ORIGINAL ARTICLE

Understanding children's behavior in an asynchronous video-mediated communication environment

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Abstract Video-mediated communication (VMC) has become a feasible way to connect people in remote places for work and play. Nevertheless, little research has been done with regard to children and VMC. In this paper, we explore the behavior of a group of children, who exchanged video messages in an informal context. In particular, this paper presents the results of 11-week VMC study of 30 children from the USA and Greece, exploring children's behavior with the asynchronous video-based messaging tool we developed called VideoPal. In the study, children's interactions, perceptions, content exchanged and emotions were collected. The results from the analyses highlight that the emotion of happiness dominated in the communication. Moreover, the content included useful personal information and is connected with children's interactions (e.g., number of views and of recipients). In addition, children generally preferred VideoPal to email because they felt that it was easier and has more fun.

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1 Introduction

Computer-mediated communication (CMC) includes a variety of electronic messages and audio–video systems. There is also increasing evidence that CMC mediums are replacing traditional forms of media and becoming a primary mode of communication in the workplace [1]. In this research, we are exploring the potential of CMC in the classroom, with a special focus on children's communication between distant places. We evaluated a video-based asynchronous tool called VideoPal [2, 3]. Our interest for asynchronous video derives from its ability to support communication between people from different parts of the world spanning many time zones and that video may be more effective for young children who have not mastered text-based technologies [4].

In particular, this study explored the benefits of asynchronous video-mediated communication to support communication among elementary school students from USA to Greece. This approach seeks to explore children's behavior with the asynchronous video-mediated communication environment; to do so, issues regarding the following research questions need to be clarified:

What kind of interactions are indicated in children's video-mediated communication?

What are children's perceptions regarding video-mediated communication?

What kind of content children exchange in video-mediated communication?

What kind of emotions dominated in children's video-mediated communication?

The paper is structured as follows. In the next section, the related work is outlined. Section 3 presents the video-mediated communication system. Section 4 indicates the methodology employed in this study while the fifth section indicates the empirical results of this paper. Finally, the paper concludes with discussion, implications and recommendations for future research.

2 Related work

Various studies have shown that children are usually ineffective communicators because they have not mastered the necessary linguistic or cognitive competencies [5]. Bruner asserted that a language-based medium like email would be more complex for children than a medium that leveraged actions, bodily movement or imagery. In addition, Marcoccia [6] and Herring [7] have claimed text-based asynchronous CMC to be incoherent for reasons such as the lack of simultaneous feedback, and the disrupted turn adjacency. However, video-mediated communication (VMC) provides social context cues such as nonverbal signals (facial expressions, gestures), paraverbal cues (voice volume) and interpersonal cues (gender, physical appearance). As such, VMC is considered the most desirable to support nonverbal communication among children [8].

Video communication can be characterized in terms of the length, the duration and the number of other user interactions with the respective video system. Sellen [9] indicates that patterns of communication are of interest because they may reveal the manner in which a communication is conducted and offer a mean for assessing the effect of communication tool. For example, difficulties in the regulation of communication may reveal itself in long turns, repeated views or unusually long duration videos. Several studies have looked at how communication interactions change with the alternation of the environment (e.g., [10]). For instance, it has been found that telephone communication has fewer interruptions and lengthier utterances than FtF communication [10]. Few researches have dealt with interactions in VMC [9, 11]. These studies suggest that VMC has sometimes similar and sometimes different interaction patterns with other mediums (e.g., telephone, FtF). As such, the question of how video interactions affect the communication process remains.

Video-based and text-based technologies are the two main pillars of CMC. Text-based communication has been found to disrupt the regulation of turn taking and to undermine higher language processes [12]. In the same direction, Ferrara et al. [13] found that interlocutors in text-based communication tend to omit subject pronouns and articles as a response to the increased costs of formulating and producing utterances in these settings as opposed to speaking. Media richness and social presence theories, which are widely accepted, suggest that video has several distinctive advantages over text-based and thus could be more effective in supporting communications. In particular, according to media richness theory, video as a medium allows the simultaneous observation of multiple cues, including body language, facial expression and tone of voice. It is of a personal nature and utilizes natural language, which is high in variety [14]. Social presence theory suggests that communicating partners can have more awareness about each other's states using videos than using other media, such as email or telephone [15]. And thus, video could be good for supporting communication among children. Ames et al. [16] compared children's use of phones and synchronous video conferencing system and suggested that the benefits of video for children include that (a) the visual aspects keep children engaged in synchronous video chat, (b) less help from parents is needed for children to participate in video chat rather than in phone conversations because children can participate by simply sitting in front of the camera, but (c) parents need to provide some scaffolding, namely conversation support, to keep children talking. However, since the context in that study was connecting children with adults, it is not clear whether this kind of conversation support is still needed when children talk with their peers of similar ages.

Since computers have changed many things in children's lives, numerous researchers have attempted to discover children's digital needs and usage. Research on children and technology (e.g., [17–19]) gives insight into the ways children view and use technology. In particular, O'Neill and Colley [17] indicate that students email communication includes work-related issues. In addition, Guiller and Durndell [20] found that students' online discussion includes "sharing of personal information beyond that of opinion and feelings." Although these studies provide a useful insight regarding the content exchanged between children in CMC environments, little attention has been given to understanding the content exchanged in VMC from children.

During CMC such as email and Internet chat, participants are unaware of the facial expressions, tone of voice and the general emotional situation of the other participants. This often causes communication problems, such as disruptions in conversations and difficulties in communication flow [21]. Riordan and Kreuz [22] indicate that emotion plays a role in choosing the communication channel. While research on emotions has flourished (e.g., [23]), the role of emotions in video communication has been largely ignored. However, in the case of VMC, the emotion effect might be more intense due to the nonverbal signals. Kay and Loverock [24] have identified an emotion

scale which includes the basic computer-related emotions. Therefore, in this study an attempt to interpret VMC emotions through this scale is made.

3 Methodology

3.1 Procedures

The VideoPal project started with a project in a private school in Washington State, USA (WA). One tradition in the WA school is that every year, each grade selects a country to study and learns about that country's culture and lifestyles. In the final week of the fall semester, the children give presentations to all the teachers, students and their parents about what they have learned about that country. In previous years, the students learned about their chosen country by reading books and looking for information on the Internet. This year, the fourth-grade students were studying Greece.

The Greek side of the VideoPal project was administered through Ionian University. Instead of the project being a part of their school day (due to difficulties with the public school system), all of the students from Corfu took part in the study during their spare time. These students came to Ionian University every Friday evening to use VideoPal and correspond with their pen pals. One teacher also volunteered to participate in the project and facilitate the interactions. The key motivations for these children and their parents was that it was regarded as a good opportunity for them to practice their English and it also enabled them to learn more about computers.

Because the number of students in WA was asymmetric to that of Corfu, we divided the 25 children from WA into 5 groups. Each group communicated with one child from Corfu during the study. Since we paired boys to boys and girls to girls, one girl from Corfu communicated with 7 girls from WA, and the other girl from Corfu communicated with the other 6 WA girls. Each of the Corfu boys communicated with 4 WA boys.

The duration of the study was approximately 11 weeks. The study began on November 12, 2010, and finished on the February 28, 2011, with breaks during Christmas (17 Dec–11 Jan) and 04–15 Feb. The following graph (Fig. 1) indicates the number of videos created each week and their length during the study. During the first week, each country group only sent videos internally, in order to get familiar with the user interface.

3.2 Sampling

The sample of participants in this study was comprised of 30 students. From the total participants, 25 pupils were from WA and 5 pupils were from Corfu. In the fourth grade at WA, there are 2 classes. Class 1 has 13 students (6 boys and 7 girls), and Class 2 has 12 students (6 boys and 6 girls). All of the students from WA are 9 to 10 years old. Both Class 1 and Class 2 have a technology lesson every week, which is taught by a specialist teacher in a technology laboratory. From the site of Corfu, five students (3 boys and 2 girls, aged 11–12 years in fifth and sixth grades) volunteered to participate in the project. They were taught technology lessons and attended intensive English lessons.

3.3 The VMC system

The asynchronous video-mediated communication was based on a system named VideoPal [2]. It enables users to capture videos, record their screen, upload an existing video, and send, receive and reply to a video message. Video messages are threaded by topic, and each conversation is visually represented. The VideoPal user interface is primarily composed of the main window, the message play window and the create new message window (Fig. 2).
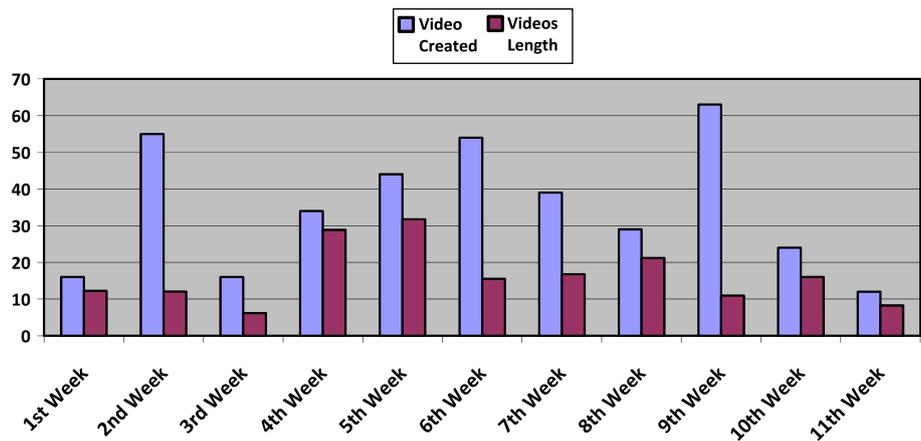
The main window allows users to quickly see which conversation threads are available, the properties of each thread (e.g., number of messages, number of unread messages in the thread), a visual presentation of one conversation, the new messages, which are shown at bottom of the visualization panel, and the current users' profile photos. From this main window, users can create a new video or play an existing video message. The visualization panel in the main window displays a topically threaded sequence of messages, which shows the flow of a conversation—seeing who responded to whom and when, based on the way messages branch. Each video thumbnail is visually decorated to indicate where the video is from. Videos sent from Greece are surrounded by a Parthenon and videos sent from Washington (The Evergreen State) are surrounded by a forest. At the bottom right corner is the new message panel, which shows the thumbnails of the new videos that have been sent to the user but have not been watched yet.

Clicking on a video thumbnail in the main window will open the message play window (Fig. 2). Children can easily create a reply message by clicking the reply button. Clicking on the new conversation button in the main window or clicking the reply button in the "message play" window will bring up the new message window. Here the children have three different options: they can (1) choose to create a new video using the webcam by clicking the red record button, (2) create a screen recording by clicking the camera icon, or (3) send an existing video by uploading a video from the computer.

3.4 Measures

A wide range of data were collected to address our research questions, including log files, surveys, interviews,

Fig. 1 The number of videos created each week and the average length of the videos each week

observations and content analysis of the videos the students sent to each other.

Descriptive data on all the video messages transmitted during the study were obtained through computer log files. In particular, we examined the following interactions: (1) number of author viewings, (2) number of recipient viewings, (3) video duration, (4) number of recipients, and (5) distance of a video from the start of the thread (Video Distance). Authors' viewings refer to the number of times the author of video replayed the video after sending it. Recipient viewings is the number of times a recipient viewed the video. Video duration is the length of each video in seconds. Number of recipients is the number of recipients per video message.

The students also completed two paper-based surveys: one at the middle (mid) and one at the end (final) of the project. The surveys gathered feedback on their use of VideoPal and explored the differences between VideoPal and email. Students were asked to rate their experience using VideoPal and email, regarding their happiness, ease to use and usefulness (e.g., "Please show us how you feel about using VideoPal to communicate with your friend over the past several weeks"). We used emoticons as visual aids for the choices (see Fig. 3).

During most of the sessions, at least one of the researchers was present to assist and observe the children when they were sending their messages. In addition, at the middle and at the end of the study, we also conducted semi-structured interviews with the students to get a better understanding about what they liked and disliked about VideoPal. In addition, all of the videos the children sent to each other were transcribed for analysis.

3.5 Data analysis

As mentioned above, the research is based on a wide range of data, including log files, surveys, interviews, observations and videos. As such, for each different type of data, a proper analysis method was used.

In order to analyze the log data, Pearson's correlation coefficient between the children's VMC interactions was used, which is about quantifying the strength of the relationship between the interactions. For identifying the differences among email and VideoPal on children's perceptions, a χ^2 test was performed. Data from interviews, observations and videos were combined for analyzing the content of children's communication. In addition, a video content analysis was carried out by two researchers, based on the four basic emotion categories of Oatley and Johnson-Laird's [25] in order to identify the emotions prevailing in the video exchanged.

Fig. 2 VideoPal main window (*left*) and message view/creation windows (*right*)

Fig. 3 Emoticons used in the survey to measure children's experience using VideoPal and email

4 Research findings

The results below characterize the findings with regard to four principal themes (interactions, perceptions, content and emotions), one for each session type.

4.1 VMC interactions

In this study, several VMC interactions (log files) were obtained. In the following table (Table 1), the descriptive statistics of the videos interactions are outlined.

In order to quantify the strength of the relationship between children's interactions, we used Pearson's correlation coefficient. This analysis suggests that some of the features are related. For example, the number of recipients' viewings is strongly correlated with the number of recipients' and the distance of the video from the start of the thread (negatively). The duration of the video has strong negative correlation with the distance of the video from the start of the thread. Moreover, authors' number of viewings was significantly correlated with the number of recipients' viewings. All the correlations between the features are indicated in Table 2.

4.2 Perceptions

As we previously mentioned, the students completed two paper-based surveys regarding VideoPal and email. The first one was completed at the middle (mid), and the second

was completed at the end (final) of the project. Although both email and VideoPal were rated highly, the mid-survey and the final survey revealed that the children were happier with their experience using VideoPal than using email (Marginal Homogeneity Test $p < .05$) (see Table 3). In addition to the surveys' results, children also express their happiness for VideoPal in the semi-structured interviews. Some comments included *"VideoPal is more fun," "(I like) the awesome movies from Corfu," "I like sending videos to my friends and my video pals,"* and *"I have enjoyed making the videos and sending them to people."*

We also asked children which tool they felt was easier to use (see Table 3). Results from both the mid-survey and the final survey revealed that most of the children (76 %) felt that VideoPal was easier to use than email (mid-survey: $\chi^2(1, 29) = 7.76$, $p < .05$; final survey: $\chi^2(1, 27) = 10.70$, $p < .05$). The children were also asked which they felt was more useful for them to learn about their friend. Most of the children felt that VideoPal was either more useful or equally useful. A one-sample χ^2 test of children's perception of usefulness showed significant differences in proportions (mid-survey: $\chi^2(2, 29) = 7.10$, $p < .05$; final survey: $\chi^2(2, 29) = 16.83$, $p < .001$). Post hoc tests showed that more children felt that video was more useful than email ($p < .05$). The perceived difference in usefulness actually grew with more children stating that VideoPal was more useful; only one child stated that email was more useful.

4.3 Content

Children's digital needs and usage are two key aspects regarding children's VMC behavior. As such, one of the main aims in our study is to investigate the content genre of the exchanged videos. At the beginning of the study, most of the videos were introductory or/and descriptive for a participant.

Table 1 Descriptive statistics of the videos

	Country	No.	%	Gender	No.	%
Authors	GR	84	21.8	Male	156	40.4
	USA	302	78.2	Female	230	59.6
Recipient(s)	GR	127	32.9	Male	110	28.5
	USA	139	36.0	Female	154	39.9
	Both	120	31.1	Both	122	31.6

	Mean (SD)				
Number of recipients	2.98 (3.26)				
Video viewings	Author	0.78 (1.39)	Recipient(s)	6.26 (9.77)
Video duration (s)	17.13 (15.19)				
Video distance	1.93 (1.23)				

Table 2 Pearson's correlation coefficient between VMC interactions

VMC features	Authors no. of viewings	Recipients no. of viewings	Video duration	Recipients number	Video distance
Authors no. of viewings	1.000				
	(386)				
Recipients no. of viewings	0.125*	1.000			
	(386)	(386)			
Video duration	0.021	0.063	1.000		
	(386)	(386)	(386)		
Recipients number	0.019	0.561**	−0.017	1.000	
	(319)	(319)	(319)	(319)	
Video distance	−0.086	−0.072*	−0.244**	−0.026	1.000
	(386)	(386)	(386)	(319)	(386)

* Correlation is significant at the 0.05 level

** Correlation is significant at the 0.01 level

Table 3 Results from the mid-surveys and final surveys regarding children's experience using VideoPal

	Happiness		Easier to use		More useful		
	VideoPal	Email	VideoPal (%)	Email (%)	VideoPal (%)	Email (%)	Equally the same (%)
Mid	4.48	4.07	76	24	48	11	41
Final	4.59	3.97	82	18	66	3	31

Ellen (9"): Hi, I am Ellen from Greece I am 11 years old, bye bye.

Jim (19"): Hi my name is Jim, I am 9 years old and I really like that video of you guys and living on buffalo.

Angy (22"): Hello, I am Angy and I am 11 years old. I go in the sixth primary school of Corfu and my favorite hobbies are basketball and basket.

Nick (28"): My name is Nick I am 9 years old I hope you can figure out what I am saying I would really like to ask you some questions a little later and I am really happy to be doing this VideoPal.

When the video exchange matures and the children get friends, videos content provided information such as favorite foods, music and hobbies of the author. For example, Aalisha plays the piano and loves music so she showed her music books in one of her VideoPal messages. In another message, Eleni explained to her WA friends that it was her birthday and showed them the shirt she received for her birthday.

Aalisha (27"): Hi I am Aalisha and I want to tell you about my lessons in piano, my three favorite books is Sonatinas, Czerny and Hanon, bye.

Alexa (20"): I used to take piano too, I did not really have any favorite books but those books sounds interesting, I was about five when I took piano so I do not remember much of this, bye.

Eleni (14"): Hello, tomorrow I will have a birthday party, my present for my birthday is this shirt, when is your birthday? Bye.

Given that the children were free to talk about anything, the topics were quite varied. This included recent events, presents they got for Christmas, new clothing, things they have learned recently, events that they have been to, their common interests (music, sports) and things happening in their everyday life (asking for daily news, losing a tooth, a van on fire near the school).

Michalis (20"): Hi in Christmas I take a game for my PSP s-compact, jacket and one watch, this is for now bye.

John (13"): Hi Nick, I just wondering how you are doing today, I just wondering how you are, this I want to tell you.

Conversations seemed to be very natural. For example, during one VideoPal conversation, two children discussed their favorite songs, while in another, two children discussed birthdays and a tooth that one of them lost recently (which she showed in the video).

Jackie (11"): Hi, Achilles. My friend told me that you are a huge Lady Gaga fan. So am I. I just want to say hi. I also like Lady Gaga. Bye.

Achilles (12"): So you like Lady Gaga. Who is your favorite singer? Alejandro?

Jackie (13"): Hi Achilles, my favorite singer is Lady Gaga. It is Alejandro, Paparazzi and Bad Romance. What's yours? Bye.

Eleni (11"): Hello, tomorrow I will have my birthday party. My present for my birthday is this shirt. When is your birthday? Bye.

Jane (14"): Hi Eleni. My birthday is Feb 14th, Valentine's Day. But my birthday party will be on Feb 13th and I lost my tooth today.

Eleni (7"): So! really! I lost the same tooth this day. Bye.

4.4 Emotions

The emotional situation of the sender in VMC environment can be easily recognized by the video recipient. This is also one of the most important benefits of VMC and was also reported in the interviews of the study: Matt said, *"(I like VideoPal because) it is easy to goof off with video and you can see their expressions in the video."* Amy emphasized that *"I think one good thing about VideoPal is that … if they really get excited about something, you can see their motions like I am so excited about this. I can explode."* Maggie also commented that *"you can actually see their emotions in VideoPal."*

This indicates the importance of participants' emotional situation in VMC. As such, a video content analysis based on children's emotions was carried out. The signals (Table 4) of the emotions served as a guide for the video coding. The sound and the images of the videos, as well as the verbal communication, were used to analyze the emotions of the participants. Four theoretically distinct categories (anger, anxiety, happiness and sadness) were used to assess emotions of perspective children. The four basic emotion categories of Oatley and Johnson-Laird's [26] were used as they have been identified as computer emotions [24].

The video content analysis procedures consisted of the following three stages: (1) studying the emotions protocol (signals) and viewing several example pictures, (2) viewing the videos several times, and (3) documenting the emotional situation of each video author.

The data collected from the study were coded independently by two researchers who have experience of using VMC environments (Table 5). In order to ensure the reliability of the coding of the two researchers, a Cohen Kappa inter-rater reliability was used. The index of reliability was 0.77, exceeding the recommended guideline (interrater reliability = 0.70) (Lombard et al. [26]). The total agreement of the raters' was 87.8 %, and the four emotions appeared in videos with the following frequency: anger = 1.6 %, anxiety = 23.3 %, happiness = 57.8 % and sadness = 5.1 %.

5 Discussion and conclusions

The Pearson's correlation coefficients demonstrate that video duration has a strong negative correlation with the distance of the video from the start of the thread. This means that long duration videos are more likely at the beginning of a thread and short duration videos are most likely at the end of a thread. However, this result may arise, at least in part, because video near the end of a thread indicates a communication flow, and this communication flow led the participants in specific subjects and so results in shorter videos. This is enforced by the fact that video-based communication increased the feeling of "connectedness" between the participants [27].

Another interesting finding was that the number of authors' viewings was significantly related to the number of recipients' viewings and the number of recipients' viewings was significantly related to video distance. This result may arise from the nature of some videos; we can assume that the relation comes from the interest in or obscurity of some videos. However, we watched the most famous (high visibility of both author and recipient sites) videos, and we realized that all these videos included useful personal information. Interestingly, we observed these videos, and we conclude that they were either introductory or descriptive for a participant. For instance, all these videos provided information such as favorite foods, music, singer and hobby of the author. These findings are consistent with those of Komlodi et al. [28] who showed that children's online profile should include useful information such as their names, gender, age, place where they live and favorite things such as color, food, holiday, game, pet and book. On the other hand, videos with low visibility contain just questions. In brief, video messages with questions do not have repeat views, but video messages with personal information and statements can get a lot of attention, both by the creator and by the recipients.

The results from the study have highlighted the potential of video to support rich conversations for children. The children generally preferred VideoPal to email because they felt that it was more fun, easier to use and more useful, and they liked being able to see each other. The use of video also enabled the children to communicate in a natural way, utilizing natural language, body language and facial expressions. These results are consistent with media richness and social presence theories and demonstrate that these benefits can be realized using asynchronous video messaging with children.

In terms of emotions in VMC, our research revealed that the emotion of happiness dominated in children's communication. This result is consistent with children's perceptions regarding their perceived happiness with VideoPal. As the second most frequent emotion in the study was anxiety, a possible explanation is that students may experience dissatisfaction during video communication [29]. Regarding the sadness and anger, they appeared in videos with very low frequency. After coding,

Table 4 Emotion signals

Emotion	Example	Signals
Anger		Eyes wide and staring; eyebrows pulled down; wrinkled forehead; flared nostrils; mouth flattened or clenched teeth bared; jutting chin, red face
Anxiety		Eyes damp; eyebrows slightly pushed together; trembling lower lip; chin possibly wrinkled; head slightly tilted down
Happiness		Mouth smiling (open or closed); possible laughter; crows-feet wrinkles at sides of sparkling eyes; slightly raised eyebrows; head level
Sadness		Eyes cast down and possibly damp or tearful; head down; lips pinched; head down or to the side

Table 5 Coding results

	Rater A			
	Anger (%)	Anxiety (%)	Happiness (%)	Sadness (%)
Rater B				
Anger	1.6	0.3	0.0	0.3
Anxiety	0.0	23.3	3.8	0.7
Happiness	0.3	3.5	57.8	0.3
Sadness	1.0	1.3	0.7	5.1

researchers viewed these videos and found that most of them contained children complaints such as "*hey no one has answered me yet*" and "*Please reply to this, please-eeeeee emergencyyyy.*" These results are consistent with those of the prior studies, who showed that problems with socializing in VMC (e.g., lack of responses) cause anger and that frustration and aggressiveness cause negative emotions [29, 30].

As with any study, there are some limitations. For example, this pilot study was performed with a quite small number of participants. Children from Greece did not communicate in their mother tongue, and as such, possibly they had difficulties to express themselves. Moreover, there was an asymmetry in the number of children between Greece and USA. Additionally, the sending and receiving of messages was done as a structured activity once a week. It would be interesting to see how the communication would differ.

Besides the immediate social context, students benefit by socializing with remote students from the same or different cultures, and they discussed about common topics of shared interest. Therefore, the system could be extended and adapted to the needs of schools, or for a particular course, such as a common school project that takes place over a distance.

To conclude, our study highlighted that the emotion of happiness dominated in the communication. Moreover, the content included useful personal information and is connected with children's interactions (e.g., number of views and of recipients). In addition, children generally preferred VideoPal to email because they felt that it was easier and has more fun.

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