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Social Interaction

Video-Based Studies of Human Sociality

Collaborative work on an online platform in video-mediated homework support

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Abstract

This study concerns the interactional work involved in the accomplishment of video-mediated homework support and is based on a single case analysis of an instructional encounter between a tutor and an upper-secondary student working together on mathematical assignments. In addition to communicating through video, the participants use an online digital platform that constitutes a shared workspace and interface between the participants, who are situated in geographically disparate locations. A crucial feature of the setting is the unequal distribution of epistemically rich artefacts, such as the maths book, to which the tutee has sole access. Drawing on ethnomethodology and multimodal interaction analysis, the analyses show how the interaction is shaped by and contingent upon the affordances of the online platform and the particular circumstances of the video-mediated setting. The findings reveal how the participants work together to establish shared points of reference from which they embark on collaborative problem-solving trajectories while establishing the problem to be worked upon and its interpretation, as well as negotiating proper presentations of solutions. Additionally, the way in which the participants overcome the interactional and epistemic challenges implicated by the unequal access to crucial epistemic resources is shown.

Keywords: video-mediated interaction; homework support; virtual workspace; tutoring

1. Introduction

Homework support is a growing phenomenon in Sweden, as in many other countries. The term encompasses educational services provided by regular schools, private actors and non-profit organisations, both face-to-face and online. It covers both organised tutoring of students with school-provided assignments or broader preparations for tests and examinations. In this study, we explore the situated and emergent interactional organisation of video-mediated homework support. The analysis builds on video-recordings of a one-on-one tutoring session involving a tutor and an upper-secondary student working together on mathematical assignments. The participants' interaction is mediated through an online dual-space environment that offers both a video channel and the possibility of writing and sketching on a shared virtual workspace. However, the tasks are completed by the tutee, who writes them with a pen on his notepad while looking at the maths book in front of him. Neither of these resources is visually available to the tutor. Previous studies of help-seeking in face-to-face homework support (Svahn & Melander Bowden, 2019; see also Forsberg, Hallsén, Karlsson, Melander Bowden, Mikhaylova & Svahn, accepted) have shown that tutors and tutees tend to treat the maths book and the notepad as decisive epistemic resources in establishing agreement upon what constitutes the tutee's problem. Consequently, it is interesting to explore how the participants manage the radically different social and material contexts of video-mediated homework support.

The focus for this study is how the video-mediated environment affords interactional practices that contribute to the specific institutional aims of homework support by exploring the opportunities and constraints on actions that arise and accountably shape these same interactional practices. Drawing on ethnomethodology and multimodal interaction analysis (Goodwin, 2000; Streeck, Goodwin & LeBaron, 2011), we analyse the participants' ways of dealing with and relating to the conditions and challenges that arise within the video-mediated context. We are particularly interested in how the online platform, comprising a shared virtual worksheet and a video channel, alongside other activity-relevant artefacts, such as maths books and notepads, figure into the organisation of actions in interplay with talk and embodied action. For this reason, the exploration of a specific case promises to contribute further knowledge about coordinated action in video-based online interaction settings more broadly, thereby demonstrating some of the ways in which the medium is procedurally consequential for the participants' actions.

2. Ecologies of multimodal interaction in video-mediated settings

Video-mediated settings have been characterised as “fractured ecologies”, in which conduct is “fractured from the environment in which it is produced and from the environment in which it is received” (Luff, Heath, Kuzuoka, Hindmarsh & Oyama, 2003, p. 55). In other words, such settings may complicate collaboration, as the participants face the challenge of designing their conduct so that it is sensible and recognisable to co-participants who have only limited access to the environment in which the action is produced. In fact, an important condition for video-mediated settings is that co-participants can only monitor the part of their co-participants’ visual environment that is framed on-screen. This means that mutual access and possibilities for mutual visual monitoring are constrained. A large part of each participant’s immediate surroundings remain off screen and therefore unavailable to remote co-participants. Consequently, within the course of video-mediated interaction, participants have to ensure that they have congruent views of each other’s domains, or that their perspectives are interchangeable (Arminen, Licoppe & Spagnolli, 2016). One important challenge reported in previous research concerns issues of reference. For example, as it is impossible to achieve mutual eye contact with a video image, it is difficult to determine exactly what the individual framed on-screen is looking at or pointing toward (Mlynář, González-Martínez & Lalanne, 2018). Moreover, not only are the domains of the participants and the ecologies around them remote from one another, but the performative significance of gaze, gestures, and bodily movements appears weakened (Heath & Luff, 1993; Luff, Heath, Yamashita, Kuzuoka & Jirotko, 2016). Hence, participants have been shown, for instance, to undertake quite complex activities in order to show an object (Licoppe, 2017).

The concept of fractured ecologies is relevant for an understanding of the interactional specificities of video-mediated homework support in several ways. Firstly, both tutors’ and tutees’ use of gesture and other forms of embodied action has been shown to be crucial for the intelligibility of a help-request (Svahn & Melander Bowden, 2019). This means that the uneven distribution of activity-relevant artefacts, in which rich epistemic resources such as the maths book and notepad are not available to one of the participants, represents an asymmetry that circumscribes interaction. Moreover, this unequal access to objects is not solely a problem of reference, but of more fundamental import relating to the purpose of the activity. With no first-hand knowledge of the assignments or of the teachers’ planning and approach to presenting the mathematical content, the tutors have been found to rely upon the information in the maths book and notepad when designing their instructions and explanations (Forsberg et al., accepted; Svahn & Melander Bowden, 2019). This leads to a second dimension of fragmentation that is actualised in the homework support context, in that the tutors occupy an outsider’s position with respect to the activities in the tutees’ classroom. Consequently, the maths book and notepad play important roles as

boundary objects that travel between home and school (Forsberg et al., accepted).

3. Configurations of mediated interaction in educational practices

Although there exists a considerable and growing volume of research concerning interaction in various computer-based learning environments (e.g. Cekaite, 2009; Gardner & Levy, 2010; Melander Bowden, 2019; Musk, 2016), research on interaction in online educational environments is still scarce, with only a small number of studies available. For instance, Duffy and Healey (2014), in a study of video-mediated music lessons, show how the side-by-side arrangement common in co-present lessons (similar to homework support) was replaced by a configuration in which the teacher was looking at the student through the video-frame, while the student was looking away from the screen to the music score. They illustrate how feedback practices were altered, as the student could not monitor the teacher's non-verbal reactions and feedback while playing. As a consequence, the teacher had to produce extensive verbal instructions in order to achieve, for example, proper bodily positioning by a student. Similarly, Hjulstad (2016) demonstrates how teachers and students of sign language manage the fractured properties of a video-mediated classroom by using pointing for referential mapping in novel ways, to establish reliable addressing practices and next speaker selection.

Collaborative peer group work in chat-based online communities has been a focus of scientific interest, not least with regard to maths education (e.g. Çakir, Zemel & Stahl, 2009; Stahl, 2006 a & b). For example, Zemel and Koschmann (2013) analyse students' collaborative work on maths problems in an online dual-space environment (i.e. chat and virtual whiteboard), focusing on referential practices and the sequential work of students in order to specify and arrive at agreed-upon representations of, and solutions to, mathematical problems. They conclude that an important constraint of the online environment revealed that participants could only write one at a time, thus imposing a particular kind of sequentiality on the organisation of actions. Moreover, the participants had no visual access to each other, but had to rely solely upon writing actions in the chat or on the shared workspace for the achievement of shared understanding. In another study, Balaman and Sert (2017) explore the multi-layered and laminated co-construction of knowledge in the context of second language learning online. They show how participants coordinate their interactions with their orientations to the task interface in order to enact epistemic progression, which consequently turns the interface into a layer, a semiotic field, and a screen-based resource in the course of achieving intersubjectivity and knowledge co-construction (see also Balaman, 2019; Balaman & Sert, 2012).

In sum, previous research shows some of the affordances and constraints encountered by participants interacting in online educational settings, as well as their consequences. However, hybrid environments consisting of a video channel and a shared online workspace have, to the best of our knowledge, rarely been the focus of previous research. In the following, we will demonstrate how the participants in such a setting collaborate to establish a shared understanding of the problem to be addressed, in ways that prepare the ground for instructional and explanatory trajectories. In particular, the focus will be on scrutinising the participants' handling of the interactional and epistemic challenges that result from the uneven distribution of activity-relevant materials and artefacts.

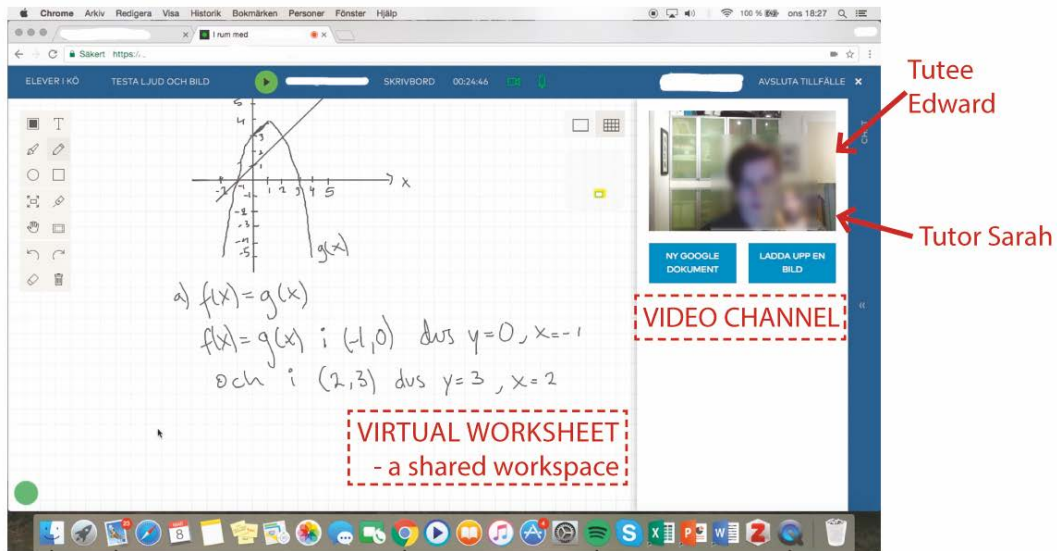
4. Data and setting: online homework support

Our selected case is drawn from a larger study exploring homework support across private, municipal, and non-profit organisations in Sweden, where one of the documented settings was a session of online tutoring organised by a private company. The online homework support takes place in one-on-one constellations, in which a tutor and a tutee located in geographically dispersed interactional settings engage in video-mediated homework support activities on a regular basis. The female tutor in our case study was employed by the company on an hourly basis, and performed the tutoring from her apartment. She was an engineering student about to finish her university degree. The tutee was a 16-year-old male, attending his first year in upper-secondary school, and was likewise located in his home during the homework support sessions. Due to them having had weekly tutoring online encounters for slightly more than a year, the participants had a developed relationship. At the time of the video recordings, the tutor was well-acquainted with the tutee's problem-solving abilities, as well as his general mathematical knowledge. Consequently, the homework support session constitutes a highly routinised activity, in which the participants display a clear and well-established organisation of the activity combined with an accompanying division of labour. Overall, the activity follows a distinct pattern, in which the participants work through a number of maths problems, one at a time, and where the tutee is responsible for deciding what should be worked on and in what order.

As Arminen, Licoppe and Spagnolli (2016) remark, the analysis of a given spate of mediated interaction needs to be contextualised within the ecology of material resources available in the mediated setting at stake. In the present case, the tutor and tutee use an online interface, a multimodal environment consisting of a shared virtual worksheet and a video channel, developed by the private tutoring company. The interface constitutes a resource that forms an assemblage of possibilities and constraints around which actions and practices are shaped. Both participants have equal access to the worksheet, on which they can simultaneously draw and write (cf. Zemel & Koschmann, 2013). Worksheet

actions appear on the screen and are indexed by colour-coded cursors (black for tutor and yellow for tutee).

Figure 1. The online platform and user interface



When it comes to the material distribution of significant artefacts, some aspects are particularly relevant for how the activity is organised. While the tutor orients to the shared online worksheet as the main material source for writing actions, the tutee does the majority of his writing on a notepad that he uses for school, which consequently travels between home and school. This is understandable given that the homework is an assignment that is completed at home and then brought back to school. Moreover, in front of the tutee is his maths book, from which he presents the different work tasks. By contrast, the tutor does not have any access to these significant sources of information, except as mediated by the tutee.

The video recordings of the online homework support take the perspective of one of the participants (cf. Olbertz-Siitonen, 2015), here the tutor, with one camera situated next to the tutor capturing her from the side, and another focusing on the screen, recording the tutor's view. Possible material and contextual constraints – arising from the fact that there is an asymmetric access to the material distribution of visible artefacts between the participants – are thus analysed from the perspective of the tutor. At all times, however, it is the joint participation framework and the various multimodal and semiotic resources upon which the participants draw that are analysed (Goodwin, 2000: Streeck, Goodwin & LeBaron, 2011).

In contrast to many other educational settings, during the homework support sessions, it is the tutee who is responsible for the content and for determining with what he needs help. In our view, this is a constitutive feature of all homework-support settings that we have studied (e.g. Svahn & Melander Bowden, 2019; see also Forsberg et al., accepted). A crucial prerequisite for the activity is that the tutor is not accountable for teaching different mathematical areas, or enhancing the tutee's overall mathematical knowledge, but rather helps the tutee with specific assignments.

Concerning the overall interactional organisation of the session, larger sequences of interaction are demarcated by a focus on one maths task at a time. Each of these sequences is introduced by the tutee, who in addition to the epistemic conditions mentioned above, by virtue of being in sole possession of the maths book, is responsible for the presentation of the problem to be addressed. The establishment of the particular assignment is followed by a problem-solving sequence that consists of both the tutee's displays of knowledge (or lack thereof), as well as instructions and evaluations produced by the tutor. As the analysis shows, the participants move on to the next (part of a) problem as soon as they have arrived at an answer that both find satisfactory.

5. Analysis

In this institutional and interactional context, task accomplishment relies upon and is highly structured by the design of the user interface. The video-mediated environment demands coordination in terms of both verbal and embodied interactions and orientations to the interface. The interface may be conceptualised as a semiotic field (Goodwin, 2000) and as a screen-based resource in the formation, ascription and co-construction of action and knowledge (Balaman & Sert, 2017). As will be shown, the participants' organisation of the activity is also highly dependent upon the unequal distribution of activity-relevant artefacts such as the maths book, which implies a strict division and distribution of labour.

In the following section, we take a closer look at a number of interactional instances that are representative for important and characteristic aspects of the participants' continuous organisation of the homework-support activity. In the first part of the analytic section, by exploring the initial phases of a typical (in this context) problem-solving activity, we demonstrate (i) the participants' work to establish a shared point of reference and a ground for understanding the assignment they are working on (Extract 1). In this section, we also examine (ii) the participants' collaborative work to produce a visual representation in connection with establishing the problem to be solved, and their distribution of labour in this process (Extract 2). In the following section, by exploring the tutor's interpretative work regarding the details of the problem at hand, we demonstrate

(iii) the interactional circumstances through which the activity is able to transition into a more instructional mode (Extract 3). In the final section of the analysis, we focus on (iv) how the participants negotiate a correct way to design a solution to a mathematical problem by drawing upon material objects and the virtual worksheet (see extracts 4a and b).

5.1 Communicating relevant information and establishing a shared point of reference in commencing the assignment

We begin by showing in detail the collaborative work of the participants in establishing a shared point of reference, and in forming a mutual ground of understanding for the current assignment. As will be demonstrated, this initial part of the problem-solving activity is highly dependent on the tutee (Edward) being able to verbally reconstruct the assignment descriptions from his maths book, as he is the only participant who has access to them and can provide the relevant information, which allows the tutor (Sarah) to interject and offer her guidance. Extract 1 begins with Edward orienting the tutor's attention to a specific assignment in his maths book.

Extract 1. A new coordinate system

Online_HWS_19:37:19-20:21:48

```

01 EDW hä:r har vi (.) ett nytt koordina:tsystem.
    he:re we have (.) a new coo:rdinate system.
02 SAR ja:, *gör vi en liten li:nje hä:ra:.
    yea:h, we'll do a small li:ne he:re.
    sar      *draws line separating tasks--->
03      (1.1)*
    sar      ---->*
04 EDW dom e så jobbia t+yp.
    they're so tedious like.
    edw      +draws y-axis---->
05      (1.4)
06 EDW (se ja vill ha dom) †d+ä:r:ɹ
    (look I want them) †the:r:ɹ
    edw      ---->+
07      (1.4)
08 EDW +°°där,°°°
    °°°there,°°°
    edw      +draws x-axis---->
09      (2.0)
10 EDW °den ska (.) di#:t,°
    °this should go (.) the::re.°
    fig      #fig.1.1
11      (0.5)+ (1.7)
    edw      ---->+
12 EDW kej, sen har vi nån linje
    kay, then we have some line
13      (3.5)
14 EDW två: å ett(h).
    two: an' one(h).
15      (1.4)
16 EDW °den ska gå frå+n (.) två: å (.)+ ne:j (      ).°
    °it should go from (.) two: an' (.) no: (      ).°
    edw      +draws line-----+deletes line---->
17      +°från två å ett så.°+ (.) skär den- (.) skä:r den# minus
    °from two an' one like that.° it cuts- (.) it cu:ts minus
    +draws new line-----+holds line---->
    fig      #fig.1.2
18      två +typ. >°n+ä.°°
    two like. >°no.°°
    ---->+deletes line+
19 SAR nä:: in*te ri#ktigt.*
    no:: not quite.
    sar      *points cursor at minus two*withdraws---->
    fig      #fig.1.3
20      (1.3)+(2.8)
    edw      +draws line---->>
21 SAR †dä#:r, (.) †bätt]re,
    †the:re, (.) †better,
    fig      #fig.1.4
22 EDW [så:.]
    the:re.

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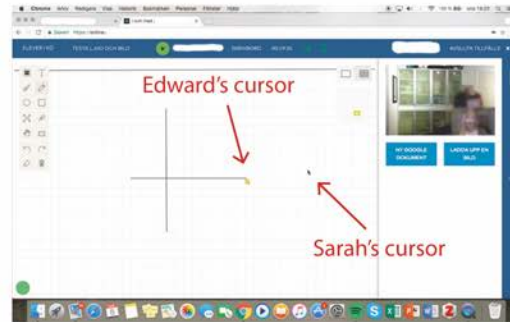


figure 1.1

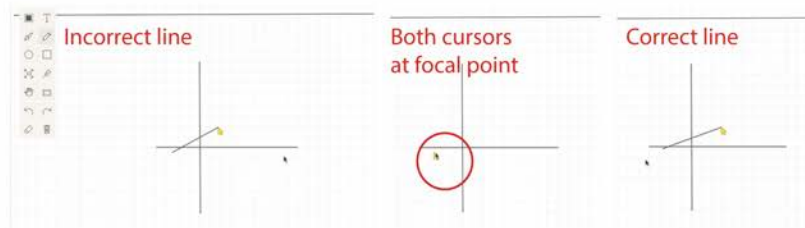


figure 1.2

figure 1.3

figure 1.4

As can be seen, Edward's use of the deictic expression: *hä:r* "he:re" (line 01) is not in itself a satisfactory communicative resource in this context, as it orients to the maths book, a source that lies beyond Sarah's visual field and holds no real possibility for a shared visual focus of attention. Hence, it necessitates a more detailed description from Edward about what this outside source of information entails: *ett nytt koordina:tsystem* "a new coo:rdinate system" (line 01). At this point, however, the unequal availability of the main source of information creates no large barriers for continued interaction, as Sarah instantly seems to understand Edward's directing. She draws a finalising line under their previous calculation, displaying her readiness to begin a new assignment (line 02). In fact, this constitutes a prototypical way of opening a new task in the homework-support setting – the tutee takes the initiative to proceed with the next assignment while the tutor focuses on preparing the online workspace.

In what follows, Edward begins to draw the base component of a new system of coordinates, in the form of two intersecting lines. He simultaneously expresses some mild frustration as he struggles to position them in alignment with the pre-existing grid of the digital platform (lines 04–11). After reaching a satisfactory standard for the baselines, he produces a transition marker *kej*, "kay", before moving on to provide the next bit of essential information regarding the particulars of the assignment *sen har vi nån linje*, "then we have some line" (line 12). While producing a form of online commentary, he initiates an attempt to draw this referred-to line in accordance with the conditions described in the assignment. As he draws, he also verbalises a direct question to Sarah, visibly orienting towards their now shared field of visual attention (his continuous drawing on the virtual worksheet), requesting her opinion on whether he has succeeded in intersecting the line from the correct angle (lines 17–18, fig. 1.2). Without waiting for her reply, he delivers a negative assessment of his own *oonäoo*, "oo no oo" (line 18), establishing that he thinks not. This is directly confirmed by Sarah's aligning assessment: *nä:: inte riktigt*, "no:: not quite" (line 19) and by her using the cursor to indicate the focal point on the screen (see fig. 1.3). After using the eraser function of the online platform, Edward makes another attempt, and is met by a more positive evaluation *↑dä:r, (.) ↓bättre*, "↑the:re, (.) ↓better" (line 21, fig. 1.4), establishing that they are now ready to move on to the next step.

As has been shown, the transition between assignments and the initial stage of beginning a new assignment is predominantly dependent on the tutee's ability to communicate the particulars of the upcoming assignment and display his understanding of it. Without this information, the tutor would be unable to step in and assist. This places a great deal of responsibility on Edward in this initial part of the problem-solving activity, in that he must be able to take charge of and guide their work towards establishing a shared agreement on what constitutes their mutual task.

5.2 Preparing the virtual worksheet and collaboratively correcting errors in the visual representation

As has been shown, the tutor's scope of action during the initial stage of the problem-solving activity is somewhat limited due to the lack of visual availability of the main source, namely the maths book. This means that the collaborative preparations in which the participants engage in the shared virtual workspace in order to proceed to the actual mathematical problem-solving phase are managed through a clear division of labour. This aspect will be further examined in the next extract, which takes place a short while later in the same problem-solving activity as in the previous example. When we join the interaction, Sarah is preoccupied with adding numbers to the baselines of the co-ordinate system drawn by Edward earlier, when he realises that the previously revised line is still not correctly executed, and verbalises this discovery to Sarah (lines 01–03). As will be seen, both participants immediately orient to this as a fact that has to be remedied, but choose different approaches for its execution.

Extract 2. I've done this line wrong

Online_HWS_20:48:36-21:27:55

01 EDW °°här har ja gjort fel (nu igen).°°
 °°here I've done a mistake (now again).°°
 02 (3.0)
 03 EDW här, ja har gjort den li:njen fe:l.
 here, I've done this li:ne wro:ng.
 04 SAR h[mɛ]

05 EDW [°°(+])°°
 edw +deletes line--->

06 SAR vi kan ju bara ta bo#rt den om du vill. (.) backa,
 we can ju just delete it if you like. (.) reverse,
 fig #fig.2.1

07 EDW >a=nä< (.)+ ja nä:: de går bra: me strecket +där.
 >yeah=no< (.) yeah no:: it wo:rks fi:ne with the line there.
 edw --->+ +deletes part of x-axis--->

08 SAR ja?+
 yeah?
 edw -->+

09 (1.2)

10 EDW ja ja. °°()°°
 yeah yeah. °°()°°

11 edw (1.3)#+(2.1)
 +retraces deleted part--->
 fig #fig.2.2

12 EDW *får vi la:gað så,+
 we'll fix it¿ there,
 edw --->+
 sar *marks units on the axes--->

13 SAR m#:?
 fig #fig.2.3

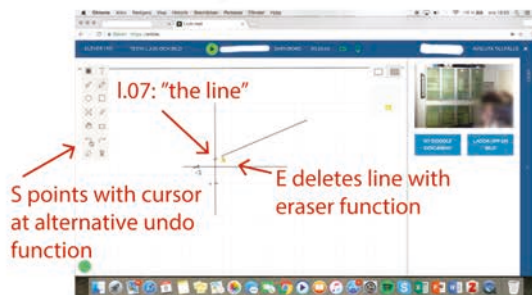


figure 2.1

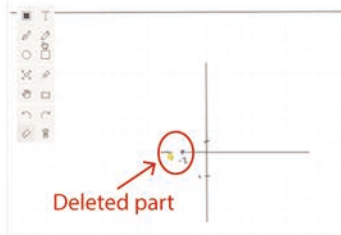


figure 2.2

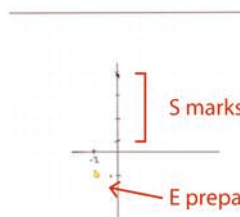


figure 2.3

14 EDW sen- (.) så nu ska vi ha: (.) mellan mi:nus ett å ett.*
 then- (.) so now we should ha::ve (.) between mi:nus one an' one.
 sar --->*

15 edw +(2.3)
 +draws straight line--->1.18

16 EDW så: va. (.) de: blir nog bra.
 the:re then. (.) tha:t will probably be good.
 (2.2)

17 SAR där: ja, +m?
 the:re yes, m?
 edw --->+

18 (2.2)

19 EDW ja, ok*ej, sen (.) s#ka ha en bö:j.
 yeah, okay, then (.) should have a be:nd.
 sar *continues marking units--->
 fig #fig.2.4



figure 2.4

While Edward begins to erase parts of the previously drawn line, Sarah simultaneously moves her cursor to the top left-hand corner of the worksheet, indicating the function that will undo their actions. She also supports this visual orientation with a suggestion for alternative action: *vi kan ju bara ta bort den om du vill. (.) backa*, “we can *ju* just delete it if you like (.) reverse” (line 06). By using

second-person plural, “we”, she formulates the proposed action as a collaborative action, while simultaneously highlighting it as something that the tutee is entitled to “like” or not. Edward wards off this proposal by referring to one part of the line (now marking a unit on the y-axis) that can remain unaltered in the corrected version (see fig. 2.1), and he too indicates this visually by pointing with his cursor. Without further interference, Sarah aligns with this proposed procedure, as Edward moves on to restore some parts of the baselines that have accidentally been erased together with the erroneous line, while referring to it as both of them having to *la:ga* “fi:x it” (line 12). Without further ado, Sarah also returns to adding numbers to the axes, the activity in which she was engaged prior to the interruption (fig. 2.2 and fig. 2.3).

Edward then proceeds with the next step of the assignment, providing a new straight line (lines 14–16). He prepares to draw the line, as Sarah momentarily stops marking units on the axes, highlighting the fact that she is now fully attentive to the tutee’s onscreen actions. As he draws the line (lines 15–18), he comments on his actions by evaluating the position of this new line *de: blir nog bra*, “tha:t will probably be good” – in this context, an utterance that works as a request for confirmation from the tutor, who is carefully monitoring his actions. No immediate uptake is forthcoming, but after a 2.2-second verbal silence, during which the tutee has adjusted the line somewhat, Sarah confirms a correct positioning of the line: *dä:r ja, m?*, “the:re yes, m?” (line 18). Having settled the first function, Edward orients to the drawing of the next function (line 20, fig. 2.4), whereas Sarah continues marking units on the axes.

As we can see, the two participants overcome what was initially a seemingly problematic turn of activity without any major difficulties, due in part to them continuously providing verbal descriptions that parallel their on-screen actions. It can also be explained in relation to their distribution of labour in this phase, where the tutee is responsible for the task-specific parts of the coordinate system (which are dependent upon the information available in the maths book), while the tutor assists the tutee by drawing the more generic parts. This appears to be a well-established routine in this specific homework-support setting, and seems to work well for the participants during the preparatory phase of the problem-solving activity, even when errors are detected and have to be remedied.

5.3 Mutual interpretation of the task and transitioning to instructional mode

In this next section, we will focus on some other conditions for the successful progression of the activity. Our primary focus is on how Edward is able to display his understanding of the assignments in a manner that is possible to interpret, and how Sarah’s ability to step into a more instructional role is dependent on an invitation from Edward. For this, we will look at a section of the video-mediated

interchange in which Edward, in more direct ways, requests Sarah's help in transforming the descriptions of an assignment into a comprehensible task.

Extract 3. What does it say on your picture?

Online_HWS_22:35:41-23:47:06

```

01 EDW [då står de:] (.) i koordinatsystemet finns gra:fen till=-
      then it sa:ys (.) in the coordinate system there is the gra:ph to-
02 SAR [( )]
03 EDW =till den rä:- till den rä:ta linjen (.) y: e lika med f x. (.)
      to the stra:- to the straight line (.) y: equals f x. (.)
04 samt a:ndragsgradsfunktionen y e lika med g x. (.) bestäm
      and the se:cond degree function y equals g x. (.) decide
05 med hjälp av gra:fen- (.) graferna de x (.) för vilka. (.)
      with the help of the gra:ph- (.) graphs de x (.) for which. (.)
06 °°ojojoj,°°
07 SAR m[hm]:?
08 EDW [ >så står de.<]
      >an' then it says.<
09 (2.3)
10 EDW så står de (.) a:ð (2.4) så står de f, (1.0) x, (1.2)
      an' then it says (.) að (2.4) then it says f, (1.0) x, (1.2)
11 e li::ka me *(.) g:. (.) x. (.) va:d (.) ska de:: nu betyda.
      equals (.) g:. (.) x. (.) wha:t (.) now is tha::t supposed to mean.
      sar *writes task 'a) f(x) = g(x)'---->
12 (1.0)*
      sar -->*
13 SAR .hh ja:: okejð e: på: din bi:ld, stå:r de vilken av
      .hh ye::s. okayð uh: on: your pictu:re. does it sa:y which one of
14 li:njerna som e f av x å vicket som e g av x.
      the li:nes that is f of x an' which one that is g of x.
15 i: koordinat[systemet.]
      in: the coordinate system.
16 EDW [ja::, ] (.) *de:: e: g av x e den böjda lin*jen.
      ye::s, (.) i::t is: g of x is the curved line.
      sar *cursor by straight line-----*moves
17 SAR ja:? *där har vi den? den heter g av x*ð
      ye:s? there we have it? it's called g of xð
      cursor to straight line*
      *writes g(x) next to curved line*
18 (1.2)
19 SAR å *då e den ra:ka (.) f av x.*
      an' then the stra:ight (.) f of x.
      sar *writes f(x) next to straight line*
20 (1.0)
21 EDW ↑ja,
      ↑yes,
22 SAR ja, .h så de- de hä*:r de a: menar de ä:r (.)
      yes, .h so thi- thi:s what a: means that i:s (.)
      *cursor by written task---->
23 va:r skä:r dom varandra.
      whe:re cu:t they each other.
      'where do they intersect'
24 (1.0)
25 SAR va:r[t ha]r dom samma vä:rde.
      whe:re do they have the same va:lue.
26 EDW [(ja)]
      (yes)
27 (1.2)
28 EDW dom skär varandra vi:: (.) ett- *m#i:n#us* ett å ¶ett,
      they cut each other a::t (.) one- minus one an' ¶one,
      'they intersect at'
      sar *cursor to -1*
      fig #fig.3.1
      fig #fig.3.2

```

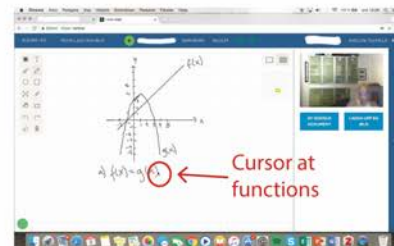


figure 3.1



figure 3.2

The first indication that Edward is struggling with comprehending the ascribed task is given in line 06, in form of a parade of interjections: °°°*ojoj*, °°°, which signal a clear emotional evaluation regarding the difficulty of the assignment. After proceeding to read the remaining section of the instructions aloud, he also makes an even more significant display of confusion by performing an evaluative question that makes relevant an epistemic position of ignorance: *va:d (.) ska de:: nu betyda*, “what (.) now is tha::t supposed to mean”. As we can see, Sarah interprets this as a direct invitation for her to change into a more instructional mode, as she delivers a decisive *.hh ja:: okejç* “.hh ye::s. okayç” (line 13), before requesting a specification from Edward regarding what is conveyed in the picture in his maths book (lines 13–15). She thus performs two significant contributions that are relevant for the progression of the activity: i) signalling that she has received Edward’s call for more direct guidance, and ii) abiding to this call by requesting additional and crucial information that he has not yet provided, namely the specific appellation of the two graphs in his maths book. After receiving this information, she visualises the distinction between the two by writing it on the virtual worksheet, thus creating a visual representation that facilitates the comprehensibility of her next instructional step. During the writing activity, talk occurs (cf. Mortensen, 2013), which in this context is a kind of pedagogical move that links the visual representations to their mathematical expressions. Some of Sarah’s comments are related to the movements and “findings” of relevant places to write. Thus, when she says *där har vi den?*, “there we have it?” in line 17, this commenting on a finding of the right curve is coordinated with a shift in the location of the cursor from the straight line to the curved one.

As Edward displays that he has now understood which graph is which, Sarah moves on to clarify the meaning of the first task by providing an interpretation: *de a:: menar de ä:r (.) va:r skä:r dom varandra*, “what a: means that i:s (.) where do they intersect” (lines 22–23). With no immediate uptake forthcoming, she adds another interpretation: *va:rt har dom samma vä:rde*, “whe:re do they have the same va:lue” (line 25). During the interpretative activity, Sarah’s cursor has moved to a resting position in the vicinity of the written manifestation of the first task. However, when Edward initiates the production of a candidate answer, she immediately moves the cursor to the identified “minus one” position on the x-coordinate (fig. 3.1 and fig. 3.2). Interestingly, the positioning of the cursor somewhat pre-empts the actual production of a full answer by locating the environment for the correct answer before the tutee has produced it. However, at this point in time, Edward is attending closely to his own materials, looking down rather than at what Sarah is doing on screen. Part of Edward’s answer turns out to be wrong, but for the current purposes we will not dwell further upon how the participants handle this mistake. Instead, we will move on to explore practices of writing-in-interaction and the establishment of intersubjectivity.

5.4 Orientations to the virtual workspace as a device for establishing intersubjectivity

As previously stated, the tutor has only limited access to the tutee's working materials. Remarkably, this rarely seems to present the participants with any greater difficulties, as they have established a distribution of labour that provides a framework for mutual intelligibility with respect to who is responsible for providing particular information (and knowledge). In this section, we will proceed to examine in more detail two extracts in which the participants negotiate what constitutes a correct way of setting up a solution to a mathematical problem. These examples make visible the consequences of the participants' unequal access to some objects, as well as the interactional work required to focus attention on relevant parts of the virtual workspace. When we join extract 4a, Edward is providing an answer to the task: " $f(x) = 2x + m$, determine a value for m so that $f(3) = 15$ ".

Extract 4a. You have to set it up neatly

```
Online_HWS_40:29:50-41:05:34

01 EDW +de e väl bara (.) ett (.) tre (.) e lika me (.)
      it's just like (.) one (.) three (.) equals (.)
edw +>>looks down--->1.05

02 två gånger tre: (.) som blir sex plus (1.3) ↑ni:e.
   two times three: (.) that is six plus (1.3) ↑ni:ne.

03 (0.5) m å- e >lika me ↑ni:e.<
   (0.5) m an'- uh >equals ↑ni:ne.<

04 SAR m:? men du måste ställa upp de snyggt också.
      m:? but you have to set it up neatly as well.

05 +(2.4)+
edw +looks up+

06 EDW +hur ställer ja upp de snyggt,
      how do I set it up neatly,
edw +looks at S--->

07 SAR du: skriver att *x e lika me tre:?*
      you: write that x equals three:?
      *writes 'x = 3'*

08 (1.4)

09 EDW e+::
      uh::
      +looks down--->>

10 SAR de ve:t du ju.=
      this you know ju.

11 EDW =°°ja skrev-°°
      °°I wrote-°°

12 (0.5)

13 EDW ja skre:v e: (.) *f av tre: e lika me två: gånger
      I wrote uh: (.) f of three: equals two: times
sar *writing '2 x 3 + m' --->

14 EDW tre: plus ni:e.
      three: plus ni:ne.

15 SAR m*:, de du f- du får göra de e att du skriver
      m:, what you h-you have to do that is to write
      ->*

16 *två gånger tre* plus m (.) *e lika me fe:mton. (0.4)*
   two times three plus m (.) equals fifteen:n.
*traces '2 x 3 + m' w. cursor*
      *writes '= 15'-----*
```


Framing his answer with *de e väl bara*, “it’s just like” (line 01), Edward produces a candidate answer. The tutee never writes his answers on the virtual worksheet, instead producing them in talk. Sometimes, the tutor transcribes these verbal formulations, but most of the time she is writing independently. In this case, during the initial part of the extract, the tutor listens to the student’s suggested solution. She then produces an assessment that implicitly confirms the correctness of the answer, but also assesses the presentation of the solution from a negative point of view: *men du måste ställa upp de snyggt också*, “but you have to set it up neatly as well” (line 04). The utterance connotes a certain ambivalence, as it refers to a specific logical structure for the organisation of the solution, and at the same time implicitly makes a written representation relevant. The latter interpretation is reinforced by the use of the adjective *snyggt*, meaning not only neat or tidy but also pretty and nice, positing that aesthetic qualities are relevant to the presentation of the solution. That this request poses problems of understanding for the student is clearly visible in the 2.4-second silence and the following request for clarification, produced in a flat tone of voice: *hur ställer ja upp de snyggt*, “how do I present it neatly”. The tutor’s response makes the orientation to writing even more visible, and explicitly refers to the act of writing: *du: skriver att x e lika me tre:?*, “you: write that x equals three:?” (line 07). As she produces the verbal version of the mathematical expression, she simultaneously writes it, thereby enacting a writing-aloud procedure and modelling a correct answer through talk and embodied action.

Already in line 09, we see a first precursor of misalignment from the tutee that produces a hesitant *e::*: “uh::” as he turns his gaze down towards his notepad. The tutor continues her communicative project, possibly taking the tutee’s lack of response as a lack of understanding concerning where the mathematical expression came from: *de ve:t du ju*, “this you know ju” (line 10). Here, the epistemic adverb *ju* works to establish what was said as something that the tutee knows (or should know) and which constitutes the participants’ shared knowledge. At this stage, the tutee initiates a description of what he has written, presented as an alternative to what the tutor is proposing. This simultaneously displays that he has indeed written something that is not visually accessible to Sarah. Skipping the first part proposed by Sarah (“ $x = 3$ ”), Edward now commences an explanation of his calculation (lines 13-14).

This time, Sarah immediately starts writing what Edward says, thereby confirming the correctness of his solution so far. However, in contrast to the previous examples of writing aloud procedures, the writing in this instance is slightly more independently of the talk. For example, in line 13, Sarah writes the part of the calculation in a way that pre-empts the tutee’s actual verbal production. In this case, a difference appears, as Edward says *plus ni:e*, “plus ni:ne”, whereas Sarah has written “+ m”. Reinforcing her correct version, Sarah responds with a corrective alternative: *de du f- du får göra de e att du skriver två gånger tre plus*

m (.) e lika me fe:mton, “what you h- you have to do is to write two times three plus m (.) equals fifteen” (lines 15–16). During the first part of the utterance, she points with the cursor at the section of the calculation that she has already written on the virtual worksheet. While producing *e lika me fe:mton* “equals fifteen” she writes the same thing on screen, thus adding more information. At this stage, however, Edward is looking down at his materials and does not attend to what Sarah is writing. The participants continue working through the correct setup of the solution, then Edward suggests that he can do an equation and proceeds to formulate it (lines 17-21).

Extract 4b. Look at how I have written

Online_HWS_41:20:55-42:06:56

17 EDW ja, å sen kan ja ju- asså ja kan ju göra en djävla
yes, an' then I can ju- like I can ju do a bloody

18 ekvation här å bara (1.2) minus sex e lika me: femton minus
equation here an' ju:st (1.2) minus six e:quals fift~~een~~ minus

19 (.) sex. (1.3) minus sex på båda si:derna å[då] kommer de bli:=
(.) six. (1.3) minus six on both si:des an' then it will be:

20 SAR [m:.,]

21 EDW =m (.) e lika me nie. as+så,
m (.) equals nine. like,
edw +looks up--->1.24

22 SAR jo preci:s. du kan hoppa över de: steget. men om du ser hur
yes exa:ctly. you can skip tha:t step. but if you look at how

23 ja: har skrivit. >asså< ja har >bara< liksom förtydligat=
I: have written. >like< I have >just< like clarified

24 =ok+ej.=x #e lika me tre å till å me d*e: e liksom överf*ö-
okay.=x equals three an' even tha:t is like superfu-
+gazing at screen--->*

edw *circles 'x=3' w. cursor*

sar #fig.4b.1

25 överflö:digt för du *fick den informationen #h+är.*
superflu:ous 'cause you got that information here.
sar *draws square around 'f(3)'

edw +gaze down-->1.29

fig #fig.4b.2

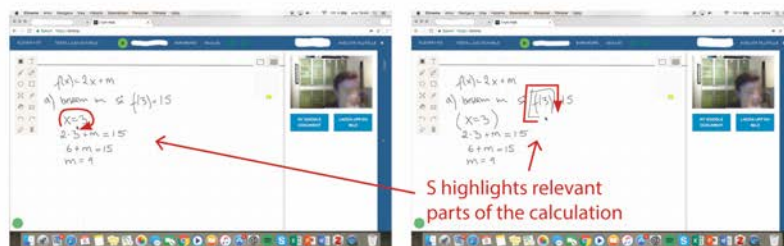


figure 4b.1

figure 4b.2

26 EDW ja,
yes,

27 SAR e:: men skri:v upp (.) just två gånger tre plus m (.)
uh:: but wri:te (.) precisely two times three plus m (.)

28 e lika me femton. just för att du skri:ver ju upp de som
equals fifteen. precisely because you wri:te ju that as

29 en ekvat+ion.
an equation.

edw +looks up--->

30 (2.2)

31 EDW ja.=
yes.

32 SAR =å sen skri:ver du >bara< sex plus m e femton, m e lika me nie.
an' then you wri:te >just< six plus m equals fifteen, m equals nine.

33 (2.4)

34 SAR de rä:cker.=
that's enou:gh.

35 EDW =+yes,
+looks down--->>

36 SAR m:??

37 (1.1)

38 EDW all right. bž

Sarah initially acknowledges the correctness of Edward's suggestion, i.e. that he can skip one step (line 22). However, she then explicitly directs his attention to what she has written. The tutee has been looking down, visibly not attending to what Sarah has been doing on screen. It is only toward the end of his verbal turn presenting the equation that he raises his gaze toward the tutor and the screen (line 21). Although Edward apparently looks at the screen, seeing cannot be taken for granted. Sarah instead proceeds to actively secure his attention to a particular place on the screen, through an explicit referral: *men om du ser hur ja: har skrivit*, "but if you look at how I: have written" (lines 22–23). This illustrates what Heath and Luff (1993) have described as a weakening of the performative "power of gaze" in video-mediated communication (see also Arminen et al., 2016), as it is sometimes difficult to determine where co-participants are looking. By directing attention to the screen, the tutor insists on the modelling character of her writing, as previously initiated in line 07 (extract 4a). What was the setting up of a tidy or neat solution has now become filled with meaning, using the notion of clarification *ja har >bara< liksom förtydligat*, "I have >just< like clarified" (line 23). The downplaying character of this utterance may be oriented to the fact that the tutee's introduction of equations as an alternative problem-solving strategy has made relevant an orientation to the setting up of the solution as a problem concerning content rather than layout. Sarah now emphasises that it is more a matter of clarification. She proceeds to describe the different parts of her solution as she uses the cursor to highlight relevant parts of the calculation (fig. 4b.1 and fig. 4b.2). Some information is described as superfluous (lines 24–25), whereas other information is highlighted as crucial (lines 27–29 and 32). The tutor reconnects to the tutee's displayed understanding of the setup in terms of an equation, and accounts for the form of the setup as related to equations: *just för att du skri:ver ju upp de som en ekvation*, "precisely because you write *ju* that as an equation" (lines 28–29). Throughout extract 4b, the orientation to writing is strong, with several mentions of the verb "write" (lines 23, 27, 28 and 32).

The interaction represented in extracts 4a and b is illustrative with respect to how the tutor's perspective, on one side of the computer, limits her access to what the tutee has written (or not) on his papers (cf. Olbertz-Siitonen, 2015), and the interactional and epistemic challenges that she therefore faces. In a previous study focusing on face-to-face homework support, we found that "the participants' use of gesture and other forms of bodily activity to establish mutual orientation to particular objects within the local environment /.../ was /.../ paramount for the intelligibility of the completion of a help request" (Svahn and Melander Bowden, 2019, p. 18). Moreover, maths books and notepads were oriented to as privileged sources of attention, and students' calculations were treated as crucial resources for determining the nature of the student's problem (ibid.). Overall, in this video-mediated setting, the participants instead rely upon verbal resources for making visible both the tasks and what the tutee has written. As the analysis shows, establishing both shared knowledge of what the tutee has written and a relevant

focus on part of the shared workspace may therefore require additional interactional work.

Extract 4b also shows a prototypical way of closing one sequence and beginning the next. Here, Sarah utters the closing-implicative *å sen skri:ver du >bara<*, “an’ then you write >just<”, followed by *de rä:cker*, “that’s enough”. Edward responds to this in the affirmative. The tutor then displays that, at this moment, no more information is forthcoming, via a third sequence-closing move *m:?* (line 36). This item, with its rising termination, orients toward a continuation of the activity to a next step. The tutee shows an alignment with closure, *all right* (line 38), and proceeds to initiate a new sequence by moving on to a new sub-assignment *b_i* (cf. Schegloff, 2007, pp. 186–194). In this, we also see a further example (similar to one in Extract 1) of the participants’ orientation to the tutee as the person in charge of moving the activity forward, as the tutor could explicitly have suggested a move to the next sub-assignment in line 36, but did not do so.

6. Discussion

Similar to what has been shown in other online settings (e.g. Heath & Luff, 1993), the performative significance of mutual gaze and bodily gestures for upholding intersubjectivity becomes subordinate to the participants’ verbal contributions in this setting, too. In fact, although part of the screen is allocated to a video channel, the participants’ visual orientation, except when they are talking about off-task topics during the initial and concluding parts of the session (not targeted in this study), is rarely focused on each other, but predominantly towards either the virtual worksheet – or in the tutee’s case, the maths book or notepad. However, bodily gestures, in the form of referential practices, do occur and are, as we have shown, predominantly performed through pointing by use of the online cursors, e.g. in relation to highlighting specific functions of the platform (as in Extract 2) or indicating particularly relevant parts of a drawn or written representation on the worksheet (as in Extract 3). The specific challenges associated with such referential practices are therefore not related to the performing of pointing per se (as in for instance Luff et al., 2003), but in orienting each other’s visual orientation towards the screen at certain times, and in achieving and upholding joint attention. The fact that the tutee has other objects at his disposal creates circumstances in which the tutor at times has to compete for the tutee’s visual attention, and must actively work to redirect it back to the screen (as in Extract 4b, for instance).

Another interesting aspect of the analysed encounters is that they reveal a rather atypical teacher-student relation. Even though a more traditional epistemic asymmetry exists, in terms of the orientation towards the tutor as having not only epistemic access to a mathematical skill set but also epistemic primacy, the unequal access to materials and information concerning the assignments and

mathematical problems also transfers the primary responsibility for directing the activity onto the tutee. In relation to the maths book being such a crucial tool, in some sense even a prerequisite for being able to perform the tutoring activity at all, it could be seen as odd that the tutor has not acquired her own copy, but is instead dependent on generating an understanding of the shared task based solely on the tutee's verbal and visual accounts, in the form of descriptions and presentations. However, after scrutinising the interchanges in more detail, it becomes evident that this particular division of labour leads to some fundamental pedagogical consequences, forcing the tutee into a more active participant role. Another aspect of the tutee having to read out loud from his book (as in Extract 3) or verbally present his executions from his notepad (as in Extract 4a), is that the tutor, in transforming these verbal accounts into writing on the shared workspace, is afforded a possibility for clarification, in terms of visualising the aspects of the information shared by the tutee that are the most essential for solving the problem. In that sense, the tutor becomes a form of interpreter and translator, through the way she is able to model, moment by moment, how the student could most adequately use the information he is sharing, or how he can best and most efficiently approach a solution. Moreover, the analyses show that the tutor is well acquainted with the semiotic structure of the maths book, as she draws conclusions about where to find information without actually seeing the book (as in Extract 3, for instance). The participants' shared writing on the virtual worksheet is also a product of value, not only in the sense of enabling collaborative problem-solving during the factual session, but as a continuous source of knowledge, in that the tutee can save it and return to it at a later stage, including during future problem-solving activities performed offline.

Overall, the studied setting, in terms of being a "fractured ecology" (Luff et al., 2003), in the sense of there being an unequal distribution of activity-relevant artefacts, still emerges as a smooth-functioning apparatus, free of upgraded gestural practices. In fact, contrary to what has been shown in previous studies (Luff et al., 2003; Luff et al., 2016), the participants continuously manage to collaboratively uphold the tutoring activity without any major obstacles, and although longer pauses in the verbal interchanges do occur, these are predominantly connected to other aspects of the activity (reading, writing, thinking) being in focus, rather than to communicative struggles. It is fair to assume that their respective responsiveness to each other's online contributions is also connected to a long line of similar encounters, and their previous experience of using the current platform. Another factor relates to them being independent of having to show objects from their respective environments, as the shared worksheet enables them to make referential practices visual on-screen.

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