schools had adapted their timetables, making it possible for small numbers of students to physically attend school. Unintentionally this made online teaching even harder. Teachers needed to pay attention to both physically present students and their online peers as well. At many schools the duration of lessons was halved. Many teachers reported the only thing they managed to do in these 25 to 30 minute lessons was to cover the content and do homework. Frustration is apparent in some of the open answers the respondents gave:

'How else can I do this?'

After a year of uncertainty and frequent changes, the many challenges teachers faced were starting to pay their toll, frustrating the learning processes of the teachers .



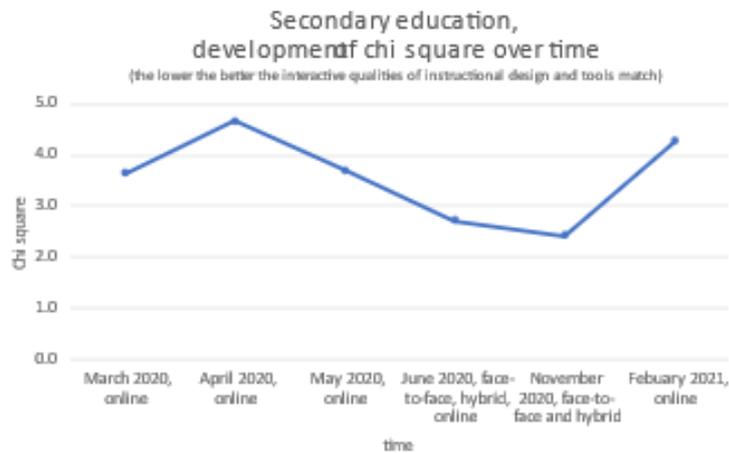


Figure 3. Changes in the average difference between the interactive quality of the instructional design and the tools over time

To date we have analysed emerging patterns of change through six rounds of the questionnaire. Sixteen secondary school teachers participated three rounds or more. We portrayed the changes in interactive quality of their instructional design and interactivity of the tools they deployed over time per teacher. We then compared the patterns and plotted them in figure 4 according the direction of the changes in interactive quality for both Instructional Design and tools used. We found respondents in all but two combinations.



Patterns of Changes in Interactive Quality of Instructional Design and Tools over time per respondent

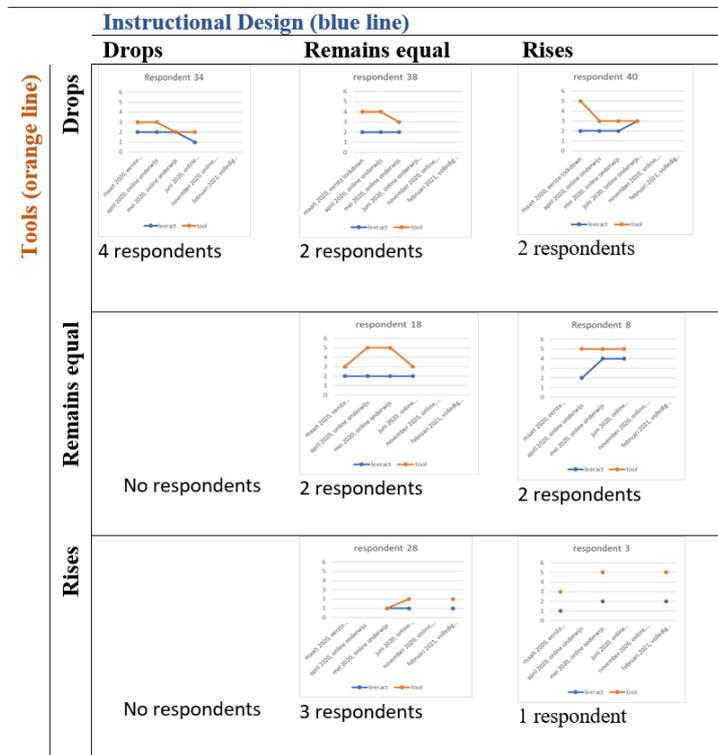


Figure 4. Patterns of changes in interactive quality per respondent over time

In all plots the interactive quality of the Instructional Design is lower than the interactive quality of the tools used. The other way round was not found in our data. Based on this analysis the impression arises that the potential of tools to facilitate interaction for learning processes remained under used. However, we do see slightly more respondents with convergence than divergence over time. This indicates that, although the interactive potential of tools remains underused, the differences between the two become smaller and match better.

In figure 4 we can see that two respondents converge by deploying tools with lower interactivity over time (interactive quality of instructional design remains equal and of tools drop). Two other respondents converge by raising the interactive quality of their Instructional Design (Interactive quality of Instructional Design rises but tools remain equal). Another two respondents converge by adapting both their Instructional Design and their tools (both interactive quality of Instructional Design and tools rise). Six respondents show no net changes over time, though they do make changes along the way (Interactive quality of both Instructional Design and tools drop; interactive quality of both Instructional Design and tools remain equal). Four respondents diverge either because the interactivity of the tools deployed rises or



because the interactive quality of both Instructional Design and tools rise, but to different extent.

All respondents tried to make sense of the situation they were in each with their own strategy. The diversity in the patterns found reveal the struggle the respondents went through whilst establishing online learning processes.

No clear or better strategy in terms of establishing interaction in online learning processes emerged from the patterns of the respondents above.

We therefor returned to the overall data to identify any differences in the combinations of tools that the respondents deployed at the different levels of interactive quality of the Instructional Design.

Tools used per interactive quality level of Instructional Design

In the last row in Table 2 we can see that teachers whose online instructional design consists merely of presenting information, interactive quality level 1, on average use four different tools to do so. The most used tools are for text, image and sound viewing, chat, recording and tools for students to hand in work. Teachers whose highest level of interactivity consists of question and answer systems on average use eight different tools. These teachers use the same tools as the teachers at level 1, but also include document sharing, image and sound editing, videoconferencing and various tools for both formative and summative testing. The largest difference with teachers with an Instructional Design at level 3 is that teachers at level 3 make less use of summative testing tools and more use of specialised tools like online picture stories, online labs and online museum visits. At level 4 of interactive quality of the instructional design, we see teachers use an average of ten different groups of tools from the list provided. The teachers make use of the same tools their colleagues at level 1, 2 and 3 use, but a higher percentage of teachers has marked the use of these tools. Tools for co-editing work is noteworthy and the use of mindmap tools seems more popular than at the other levels. At level 5 we see a slightly lower average of tool use per person, but we see an even higher percentage of teachers making use of the different tools than the teachers of level 4. A higher percentage of teachers in this group uses online search engines and simulations.

The general impression from this table is that teachers who conduct group work in their online classes at interactive quality levels 3, 4 and 5 use more different tools and use them more intensively than teachers at interactive quality levels 1 and 2.

A rather puzzling result is the interactive quality of the tools used by teachers with an interactive quality 4 or 5 of the instructional design. Amongst the ten most frequently used tools, only videoconferencing can facilitate the interactive quality for that instructional design. Only half of the respondents indicates the use of this tool. It is an intriguing finding that not all teachers use tools that facilitate the interactions needed for their instructional design.



Table 2
 Percentage of respondents that use tools per interactive quality of the instructional design

Percentage of respondents using tools per interactive quality of their instructional design						
Tool	interactive quality tool	Interactive quality of instructional design				
		1	2	3	4	5
Text, image and sound viewing	1	0.9	0.9	0.8	0.9	0.9
Chat (synchronous)	3	0.5	0.8	0.7	0.8	0.8
Recording	1	0.6	0.6	0.6	0.8	0.6
Hand in	2	0.4	0.8	0.5	0.7	0.8
Share documents	2	0.4	0.6	0.6	0.6	0.8
Text image and sound editing	2	0.3	0.4	0.4	0.6	0.5
Answering questions	2	0.2	0.5	0.5	0.3	0.8
Videoconferencing	5	0.2	0.4	0.4	0.5	0.5
Formative testing	3	0.2	0.4	0.4	0.5	0.4
Summative testing	2	0.2	0.3	0.2	0.3	0.5
survey	2	0.1	0.3	0.2	0.4	0.3
co-editing	3	0.0	0.1	0.2	0.6	0.1
lessonup/nearpod/learnbeat	2	0.1	0.3	0.2	0.4	0.0
interactive whiteboard	1	0.2	0.2	0.2	0.2	0.1
search engines	2	0.1	0.1	0.1	0.2	0.3
Whats app (a-synchronous)	4	0.1	0.2	0.1	0.2	0.0
Poll	2	0.1	0.1	0.1	0.2	0.1
data collecting (science)	2	0.1	0.1	0.1	0.2	0.1
reacting to answers	3	0.0	0.1	0.1	0.2	0.1
games (individual)	2	0.0	0.1	0.1	0.2	0.1
mindmap	2	0.1	0.1	0.1	0.2	0.0
simulation	2	0.1	0.0	0.1	0.0	0.3
interactive book	2	0.1	0.1	0.0	0.1	0.0
picture stories	2	0.0	0.0	0.2	0.0	0.1
digital method	2	0.0	0.0	0.2	0.1	0.0
portfolio	2	0.0	0.1	0.0	0.1	0.0
social media	4	0.0	0.1	0.0	0.1	0.0
museum	2	0.0	0.0	0.1	0.1	0.0
games (group)	5	0.0	0.0	0.0	0.1	0.0
instant answers (like answer gar	3	0.0	0.0	0.0	0.0	0.0
online lab	2	0.0	0.0	0.1	0.0	0.0
feedback	4	0.0	0.0	0.1	0.0	0.0
conceptmap	3	0.0	0.0	0.0	0.0	0.0
storyboard	2	0.0	0.0	0.0	0.0	0.0
projectmanagement	3	0.0	0.0	0.0	0.0	0.0
podcast	1	0.0	0.0	0.0	0.0	0.0
timeline	2	0.0	0.0	0.0	0.0	0.0
virtual reality	2	0.0	0.0	0.0	0.0	0.0
Slido	3	0.0	0.0	0.0	0.0	0.0
wordcloud	3	0.0	0.0	0.0	0.0	0.0
meeting	4	0.0	0.0	0.0	0.0	0.0
other		0.0	0.0	0.0	0.1	0.0
Average number of tools used per person		4.0	8.0	8.0	10.0	8.0

average percentage of respondents using these tools 0,1 to
 average percentage of respondents using these tools 0,3 to
 average percentage of respondents using these tools 0,5 to
 average percentage of respondents using these tools 0,7 to
 average percentage of respondents using these tools 0,9 to



DISCUSSION AND CONCLUSION

Though all teachers could participate in this study, the focus was on secondary school teachers in the north of the Netherlands. The study took place under very unpredictable circumstances. Covid measures changed frequently over time with an overload of challenges. Besides having to work online, teachers were also confronted with hybrid situations, changing schedules and changes in duration of lessons, facemasks, self-tests and last but not least the constant fear of contamination in poorly ventilated classrooms with near to no protection.

Despite the circumstances the interactive quality of online education has slightly increased over time. Several respondents managed to better match the interactive qualities of their Instructional Design and the interactivity of the tools. Some respondents did so by adapting their Instructional Design towards the interactive possibilities the tools provided. Others changed the tools they used. On average, respondents who report higher levels of interactive quality for their Instructional Design also report the use of both more and different groups of tools than respondents who reported lower levels of interactive quality in their Instructional Design.

During the first nine months of the pandemic we saw a steady decrease of the difference in interactive quality between the Instructional Design and the tools. However, during the second lockdown this trend stilled, possibly due to organisational changes that were intended to relieve teachers and students from the strains of online teaching and learning.

Our results show that over time more group work was adopted during online education. In concordance with Roblyer & Ekhaml (2000) we refer to this as an increase of interactive quality. However, the individual tools the teachers used could not facilitate the interactions needed to establish the higher levels of interactive quality for the group work. This contradicts the line of thought that technologies that allow high interactivity might be necessary to allow high interpersonal interaction (Roblyer & Ekhaml 2000).

At our round table discussion, E03 Secondary School Education, during the EAPRIL 2021 we discussed this finding. During the online EAPRIL event we were ourselves physically thousands of miles apart yet we all experienced a feeling of collectiveness. It gave us the inspiring insight that even though individual technologies might not facilitate the interactions needed to establish a higher level of interactive quality like Roblyer and Ekhaml (2000) suggest, a smart combination of tools and artful orchestration by the teacher might.

We do not know how often we will depend on online education in the future. If it becomes a regular back up, we will need to make online learning more inspiring. Roblyer and Ekhaml first reported interactive quality to be important for distance learning in the year 2000. Since then, the interactivity of the technologies available have improved, but our findings suggest many remain underused. This suggests that improving interaction in online education is more a pedagogical challenge than a



technical one. To progress teachers will need to increase their pedagogical knowledge on the importance of interaction for learning processes and learn how to deploy the full interactive potential of the technologies they already use. Despite the enormous constraints of the pandemic that faced them, several respondents in this study did so. They show us we can all adopt more interaction in our online classes. Let us do so too, on behalf of the learning of all the students entrusted to us.

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