Social and cognitive interactions through an interactive school service for RTT patients at the COVID-19 time

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Abstract

Background

The closure of all educational institutions and most rehabilitation centers represents a precautionary measure to face the COVID-19 pandemic, but the isolation and social distancing may be particularly challenging for children with special needs and disabilities (SEND), such as Rett Syndrome (RTT). The main aim of this study was to promote cognitive and social interactions among children and girls with RTT, through the interactive school program

Methods

The Interactive School palimpsest was composed of moments in which the teacher spoke directly to the subjects with RTT and expected a response through eye gaze, and moments in which stories-cartoon were presented while tracking the eye gaze of the patients. We investigated behavioural, social and cognitive parameters.

Results

Patients attended both social and cognitive tasks with the spontaneous reduction of stereotypies and with the increase of attention. They recalled more significant indexes when the music or the song was presented together with the cartoon or the cognitive task.

Conclusions

this study provides initial insights in promoting cognitive and social interactions and into the support needs of families with a child with RTT during the COVID-19 pandemic.

Background

On 10th March 2020, schools, universities and all centers that hosted patients with special needs and disabilities (SEND) in Italy were closed to all pupils. This imposed closure of all educational institutions and most rehabilitation centers represents a precautionary measure to face the COVID-19 pandemic and similar measures have been taken in countries all around the world. Although this change was necessary, the isolation and social distancing may be particularly challenging for children with SEND and their families, given the reliance of many on carefully established routines and relationships as well as professional and informal support [1]. For example, children and girls with Rett Syndrome (RTT) constantly need to access equipment and professional support only available in rehabilitation centers. But, as RTT is a complex and rare disease, affecting 1:10,000 people, the management of this syndrome requires a high level of preparation and there are few specialized centers and specialists in Italy [2, 3]. As a consequence, accessing adequate rehabilitation and special education treatments was particularly challenging for RTT patients, already in before the COVID-19 pandemia, and the current imposed measures render conventional treatments even harder to access. In this context, life may become extremely difficult also for parents of children and girls with SEND, such as RTT, who meet their child's needs all day and every day, without the usual support of external professionals, teachers, schools and rehabilitation centers.

The use of technology to learn, live, and stay connected has become essential during a time of isolation and social distancing [4]. Indeed, one of the most significant changes for millions of families and their child has been the virtual-school [5]. Public and private school have created virtual platforms for virtual learning, but for students with SEND, such as RTT, the online learning has not been fully accessible [6]. Hence, the closure of schools due to the COVID-19 emergency has caused children with SEND and their families to experience serious

educational problems [7, 8]. To our knowledge, no research exists addressing the question of how promoting social and cognitive interactions among children with SEND during the COVID-19 pandemic, there are only general recommendations and suggestions [7, 9].

Supporting the families with children with SEND such as RTT is clearly necessary during the COVID-19 pandemic, for this reason the Interactive School for RTT patients and their parents was created. The aim of the Interactive School was to bring the whole class or center to the RTT patients' homes through interactive teaching that motivated them to learn more, but, above all, to have fun being together with other children or girls and teachers. The underlying rationale of this project is twofold: technological and psychological. From the technological point of view, RTT patients suffer from severe difficulties in physical interaction, which in some cases leave them with only the ability to communicate and interact by means of their eye gaze [10]. This requires a technological support based on gaze tracking to allow for interaction with other people and with other technological platforms [11]. From the psychological point of view, studies examining the effectiveness of multimedia technologies have demonstrated positive effects on the cognitive, communicative and motivational abilities of children with RTT [12, 13]. In particular, it was found that multimedia presentations activate motivational factors which, in turn, increase the attention levels of patients with RTT. Moreover, although RTT is a complex disorder characterized by loss of purposeful hand movements and speech, regression of acquired cognitive and motor skills, RTT patients have not specific impairments in the theory of mind (ToM) ability and the teacher's face is an additional motivating factor in attracting their attention [14]. In addition, subjects with RTT often remain visually attentive to objects and people, showing preferences to the human face and eyes, and they successfully use eye gaze to communicate [15, 16]. For all these reasons, it was hypothesized that children and girls with RTT can benefit from the possibility of social and cognitive school interactions through online system, boosting their cognitive and social communication skills. Thus, the Interactive School for RTT was designed to catch RTT patients' attention and curiosity, and partly based on the communication platform previously developed for a tele-rehabilitation project [17].

The main aim of this study was to promote cognitive and social interactions among children and girls with RTT, through the interactive school program. The Interactive School palimpsest was composed of moments in which the teacher spoke directly to the subjects with RTT and expected a response through eye gaze, and moments in which stories-cartoon were presented while tracking the eye gaze of the patients. We investigated:

- Whether the number of seconds of attention (fixation length) was higher on the cognitive or on the social task;

- If the time spent in stereotyping was higher in the absence of stimulation, in social and cognitive tasks;
- If the time of attention (fixation length) was higher on the teacher's face or other participants.

Because RTT patients have not deficits in the ToM and the human face attracts their attention, we expected that the time of attention would be high both on cognitive and social tasks, that it would be also higher on the teacher's face than participants' face, and that the time spent in stereotyping would be lower when RTT patients were engaged in social or cognitive task than when in absence of stimulation.

Methods

Participants

Thirty-nine girls with RTT, ranging from ages 3 to 24 years (mean = 9.8 years) were classified between clinical stage III and IV. They were recruited by the Italian Rett Syndrome Association (AIRETT). Demographic, developmental, clinical, behavioural, and genetic information, collected from all available sources such as parent/caregiver reports of past history and current behaviour and features, latest clinical reports. Table 1 summarizes the characteristics of all participants.

Table 1
Means and (standard deviations) of point scores on functional scales.

RTT participants	RARS[1]	VABS[2]	Raven[3]
61.89 (2.40)	61.89 (2.40)	89.91 (2.32)	5.1 (3.45)
[1]Rett Assessment Rating Scales (RARS)			
[2]Vineland Adaptive Behaviour Scales-Interview second edition (VABS)			
[3]Raven's Progressive Advance Matrices			

———— insert Table 1 about here ————

Technological Architecture

The Interactive School communication architecture leverages on the Cisco Webex conferencing system. The reason why we chose such a system is that, at the time the CoVID-19 emergency started, we were already using this platform for a telerehabilitation project [11]. This timing coincidence helped us to start immediately with the Interactive School, since educators and therapists had already acquired skills to manage a videoconference with RTT subjects, though with a different purpose. In fact, during a telerehabilitation session the therapist supervises activities that are conducted locally by the patient with the help of a caregiver. On the contrary, during an Interactive School lesson, the educator administers several activities by means of multimedia material (such as presentations or videos) or asks for physical movements (e.g. play a tambourine). Then, RTT patients have to respond to these stimuli, helped by the caregiver, and the interactions and levels of attention can be observed by means of an eye-tracker.

In Fig. 1, the overall architecture is shown.

——— Insert Fig. 1 about here ————

As we already mentioned, during a lesson the educator administers multimedia material through the videoconferencing software. Multimedia material is of different kinds, each one requiring a different level of interaction by the RTT patients. In Fig. 2 we illustrate what is shown by the educator for each lesson activity. While the educator shares a video (e.g. a cartoon), each one of the connected RTT patients sees the same content (Fig. 2 - A). On the patient side, the interaction is acquired by the eye-tracker. Data about this interaction will be subsequently used for attention analysis. During the slide sharing, the educator shows some content and asks the children to answer a question, by choosing an image on the screen (Fig. 2 - B). In this case the caregiver in turn shares the screen to the educator, so that the educator can see the choice of the patient by looking at the cursor on the screen, moved through the eye-tracker.

Finally, when the interaction between the patients is needed, the educator switches to grid view, in such a way that each participant can see the other participants. This occurs, for instance, when the educator asks the children to greet one each other (Fig. 2 - C).

——— Insert Fig. 2 about here ————

Procedure

The Interactive School was composed of social and cognitive interaction intervals. With reference to the social interaction intervals, at the end of the opening multimedia, the teacher expanded the video of each participant in turn, and invited them to introduce themselves according to their skills. The caregiver could help the participant during this first social interaction, for example, she/he could raise the participant’s hand. When some participant spoke, the full screen mode displayed zoomed view of the speaker’s face, thus allowing each participant to focus her attention on the speaker. After these initial greetings, the teacher noted the presence or absence of participants in a nice way, for example, the picture of each girl or children in a school bus displayed on the screen. This was the second social interaction. The third social interaction occurred at the end of each teaching session, when the teacher thanked the participants and closed the session with a musical video.

With reference to the cognitive interactions, after the second social interaction, the video of a cartoon story was presented. The tale changed in each section. The cartoon story, presented while tracking the eye gaze of the participants with the eye-tracker, was easy to understand and remember and the descriptions of facts were presented in a logical order. The cartoon sequences were extracted from famous animation movies, such as “Heide”, “Minnie”, “Mary Poppins” and calibrated according to the comprehensibility of the story. Each cartoon sequence lasted 2:30 minutes. During this viewing it was important for the teacher to have feedback of the girls' faces to draw attention if necessary or reinforce them. At the end of the cartoon sequences, a recognition test was carried out for each participant. They were asked to perform, in turn, immediate recall of the cartoon with a recognition test composed of 10 questions regarding the story. For each question, two pictures were presented on the screen, the correct answer and the distractor answer.

The scoring standard used in the present study involved giving 1 point for choosing the correct answer, and 0 point for choosing the distractor. The total time of each session was about 20 minutes.

Data analysis

Eye-tracking. Within each stimulus, a squared area of interest (AOI) around the target was defined. The size of the AOI covered a visual field of about 19 degrees.

For each AOI, relative to each stimulus, the Fixation Length (FL) was measured, which is the amount of time (seconds) spent by the girl when looking at the target. Fixations were extracted using a threshold of 100 ms.

Measures

Behavioural and cognitive measures. With reference to the general behaviour of the patients with RTT the parameters were:

1. Number of seconds of attention (fixation length) to social and cognitive tasks for a maximum time of 10 minutes (600 s)
2. Time spent in stereotyping in the absence of stimulation, in social and cognitive tasks for a maximum time of 10 minutes (600 s)

Social communication task. With reference to social communication the parameters were:

1. Fixation length (FL) of the participant on the teacher during the assignment of tasks or during reinforcements or singing a song (Fig. 3);

1. FL of the same participant on the first girl that was invited move or reply when she was called by the teacher;
2. FL of the same participant on the second girl that was invited to move or reply when she was called by the teacher;
3. FL of same participant on the third girl that was invited to move or reply when she was called by the teacher;
4. FL of same participant on the fourth girl that was invited to move or reply when she was called by the teacher.

——— Insert Fig. 3 about here ———

Cognitive tasks. With reference to cognitive tasks the parameters were:

1. FL of the participant on the main character of the cartoon
2. FL of the participant on the PC screen but out of the main character
3. FL of the participant out of the PC screen
4. Number of correct replies to the questions on the cartoon. The recognition test was based on 10 questions regarding the story posed immediately after the vision of the cartoon.

More in detail, with reference to the cognitive task, FL was computed in the following way (Fig. 4):

——— Insert Fig. 4 about here ———

In both tasks FL refers to the amount of time (seconds) spent by the subject when looking at the correct stimulus. Fixations were extracted using a threshold of 100 ms.

Statistical analysis

The data were analysed using SPSS version 24.0 for Mac. The descriptive statistics of the dependent variables were tabulated and examined. Alpha level was set to 0.05 for all statistical tests. In the case of significant effects, the effect size of the test was reported. The relationship between variables was evaluated by determining Pearson's r.

Results

The results are first discussed with reference to behavioural and cognitive measures, secondly with reference to the social communication task and finally with reference to the cognitive task.

Behavioural And Cognitive Measures

As regards the number of seconds of attention (Fixation Length, FL) to social and cognitive tasks, Table 2 shows the means and standard deviations of the parameters attention and time spent in stereotyping.

Table 2
Means and (Standard deviations) of the seconds of behavioral indexes

	No task	Social task	Cognitive task
FL in ss (attention)		228.32 (210.21)	264.32 (190.21)
Time spent in stereotyping	539.94 (56.12)	385.41 (76.20)	360.21 (45.21)

With reference to the seconds of selective attention, the ANOVA repeated measurement design was applied to verify the effects of the variable *task* (social VS cognitive). *Task* shows significant statistical effects F (2, 38) = 11.97, p < .0001. As shown in Table 1, FL is higher on the cognitive task than in the social task. With reference to the seconds of stereotyping, the ANOVA repeated measurement design was applied to verify the effects of the variable *task* (no task VS social task VS cognitive task). Task shows again significant statistical effects F (2, 38) = 13.97, p < .0001. As shown in Table 2, the stereotypes tend to be higher when the patients are not engaged than when they are engaged in a social task or on cognitive task (paired-t test is respectively t(36) = 8.1, p < .001 and t(36) = 7.21, p < .001). These results suggest that when patients with RTT are engaged in social or cognitive task they attend them and reduce stereotyping behavior.

——— Insert Table 2 about here ——

Social Communication Task

With reference to the Fixation Length (FL) of the participants on the teacher target and on the other participants targets, data were collected during the assignment of tasks, during reinforcements and during social phases such as “say hello”, "say goodbye” or “introduce yourself”. Table 3 shows the means and standard deviations of the FL parameters. Since social pattern vary in relation to context (a patient may need more time to look when called into question or the teacher may speak for a longer time), pattern of attention and time spent are referred to percentage (i.e., if the total speaking time of the teacher was 38 s and participant 1 looked at her for 38 s, 100% time was assigned; if participant 2 was requested to make a noise with an instrument for 12 s and participant 1 looked at her for 10 s, then 83.33% time was assigned).

Table 3
Means (and Standard deviations) of percentage of fixation length for each member of the interactive school

	Teacher	Participant 1	Participant 2	Participant 3
Percentage of FL	55.58 (41.17)	47.22 (32.86)	33.16 (23.12)	36.59 (22.67)

—— insert Table 3 about here ———

An ANOVA repeated measurement was applied to verify the effects of the variable *participants* (teacher, participant 1, participant 2, participant 3). Participants shows significant statistical effects $F(3, 90) = 4.97$, $p < .01$. More specifically, the participants tend to pay more attention to the teacher than to the other participants.

Cognitive Task

With reference to cognitive tasks the parameters were again the FL on the main character of the cartoon (on the main character, on the PC screen but out of the main character and out of the PC screen; see Fig. 1) and the number of correct replies to the 10 questions regarding the story of the cartoon.

——— Insert Table 4 about here ———

Table 4
Means (and Standard deviations) of percentage of fixation length for the cartoon

	Main character of the cartoon	**Out of the main character on the screen**	**Out of the screen**
Percentage of FL	76.38 (27.01)	6.12 (7.86)	15.86 (14.12)

An ANOVA repeated measurement was applied to verify the effects of the variable *Attention* (to the main character, away of the main character but on the screen, out of the screen). *Attention* shows significant statistical effects $F(2, 76) = 37.97$, $p < .001$. More specifically the participants tend to pay more attention to the main character of the cartoon than away of it or out of the screen.

However, if only cartoons containing were songs are considered, the time spent in looking at the main character was significantly higher (almost 100% of FL).

The percentage of correct replies to the 10 questions on the story of the cartoon was very high: 68%. And this performance showed high correlation with the FL.

Correlational Analysis

R Pearson correlation measurement was applied to verify the correlation between the fixation length and the CR (Table 5).

Table 5
Pearson correlations

CR	Main character of the cartoon	Out of the main character on the screen	Out of the screen
CR 1	.37*	− .128	− .55**
Main character of the cartoon	1	− .35*	− .88**
Out of the main character on the screen		1	− .046
Out of the screen			1

—— Insert Table 5 about here ———

The correlation between fixation length (FL) of the target stimuli and CR of the stimuli is very high, $r(40) = .37$, $p < .011$, and it is also consistently inversely related to the fixation out of screen, $r(40) = -.55$, $p < .001$.

Discussion

The main aim of the present study was to promote cognitive and social interaction among children and girls with RTT, through the Interactive School program presented through a teleconference platform. As described in this paper, the Interactive School was composed of social moments in which the teacher spoke directly to the subjects with RTT and expected a response, and moments in which different cartoon stories were presented while tracking the eye gaze of the subjects, followed by a recognition test. We examined behavioural, cognitive and social skills of the participants in terms of number of seconds of attention to social or cognitive tasks, duration of attention to the teacher or the other participants.

As expected, participants attended both social and cognitive tasks with spontaneous reduction of stereotypes and with increased attention. They recalled more significant indexes when music or songs were presented within the cartoon or the cognitive task. Also, we found that when patients with RTT were engaged in social or cognitive tasks, they attended to them and reduced their stereotyping behavior. These findings confirm results presented in the literature, demonstrating that subjects with RTT show a high level of attention and reduce their stereotypes if correctly stimulated [18–20]. They also confirm the preference of patients with RTT for human faces, because in this study, we found that the participants tended to attend more to the main character of the cartoon than away of it or out of the screen and they focused more time on the teacher’s face than on the other participants. As regards correlation analysis, Pearson's coefficient r was chosen as the measure of the correlation strength. The relationship between fixation length and correct reply was very high. This result suggests that when the attention of subjects with RTT is correctly focused and captured by tasks, the number of correct responses increases.

This study supports the idea that the subjects with RTT can benefit from the use of technology-aided programs, such as teleconference platform plus cognitive and social tasks, to promote cognitive and social skills. However, it is important to consider that these technologies are subject to some limitations, because even though they have universal design features, the subjects with RTT present heterogeneous and complex impairments. As a consequence, the technology must be matched with RTT profile to meet the individual's needs [21]. In accordance with previous studies [22–26], we suggest that more accessible online education tools should be designed to consider a wider range of concerns, such as feature of the syndrome, age and online environment. In addition, given the complexity of RTT, it is necessary to develop specific validation approaches through well-designed evaluation processes, to confirm the benefits and potential effects of technology-mediated, and remotely administered, social and cognitive tasks for patients with RTT.

Conclusion

The present findings also shed new light on how parents of children and girls with RTT would like to be supported during the COVID-19 pandemic. In particular, this study suggests that teleconference platforms can be used both in daily living and typical clinical settings and that they have a positive impact on more levels of functioning from cognitive to social. Teleconference platforms can involve both patients and their caregivers, in cases such as RTT [27–33]. In summary, the present study provides initial insights in promoting cognitive and social interactions and into the support needs of families with a child with RTT during the COVID-19 pandemic.

Abbreviations

AIRETT
Italian Rett Syndrome Association
AOI
area of interest
FL
Fixation Length
RTT
Rett Syndrome
SEND
Special needs and disabilities
ToM
theory of mind

Declarations

Ethics Approval and consent to participate

The Ethics Committee of the University of Messina approved the study protocol. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent for publication

Informed consent was obtained from all parents of participants included in the study. The consent was written.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare no conflict of interest

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Author Contributions

Conceptualization, L.D. and R.A.F.; methodology, R.A.F.; software, A.N. and G.I.; resources, L.D. data curation, T.C., M.S., and S.G.; writing—original draft preparation, R.A.F., T.C., A.N., and G.I.; writing—review and editing, T.C. and R.A.F.; supervision, L.D. and R.A.F.; project administration, M.S., T.C., L.Z., and S.G. All authors have read and agreed to the published version of the manuscript.

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Figures

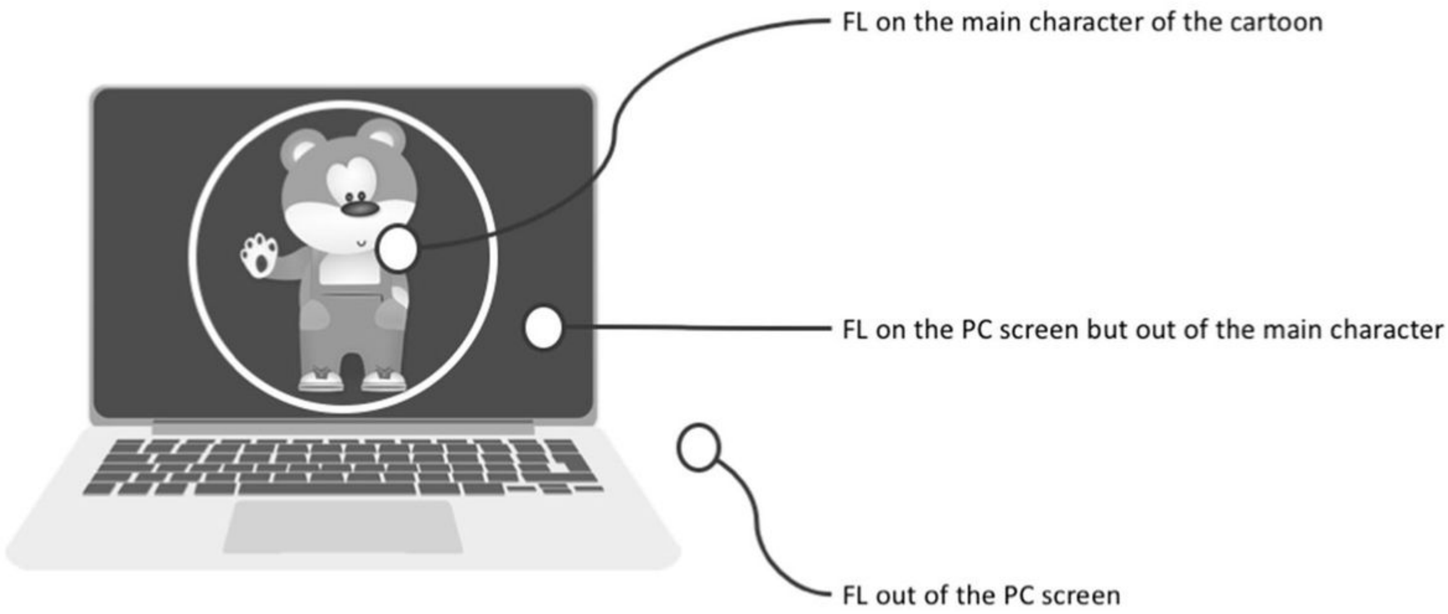

Figure 1

Computation of the three different FL

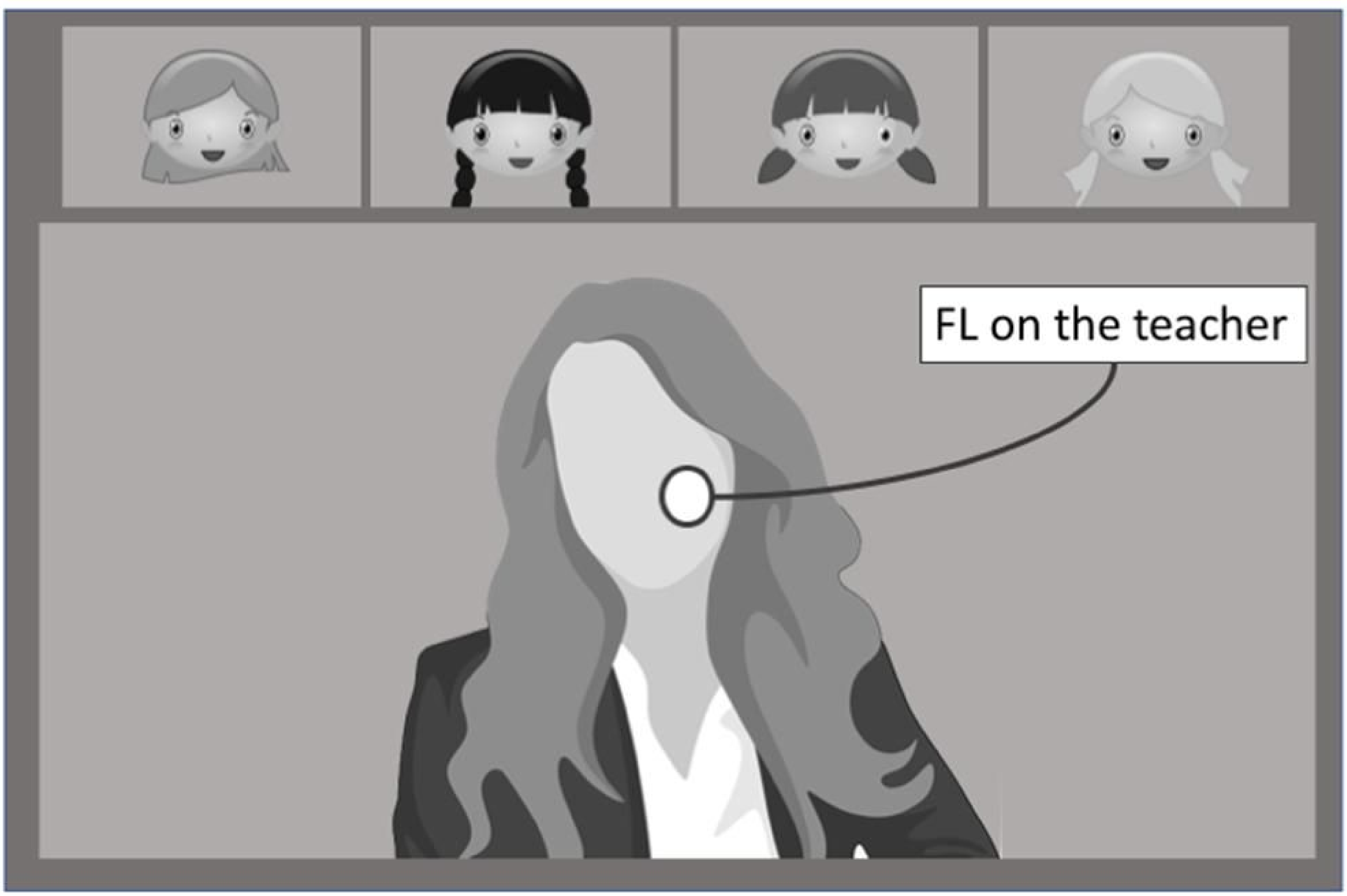

Figure 2

Computation of FL on the teacher

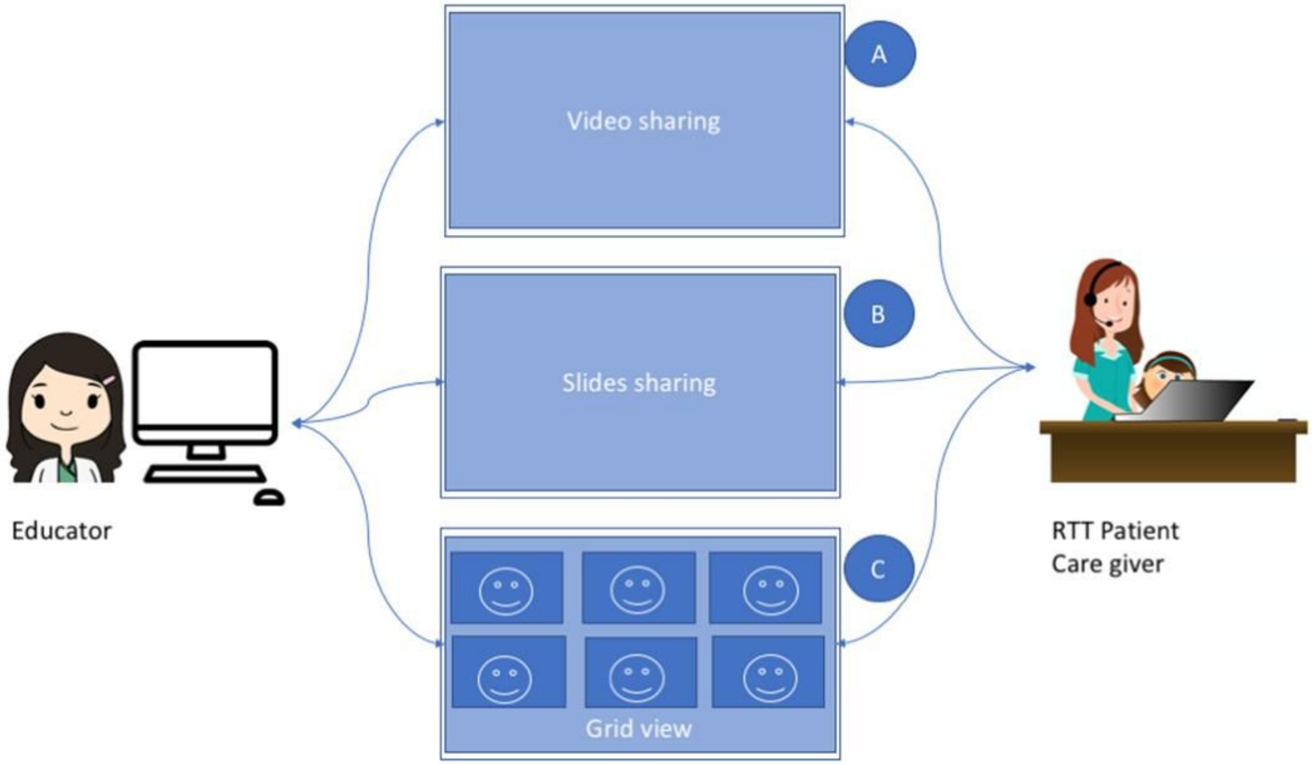

Figure 3

Lesson activities

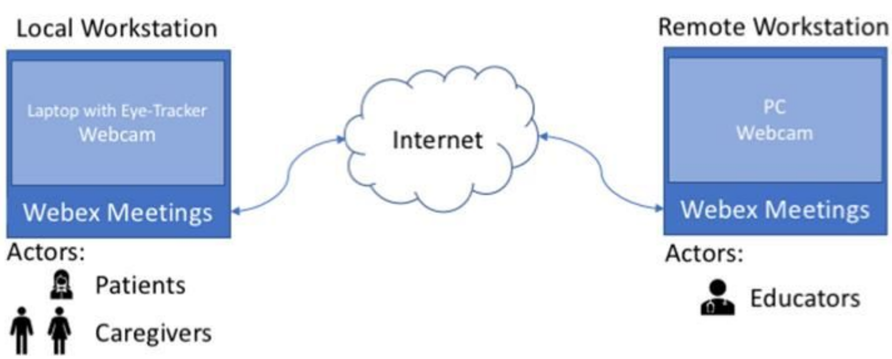

Figure 4

Interactive school architecture