Video Annotation as a Supporting Tool for Video-based Learning in Teacher Training – A Systematic Literature Review

Jana-Kristin von Wachter[1] & Doris Lewalter[1]

[1] Technical University of Munich, Germany

Correspondence: Jana-Kristin von Wachter, Technical University of Munich, Germany

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Abstract

Digital video annotation tools, which allow users to add synchronized comments to video content, have gained significant attention in teacher education in recent years. However, there is no overview of the research on the use of annotations, their implementation in teacher training and their effect on the development of professional competencies as a result of using video annotations as a supporting tool for video-based learning. In order to fill this gap, this paper reports on the results of a systematic literature review which was carried out to determine 1) how video annotations were implemented in studies in educational settings, 2) which professional competencies were investigated to be further developed with the aid of video annotations in these studies, and 3) which learning outcomes were reported in the selected studies. A total of 18 eligible studies, published between 2014 and 2022, were identified via database search and cross-referencing. A qualitative content analysis of these studies showed that video annotations were generally used to perform one or more of three functions, these being feedback, communication, and documentation, while they also enabled a deeper content knowledge of teaching, reflective skills, and professional vision, and facilitated social integration and recognition. The convincing evidence of the positive effect of using video annotation as a supporting tool in video teacher training prove them to be a powerful tool supporting the development of professional vision and other teaching skills. The use of video annotation tools in educational settings points towards further research as well.

Keywords: video annotation, teacher training, teacher education, professional vision, video-based learning

1. Introduction

Video is a tool whose impact on teacher training has grown immensely in the last decade. Its use in teacher education has directly contributed to improvements in the quality of teaching (Christ, Arya & Chiu, 2017). When it comes to its benefits in developing students' professional vision, it is the focal point of recent methods in teacher training. Sherin and van Es (2009) describe professional vision as a layered concept. To enable teachers to make efficient use of video and so enhance their professional skills, learning tools have emerged, one of which is video annotation. Annotations are used as an auxiliary tool in educational settings, i.e., to promote teamwork, reflective abilities, or communicating skills (Gayoso-Cabada, Sarasa-Cabezuelo & Sierra-Rodriguez, 2019). They have been applied to a variety of educational approaches, such as massive open online courses (MOOC) or blended classroom settings (Pardo, Mirriahi, Dawson, Zhao, Zhao & Gašević, 2015). Frequently, video annotation tools are used to support deeper analysis of video content (Pérez-Torregrosa, Díaz-Martín & Ibáñez-Cubillas, 2017).

Viewers previously wrote annotations by hand on paper. Nowadays, computers have shifted the annotation process into the digital realm (Gayoso-Cabada et al., 2019). A digital video annotation tool enables the learner to make virtual notes directly relating to the video, complete with a time stamp, thus enriching the video content with additional information. Moreover, as annotations are created while watching a video-recording, it is an active learning process (Sauli, Catteneo, & van der Meij, 2018). It enables the learner to reflect on the learning material or process and to externalize the learner's knowledge and insights (Blau & Shamir-Inbal, 2021). Furthermore, it deepens reflective activities on teaching situations, when novice teachers start forming teaching alternatives triggering changes in future actions (Jacobs, Lamb & Philipp, 2010).

As the use of video annotation in teacher education has increased in recent years, so has the number of available tools, which vary widely in their form and function (Rich & Tripp, 2011). Consequently, not every tool suits every teaching situation. Teacher educators need to consider what purposes annotations aim to fulfil in each specific

context (Rich & Tripp, 2011). To determine how video annotation tools are used in educational settings in teacher education and how they support the development of teaching skills, we conducted a methodical literature review.

2. Theoretical Background

As an overview of the theoretical background to this review, three aspects of active video use in teacher training are considered: 2.1 The use of video in teacher education, 2.2 Video annotations and their functions, and 2.3 Developing reflective skills as an element of professional vision.

2.1 The Use of Video in Teacher Education

In recent years, many uses of video in teacher education have evolved, each facilitating a different goal. These include case studies, video embedded in multimedia, and video reflections, including reflection with peers (Christ et al., 2017). The video material ranges from movies and curriculum-related clips to recordings of interviews or school lessons. Learners may have been present at the recordings, some recordings might be of the learners themselves, while others are completely unconnected to them. Many variables are still to be explored.

New learning opportunities arise from the increased use of videos in educational settings. Video allows for repeated viewing, pausing, skipping forwards or backwards, and annotating. Studies show that learners accept the use of video tools and consider video analyses of classroom situations to be beneficial (Seidel & Prenzel, 2007). They also think that such activities support the development of learners' professional skills (Sherin & Van Es, 2009; Star & Strickland, 2008) as they give them time to analyse teaching situations in their own time. Being able to observe students' behaviour in the classroom is an important skill which furthers our understanding of how they learn (Barth-Cohen, Little & Abrahamson, 2018).

2.2 Video Annotations and their Functions

There has been considerable growth in software designed to analyse video content with the aid of annotation over the last ten years. The functionality of the software varies, but most allow notes to be appended to any video fragment including a time stamp. Textual data is the most common form of video annotation, as it is the easiest both to produce and to use further (Aubert, Prié & Canellas, 2014). However, there are also other content types, such as audio comments, images, lesson plans, etc. There are also tools that integrate annotations into a social platform to enable collaborative learning (Cebrian, Bartolome, Cebrian-Robles & Ruiz, 2015).

Annotation tools generally perform three functions: 1) to enable students to annotate videos and allow both teachers and students to annotate videos made by the students (Colasante, 2011; Pardo et al., 2015) documenting thoughts related to certain aspects (documenting function), 2) to enable students to reflect on their teaching and learning experience (Rich & Hannafin, 2009) (reflective function), and 3) to support communication and feedback processes by enabling teachers, experts, and supervisors to annotate students' work so as to convey messages or provide feedback (communication and feedback function). Whereas many studies explore video annotation in the context of self-recorded videos, only a handful consider video material that is new to students (Cebrian et al., 2015). Little research has yet been devoted to how students benefit from annotating classroom videos in which they do not appear themselves regarding the implementation and the effect of annotations on teaching skills. Therefore, the present review focuses specifically on video annotations and their functions in teacher training and on their impact on the development of the users' professional skills.

2.3 Developing Reflective Skills as an Element of Professional Vision

Professional vision was first conceived by Van Es & Sherin (2002) to describe how novice teachers view and interpret classroom situations while relying on their prior knowledge of teaching and learning (Seidel & Stürmer, 2014). It is a two-layered concept, through which students learn to recognize important aspects of a teaching situation (noticing and describing) and to analyse the event based on their prior knowledge of the context. This creates a link between their personal experience, their understanding of it, and general principles and theories of learning and teaching (knowledge-based reasoning). Some researchers consider a third aspect, referred to as interpreting, in which learners explore the possible effects on students' learning (Jahn, Stürmer, Seidel, & Prenzel, 2014).

The integration of a broad range of video-analysis methods in teacher training over time affords greater depth to users' learning (Arya, Christ & Chiu, 2015). The ability to reflect promotes learners' awareness of their strengths and limits, encourages them to explore new ways of improving their teaching and furthers their development in instructional decision-making (Nagro, de Bettencourt, Rosenberg, Carran, & Weiss, 2016; Calandra, Brantley-Dias, Lee, & Fox, 2009; Crawford, O'Reilly, & Luttrell, 2012). However, merely viewing a video of a teaching situation

does not immediately encourage novice teachers to develop their reflective practice (Brouwer, Besselink, & Oosterheert, 2017). As a matter of fact, during their reflection process, novice teachers still require guidance towards instructional decision-making (Nagro, et al., 2016). Frequently, learners find it challenging to transition from noticing to reflecting to improving their instructional skills when left without guidance (Calandra, Gurvitch, & Lund, 2008). They, therefore, need a model to support their learning process and reflective activities.

Tripp and Rich (2011) synthesized multiple definitions of reflection into a single one: Reflection is "a self-critical, investigative process wherein teachers consider the effect of their pedagogical decisions on their situated practice with an aim of improving those practices" (Tripp & Rich, 2011, p.678). The availability of self-recorded videos with which student teachers can practice reflection, as well as unrelated material, has greatly increased possibilities of using video reflections in educational settings.

When it comes to developing learners' reflective skills, writing has been found to be an excellent tool for student teachers. Combining written reflection with video reflection even serves to enhance the student teachers' ability to reflect on their teaching skills and advances the process of self-reflection (Coffey, 2014). Based on the literature presented, the following research questions are derived.

2.4 Research Questions

The literature review will investigate the following research questions:

1. How are video annotation tools generally used in educational settings in the studies considered?

2. What professional skills are supported by video annotations in the studies considered?

3. What learning outcomes associated with the use of video annotations in educational settings were measured in the studies examined?

3. Method

The review was conducted in three consecutive phases: 3.1 Devise a detailed literature research strategy, 3.2 Select studies that match the research question, and 3.3 Categorize the findings.

3.1 Devise a Detailed Literature Research Strategy

In the first phase, a literature research strategy was developed. The literature research was conducted between September 2021 and June 2022. Manuscripts were selected according to certain inclusion and exclusion criteria, in accordance with the PRISMA guidelines (Higgins et al., 2019). To be eligible for this review, a study had to be an original peer-reviewed research contribution. The language had to be either German or English, due to a lack of further available language skills. All studies published after 1990 were included in the search to trace the complete development of digital media in higher education.

The sources used were well-established online research databases in the fields of psychology and education. To obtain as many matches as possible, we searched Scopus, ERIC and Web of Science, using the following English and German keywords: video annotation or Videoannotation, and teacher training or Lehrerbildung or Lehrkräftebildung.

Table 1. Selection criteria for the studies

Selection criteria
Study is original and peer-reviewed
Study includes video annotation and teacher training keywords
Study published since 1990
Study written in English or German
Study available as full text

Table 1 shows the selection criteria.

Table 2. Search syntax used with international databases

Database	Syntax	Period	Number of Documents
Scopus	ALL ("Video annotation" OR "Videoannotation") AND ("teacher training" OR "teacher education" OR "Lehrerbildung" OR "Lehrkräftebildung") AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English") OR LIMIT-TO (LANGUAGE , "German"))	1990-2022	84
ERIC	("teacher training" OR "teacher education") AND "video annotation"	1990-2022	(1)
	(“video annotation”)		58
Web of Science	((ALL=(teacher training) OR ALL=(teacher education)) OR ALL=(Lehrerbildung) OR ALL=(Lehrkräftebildung)) AND (ALL=(video annotation) OR ALL=(Videoannotation))	1990-2022	20

Table 2 shows the search syntax used for collecting the studies.

As there was only one search result in ERIC using the full syntax, we repeated the search using the main key word, i.e., “video annotation”. This produced 58 results, which, after screening, we deemed relevant to this review. As seven of the final relevant studies were obtained from ERIC, we decided to retain the shortened syntax. All in all, this led to 162 possible studies. The following selection process can be seen in Figure 1.

3.2 Select Studies that Match the Research Questions

The search results were checked for duplicates between databases, which resulted in the exclusion of four entries. Next, the title and abstract of the remaining 158 results were assessed for eligibility, leaving 123 results. They were then screened in accordance with the selection criteria, with a particular focus on video annotation and professional vision (with 16 results remaining). The remaining articles were cross-referenced to find further relevant studies (two results). Cross-referencing involved conducting a backward search, in which the reference list of each article was checked for other relevant studies, and a forward search, using Google Scholar, in which studies were identified that cited one of the included articles. All in all, 18 studies were selected for inclusion in our final analysis.

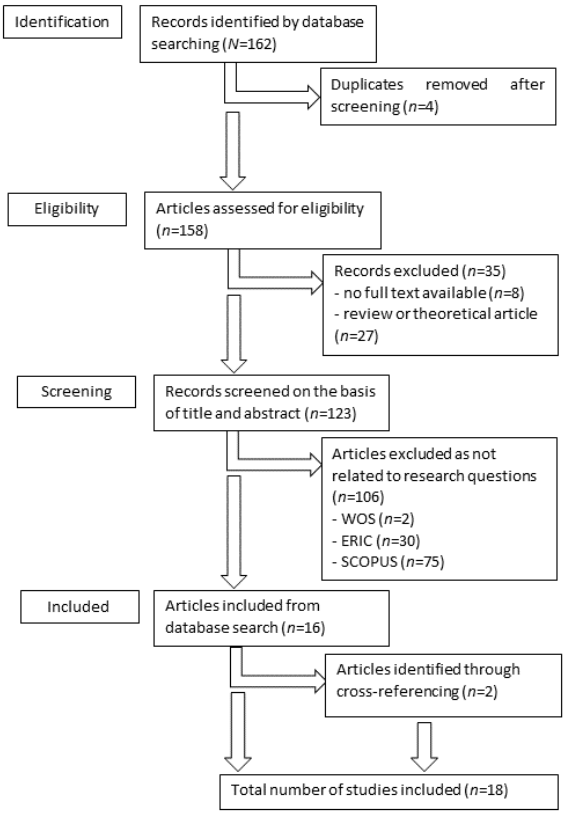

Figure 1. The Selection Process

Figure 1 shows a flowchart of the selection process.

3.3 Categorize the Findings

The studies that met the above criteria were subjected to qualitative content analysis. Categories were deduced for each of the three research questions from a paper by Rich and Tripp (2011) that investigated questions relating to video annotations, which the studies made detailed reference to. Next, the studies were manually coded according to their characteristics and sorted into the defined categories. The categories deduced for the three research questions are explained in the following.

Our analysis of the general characteristics of video annotation tools focused on the video characteristics and the annotation characteristics (see Tab. 2). Video characteristics include information about the type of video, such as authentic lessons and graphic presentations, who uploads the video, and the content of the video, in which a distinction is made between self-monitoring and other content not connected to the participants. Annotation characteristics refer to the type of annotation, the creator of the annotation, and the software used. Since all annotations were textual, it was not necessary to add a media category.

We then determined the specific use of video annotations in each study and the instructional aims supported by their use (see Tab. 3). We considered the use of annotations in terms of their types of function and topic. Function categories are feedback, communication, and documentation, while those of the topics are content knowledge and professional vision, the latter of which is further subdivided into noticing, reasoning, and interpreting. We also noted the guiding framework used by students when working with annotations, resulting in an additional instruction category, and the final form of the study categorised as the output.

To categorize the effects of the use of video annotations, we defined four categories (see Tab. 4). The data collection method refers to the method used to evaluate the data. This also includes the form of the data itself. We also determined the research design, which includes the comparative nature of the studies. Finally, we noted the key outcomes of the studies and any issues that might have arisen.

4. Results

This section presents the findings of our analysis, organised according to the research questions. We begin with an overview of the 18 studies reviewed.

4.1 Overview of Studies Reviewed

The 18 studies selected were published between 2014 and 2022, although the majority (14) were published since 2018. Almost all the studies were conducted at a higher education institution, and thus the participants were students, only three worked with in-training teachers at a later stage of their education. The exception was one study whose participants were university teaching staff. Participants numbers varied from 11 to 880. In two studies the exact number was not specified. Just over half of the studies had less than 100 participants (11 studies). A total of 2,159 participants took part in the 18 studies reviewed.

The majority of the studies were based on courses of education studies (10), followed by science (6), performing arts (1), and coaching (1). Most of the studies investigated courses incorporated into a curriculum (12 studies). Four studies were conducted on students in a field-based setting. In the remaining two cases, participants were taking part in a professional development programme. The duration of the studies ranged from four days to three semesters, however the majority lasted one semester (6). Table 1 of the Appendix contains an overview of the studies.

4.2 How are Video Annotations Generally Used?

Regarding how video annotations are used (research question 1), the studies are analysed according to the type of video, the types of annotations created by participants, and the annotation tool used. An overview of the general characteristics is presented in Table 2. In the majority of cases, students annotated their own video recording of participants (13 studies). The majority of these 13 studies used recorded lessons (8), while others used a recorded presentation (2), or a role-play situation (2). Mirriahi et al. (2018a) used recordings of the participants performing a choreography. Other studies were based on actual university classes (2), an unrelated classroom situation (1), educational videos (1), and an interview (1).

In the present analysis, the type of annotation is characterised by the person creating the annotation and by accessibility to others, meaning who could read the annotations and, in the case of two or more rounds of annotating, respond to them. In regards to the person creating the annotation, there were ten cases in which the annotation tool was used in only one of the following ways: Videos were annotated by the students themselves (8 studies), videos of the students were annotated by their peers (1), and by teachers (1). Usually they worked on their own. Only in the study by Boldrini and colleagues (2019), annotations were written by students themselves but in pairs. Six studies used two rounds of annotating where the second group annotated the first group's annotations. The annotating groups consisted of either students followed by their peers (3), peers annotating one of their classmates' video followed by the lecturer (1), or students followed by the trainer/supervisor (2). In two cases, three groups used the annotations, namely students, peers, and a supervisor (1), or peers, supervisors, and cooperating teachers (1).

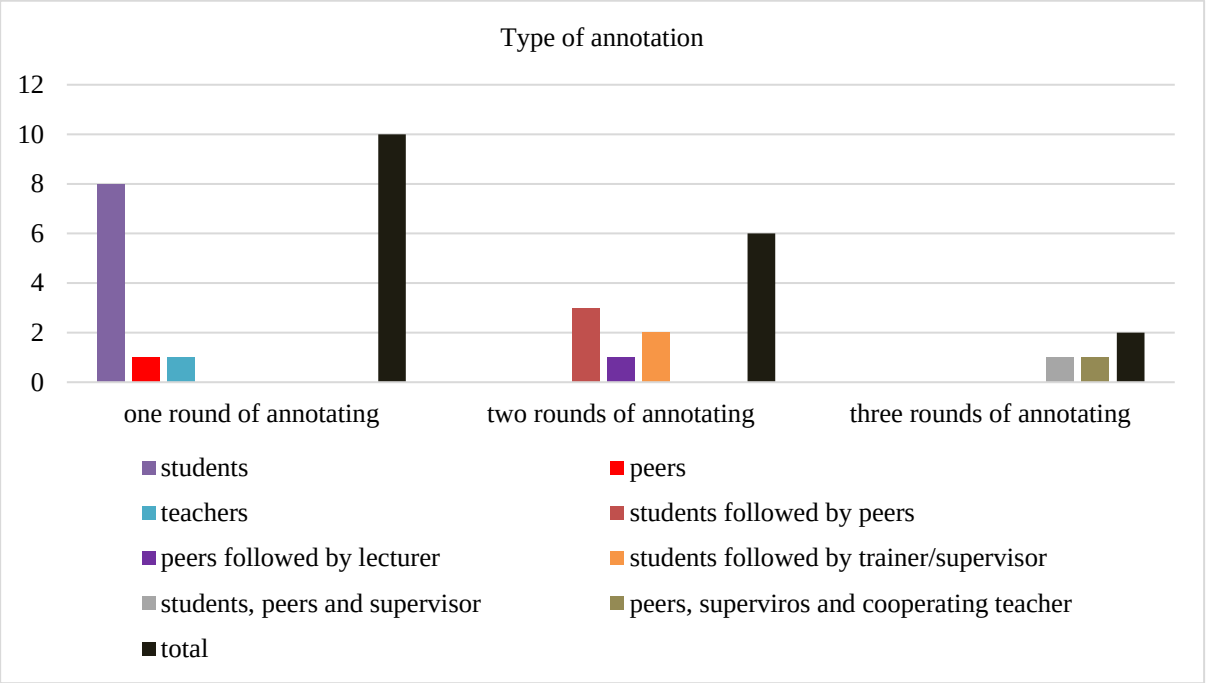

Figure 2. Types of annotation regarding number of rounds of annotating

Regarding the accessibility, seven studies incorporated the annotations strictly for the students' personal use. In these cases, all the annotations were created by the students. Blau and Shamir-Inbal (2021) took a mixed approach by using shared and personal annotations where the students could choose if they wanted to write personal notes or shared posts. The remaining ten studies chose to use shared annotations. In six cases, this meant the annotations created were then shared with the creators' peers, shared with their supervisors (3), and shared with their lecturer (1).

A wide variety of software was used for creating annotations. Three studies used a specifically created online platform. The others chose existing software: VideoAnt was used three times, YouTube was used twice, so was iVideo. The other studies used celluloid (1), Annoto (1), ed puzzle (1), Clipper (1), teachscape (1), GoReact (1), Studio/Canvas (1), and coannotation.com (1).

Two studies used other tools to link annotations with additional information. Ardley and Hallare (2020) incorporated a library in the software which contained lesson plans, assignments, rubrics, and instructional video clips as well as additional information. Boldrini, Cattaneo and Evi-Colombo (2019) used so called Active Points, which also included additional multimedia material.

4.3 Implementation of Video Annotations in the Examined Studies

With regard to teaching skills (research question 2), the annotations fulfilled documentation functions, feedback functions, and communication functions. In nine cases, one function was fulfilled, generally documentation (7). The remaining two cases addressed the feedback function. Nine studies employed two annotation functions: feedback and documentation (6), communication and documentation (2), and communication and feedback (1). No study used all three functions. We also found that two topics were covered, which are content knowledge and professional vision. Fourteen studies focused on a single topic. All but one of these studies were based on professional vision, while only Aguillon and Monterola (2020) focused on content knowledge. Perini, Cattaneo and Taconi (2019) incorporated both topics. The remaining three studies did not specify their topic. We counted professional vision as one topic. Table 3 of the appendix contains details on how the video annotations were implemented.

Only eight studies mentioned the instructions accompanying the annotation process. In five of these cases, participants were required to create a certain number of annotations. Four studies used a previously prepared framework which guided participants in attaching thematic tags to their videos. In the study by Karlsson and Nilsson (Karlsson & Nilsson, 2019; Nilsson & Karlsson, 2019), the students were given precise instructions to focus on critical incidents that they first defined using a specific framework. Ten studies did not specify instructions.

Regarding the output the participants created, four studies concluded with reflective (peer) annotations. In the

remaining 14 studies, annotations were used as a tool to create further work. In four cases, participants were required to compile a complete video/lecture analysis. Nine studies resulted in a reflective output of various forms: paper (1), portfolio (1), report (1), form (1), journal (3), video project (1) or assessment rubric (1). Aguillon and Monterola (2020) ended with a group discussion.

During their work phase the participants generated an output which was used for evaluation by the respective studies, this output being either the annotations themselves or the product of a further activity. Evaluation of the output results in three categories regarding the role the annotations play in the studies: they are measuring effects on the quantity and quality of the annotations themselves (7), measuring the effects of the annotations as a tool supporting the creation process of a reflective activity (5), and measuring effects not directly related to the annotations but to teaching competencies in general (6).

In the first category, there was one study that evaluated the quantity of annotations (Mirriahi et al, 2018a), while four measured the quality and the content (McFadden, Ellis, Anwar, & Roehrig, 2014; Cavanagh, 2021; Cebrian-de-la-Serna, Gallego-Arrufat, & Cebrian-Robles, 2021; Nagel & Engeness, 2021). In two cases, shared and personal annotations were examined (Ellis, McFadden, Anwar, & Roehrig, 2015; Blau & Shamir-Inbal, 2021). In the second category, three studies examined a reflective task which was accomplished using annotations (Perini et al., 2019; Leung & Shek, 2021; Shek, Leung, & To, 2021). Nilsson and Karlsson (2019) showed that a video analysis using annotations helped student teachers to focus their attention on specific aspects of their teaching and enabled reflection-on-action and decision making in their planning of future lessons. Zaier, Arslan-Ari and Maina (2020) found that self- and peer-evaluation using video annotation differed from each other, and in both cases, participants did not present evidence from the videos in their evaluation. In the third category, two studies focused on the forms of interaction between students (Ardley & Hallare, 2020; Tessier & Tremion, 2020). In two cases, video annotation tools were utilized to further understand or to support learning (Mirriahi, Jovanović, Dawson, Gašević, & Pardo, 2018b; Boldrini et al., 2019; Aguillon & Monterola, 2020) In Karlsson and Nilsson (2019) the reflection framework, of which video annotations were a part, was rated by participants as helpful for their self-reflection.

4.4 Effects of Using Video Annotations on the Development of Teaching Skills

When analysing what effects the use of video annotations have (research question 3), we examined the studies to determine the data collection method used, the research design, outcomes, and issues. Details can be found in Table 4 of the Appendix.

Among the 18 studies analysed we found qualitative (9), quantitative (4), and mixed-method approaches (5). Karlsson and Nilsson (2019) reported on a combination of two studies, one using a mixed-method approach and the other using qualitative research methods. In terms of research design, 12 studies did not use any comparison. In these cases, the annotations were simply used without varying the instructions or employing a control group. Six studies took a comparative approach, three of which compared the use of an annotation tool vs. no annotations. Mirriahi et al. (2018a) compare the effect of grading on the quantity of annotations. Boldrini et al. (2019) implement the control group as direct observers in the classroom vs. the treatment group using a video with annotations. Finally, Cavanagh (2021) compares the level of expertise of using video annotation tools.

In the qualitative studies, the main assessment instruments used to collect data were annotations (3), video recordings (3), questionnaires (2), and journal entries (2). In the mixed-method approaches, data was collected using a combination of two to five different instruments, in most cases annotations (3), questionnaires (3), and written entries in digital databases (2). In the quantitative studies, data was collected with log files (2), annotations (1), and a self-reflective journal (1). Across all research approaches, it can be seen that annotations (7), questionnaires (5), and journal entries (3) were the main methods used to gather data.

The outcomes of the studies can be divided into three categories based on their measured content: cognitive outcomes, which describe an advancement in professional knowledge, social outcomes, which cover levels of communication between students and their peers or a supervisor, and outcomes related to the nature of the annotations themselves, which refer to the quality and quantity of the annotation.

Cognitive outcomes are assessed in nine studies. Our analysis shows that effects on reflective skills in general (5) were mainly measured. For example, in the study by Shek and colleagues (2021), student-teachers' self-reflective journal entries improved over time when using video annotations. Two other cases measured aspects of professional vision. One of these is Ardley and Hallare (2020), who evaluated the text logs stored on their GoReact software, which supports observation, assessment, and monitoring of student teaching behaviours. The other is McFadden et al. (2014), who showed in a mixed-method approach that most annotations were on the level of describing and

explaining, although the participants were also beginning to see the need to make evaluative choices. Further cognitive outcomes assessed improvements in the use of learning strategies (1) and content knowledge (1). All nine studies found that the use of video annotations had only positive and no negative cognitive effects.

There were four studies that assess social outcomes. The analysis shows that the development of social aspects stem from the use of shared video annotations, marked by an increase in social integration (2), social recognition (1), and positive peer influence (1). The study by Ellis et al. (2015) analysed the peer response annotations and showed that 40% of the total coded annotations involved praising or agreeing with their partner about the quality of their teaching. Then again, Zaier et al. (2020) reported a negative effect on social recognition. In their qualitative analysis of an online discussion forum that was additionally used during the course, they found participants gave their peers' lessons far lower evaluation than their own. They rated peer teaching as not meeting expectations. Thus, using annotations as a shared resource in a learning community can lead to both positive and negative effects.

Outcomes relating to the annotations themselves are assessed in nine studies. Six of these measured the quality of the annotations, followed by two that assessed the quantity. Cebrián-de-la-Serna et al. (2021) reported findings in which both quality and quantity were assessed. As an example of the studies focusing on quality, Cavanagh (2021) coded annotations according to four levels of reflection: descriptive, evaluative, reflective, and imaginative. This resulted in annotations being generally divided between describing a situation (32%) and imagining different teaching approaches (39%). The study by Mirriahi et al. (2018a) showed that the level of expertise in using the annotation tool positively influenced the number of annotations created. In the study by Karlsson and Nilsson (2019), on the other hand, participants praised video annotations and regarded it as a tool that offers good means of linking theory and practice that can promote the interpretive stage of professional vision. All ten studies reported a positive effect on the quality and quantity of the annotations.

To sum up, 12 studies measured outcomes for only one of the three categories (cognitive (5), social (2), and annotation (5)). Six studies examined two categories (cognitive and annotations (3), cognitive and social (1), and social and annotations (2)). No study covered all three categories. This shows that annotation tools can be used and analysed in various ways. Nonetheless, it is apparent that the selected studies preferred to focus on one or two categories of outcome. There is further need for studies covering all three categories.

5. Discussion

As a tool for developing digital teaching skills video annotation has become increasingly popular in education ever since Rich and Hannafin published their first work on the subject in 2009. It is seen as a support tool for developing both reflective practices and professional vision (Colasante, 2011; Lam & Habil, 2021). The aim of this literature review is to provide an overview of research into the use of video annotation in education and to evaluate the learning outcomes.

The present review shows that the majority of studies are conducted during teacher training at university. There is little research into field-based traineeship or during a teacher's professional development. It is noteworthy that the majority of studies were published since 2018. Video annotation tends to be used in particular courses over a duration of one semester, and they are generally in the form of shared annotations to be discussed with peers.

5.1 General Characteristics of Video Annotations Used to Develop Teaching Skills

In the majority of cases participants record themselves teaching and then analyse their videos either individually or together with peers. It is noteworthy that the studies published in 2021(Leung & Shek, 2021; Nagel & Engeness, 2021; Shek et al., 2021) expanded the scope of the recordings to include role-plays and presentations. The use of the participants' own recordings links reflection-in-action and reflection-on-action (Schön, 1987) and facilitates the development of a reflective ability as a whole. However, research into the use of unrelated video material for reflection is still lacking.

In most studies, participants are able to see not only their own annotations, but also those of their peers and they are able to comment on them. Sharing ideas and theories with peers through annotation enables participants to experience the complexity of interpreting classroom interactions, with several perspectives applied to the same video situation (Blomberg et al., 2014). This further extends the students' reflective abilities because they cannot only develop their peers' ideas further by linking them to other theories, but they can also contradict them by using a different approach.

Finally, the majority of the studies employed an annotation tool that was either designed for or adapted to a unique use. This makes it very difficult to compare implementations of the tools, since each of them has a different focus and range of functions. Most importantly, the annotation tool either has to be easily accessible, which could explain

why web-based platforms or services are used, or it has to be sufficiently secure for uploading data-sensitive content, in which case the software is chosen or developed individually (Rich & Trip, 2011).

5.2 Implementation of Video Annotations in the Examined Courses

The most common function found in the studies is documentation. Writing down thoughts and ideas in the form of video annotations helps learners structure their viewing process and focus on important aspects of educational theories. Annotations made with the documentation function are the leading tool when it comes to developing professional vision in the studies examined as they support the analysis of videos (Peréz-Torregosa, Díaz-Martín & Ibáñez-Cubillas, 2017). The feedback function is also used. Here, video annotation facilitates sharing thoughts and ideas, and receiving new ideas as it is easier to discuss in an externalized form (Blau & Shamir-Inbal, 2021). The main benefit of reflective annotation using the feedback function is the interactive discussion it enables with peers and supervisors. As much as learning is influenced by others, reflection in the presence of peers is more beneficial than in isolation (Sydnor, 2016), and thus annotations can support personal development in response to the feedback received.

It was surprising that only a few studies specified instructions for creating annotations. For the most part, participants were either told to write annotations with no instructions provided, or they were required to write a certain minimum number of annotations. However, not giving students any clear instructions is problematic, since learners need clear guidelines to enable them to fully grasp a learning process and to help them prepare for the learning tasks (Lam & Habil, 2021). Participants might have benefitted from precise instructions on how and why to write annotations. Also, a guiding framework would be helpful for directing the participants' attention to specific situations and practices in the video (Rich & Trip, 2011).

Finally, regarding the output that the participants were required to produce, half of the studies did not focus on the annotations themselves but merely used them as a supporting frame for another task, which was then evaluated. In those cases, in which the participants concluded the course with a reflective assignment, a framework of reflection would have supported their learning process tremendously. Moreover, a closer look into the annotations themselves would have been worthwhile.

5.3 Measured Outcomes Related to the Functions of Video Annotations in Educational Settings

Overall, it is reported that the use of annotations has a positive effect, especially when it comes to reflecting on teaching situations and giving performance feedback to peers (McFadden et al., 2014; Zaier et al., 2020). The latter might be because students show an active willingness to analyse and write shared annotations about the video for the purpose of giving feedback (Cebrián-de-la-Serna et al., 2021). When it comes to the development of students' professional vision, it is shown that video annotations are a powerful tool. Students who use annotations pay more attention to reflective activities and less to describing (Perini et al., 2019). This can be explained by the scaffolding effect annotations have on student teachers' reflections (Colasante, 2011; Nilsson & Karlsson, 2019).

Regarding the research design, qualitative and mixed data collection approaches are mainly used, hence quantitative research is relatively rare. It is also apparent that most studies do not take a comparative approach and rarely compare the use of the annotations to a control group. This might be because research into video annotations is relatively new, especially considering that the focus of prior research was not on the effects of using annotations. For the future, it might be interesting to research the detailed implementations of video annotation and to test them using comparative methods.

5.4 Limitations

It cannot be ruled out that the selection of databases might represent a limitation, even though Eric and Scopus are among the most prominent databases used in the education field. To counteract this effect, we employed cross-referencing in the selection process. The literature search was completed in June 2022, representing the cut off point for articles included in the evaluation process. The fact that the use of video annotation in education has risen in prominence in the last two years shows that working with them is an emerging field of interest, and we can expect more findings to be published in the coming years. Although this search focused on the use of video annotation in teacher education, future research could benefit from extending the search to other fields of teaching outside classic teacher training. The article selection was conducted methodically to counteract bias. Nevertheless, the number of articles included in the literature review was limited. However, the existence of publication bias might still be possible, since positive findings are easier to publish in peer-reviewed journals, and all articles we used fulfilled this criterion.

6. Conclusions

This systematic literature review gives an overview of research into the implementation of video annotation in educational settings in teacher training and its impact on learning outcomes. The studies reviewed indicate an increase in video annotation over the years, with many possibilities for its instructive usage. Although the study does not claim to be comprehensive, it provides important insights for interactive video-based educational research. The first research question aimed at identifying the general characteristics regarding the use of video annotation to develop a professional vision. In recent years, there has been an increase in the scope of video annotation in education, leading to an abundance of tools and software that support students learning. Two approaches that have evolved use shared annotations to promote social aspects of learning and personal annotations to facilitate individual reflection processes. It remains to be seen how effortlessly and seamlessly annotations will be incorporated into educational situations in the face of ongoing technical advancements. This process should and could be guided by conducting more research into the effect of personal and shared annotations on the development of professional teaching skills.

In terms of the functions, it has been found that video annotations mainly support reflective activities by fulfilling the documentation function. None of the reported implementations of video annotation matched all three functions (documentation, feedback, and communication), and we are sure that many other settings are possible. The concrete instructional design is rarely explained in the studies examined, so it could not be compared fully. Therefore, it would be interesting for future research to focus on using different instructional approaches and to describe them in detail in order to measure their effect on the quantity and quality of the annotations. With regard to the results reported in the studies reviewed, video annotations have been shown to promote and deepen reflective activities and facilitate social interaction. The studies selected show that video annotation is a powerful tool that supports the developments of professional vision as well as other teaching skills. However, as studies do not focus solely on annotations, their use and effect are under-researched. It may be of interest to conduct another, similar review in a few years to measure the progress made in the field, as it can be assumed that the amount of research will increase substantially over time.

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Appendix A

Overview of Studies Reviewed

Primary Author, Publication Year	Educational Level	Participants	Number of Participants	Domain	Duration of Treatment	Placement		
						In course	During field-based experience	Other
McFadden et al., 2014	Teacher training	Beginning teachers	16	Science	-	x		
Ellis et al., 2015	Teacher training	Beginning teachers	19	Science, mathematics	-	x		
Mirriahi et al., 2018a	Higher education institution	Students	119	Performing arts	2 semesters	x		
Mirriahi et al., 2018b	Higher education institution	Teaching staff at university	127	Professional development	-			x
Boldrini et al., 2019	VET teacher training diploma	In-training teachers	36	Professional development	4 days			x
Karlsson & Nilsson, 2019	University	Student teachers	63	Science	-		x	
Nilsson & Karlsson, 2019	University	Student teachers	24	Science	-	x		
Perini et al., 2019	University	Students	56	Education	1 semester	x		
Aguillon & Monterola, 2020	University	Students		STEM	6 lessons	x		
Ardley & Hallare, 2020	University	Students	32	Field experience	3 semesters		x	
Tessier & Tremion, 2020	University	Students	Group 1: 94 Group 2: 26	Education	1 semester	x		
Zaier et al., 2020	University	Pre-service teachers	25	Math, PhysEd, English, History	1 semester		x	
Blau & Shamir-Inbal, 2021	University	Undergrad students	880	Exact science, social science	9-15 lessons	x		
Cavanagh, 2021	University	Pre-service teachers, university supervisors	11	Education	4 weeks		x	
Cebrián-de-la-Serna et al., 2021	University	Students	274	Education	4 semesters	x		
Leung & Shek, 2021	University	Student teachers	73	Life coaching	1 semester	x		
Nagel & Engeness, 2021	University	Students	104	Education	6 weeks	x		
Shek et al., 2021	University	Students teachers	80	Comprehensive school guidance	1 year	x		

Appendix B

General Characteristics of the Use of Video Annotations

Primary Author, Publication Year	Video Characteristics				Annotation Characteristics			
	Type of video		Uploaded by	Content of video	Type of Annotation		Written by	Software used
	Self-monitoring	Other			Personal	Shared with Peers		
McFadden et al., 2014	x		Beginning Teachers	Teaching	x		Beginning teachers	VideoAnt
Ellis et al., 2015	x		Beginning Teachers	Teaching		x	Beginning teachers in pairs	VideoAnt
Mirriahi et al., 2018a	x		Lecturer	Performing	x		Students	CLAS
Mirriahi et al., 2018b		x	Lecturer	Lecture video		x	Teaching staff	OVAL
Boldrini et al., 2019	x	x	Students	Teaching, unknown teacher		x	Students, Peers, supervisor	iVideo
Karlsson & Nilsson, 2019	x		Students	Teaching	x		Students	YouTube
Nilsson & Karlsson, 2019	x		Students	Teaching	x		Students	YouTube
Perini et al., 2019	x		Students	Video-interview	x		Students	iVideo
Aguillon & Monterola, 2020		x	Students	Educational videos		x	Students, peers	VideoAnt
Ardley & Hallare, 2020	x		Students	Teaching		x	Peers, university supervisors, cooperating teachers	GoReact
Tessier & Tremion, 2020	x		Students	Presenting (Group 2 optional: YouTube Video)		x	Trainer, students	celluloid
Zaier et al., 2020	x		Students	Teaching		x	Students, peers	teachscape
Blau & Shamir-Inbal, 2021		x	-	University lesson	x	x	Peers, lecturer	Annoto
Cavanagh, 2021	x		Students	Teaching		x	Students, supervisors	Web-based platform
Cebrián-de-la-Serna et al., 2021		x	Lecturer	School lesson, voiceless	x		Students	Coannotation
Leung & Shek, 2021	x		Students	Role-playing		x	Peers	Web-based platform
Nagel & Engeness, 2021	x		Students	During oral presentation	x		Students	Studio (Canvas)
Shek et al., 2021	x		Students	Role-Playing		x	Students, peers	Web-based platform

Appendix C

Implementation of Video Annotations

Primary Author, Publication Year	Functions			Topic	Professional Vision			Instructions		Output
	Feedback	Communi-cation	Document-ation	Content Knowledge	Noticing	Reasoning	Interpreting	Min. amount required	Details	
McFadden et al., 2014			x		x			x	Instructor-generated prompts	Reflection paper
Ellis et al., 2015	x		x		x	x	x	x	Write minimum amount	Peer response annotations
Mirriahi et al., 2018a	x		x			x	x		-	Reflective annotations
Mirriahi et al., 2018b			x		x	x	x		1. Create individual annotations, 2. Review, 3. Make general annotation reflecting on video	Reflective e-portfolio
Boldrini et al., 2019	x		x		x	x	x		Give feedback in pairs	Analysis of whole lesson
Karlsson & Nilsson, 2019			x		x	x	x	x	Highlight two critical incidents (supported by CoRe framework)	Written video analysis
Nilsson & Karlsson, 2019			x		x	x	x	x	Highlight two critical incidents (supported by CoRe framework)	Written video analysis
Perini et al., 2019		x	x	x	x				-	Reflective report
Aguillon & Monterola, 2020			x	x					-	Group discussions
Ardley & Hallare, 2020	x								-	Supervisor feedback
Tessier & Tremion, 2020	x	x							-	Group 1: Feedback Group 2: Video project
Zaier et al., 2020	x		x		x	x	x		Attach video tags, each video reviewed by two peers	Self-reflection form, peer feedback
Blau & Shamir-Inbal, 2021			x		x	x	x		-	Video analysis
Cavanagh, 2021	x		x			x	x		-	Reflective annotations
Cebrián-de-la-Serna et al., 2021			x		x	x	x	x	Four tags provided	Reflective annotations
Leung & Shek, 2021		x	x			x	x		-	Self-reflective journal
Nagel & Engeness, 2021	x								-	Assessment rubric, written feedback
Shek et al., 2021	x		x		x			x		Self-reflective journal

Appendix D

Measured Outcomes of Using Video Annotations

Primary Author, Publication Year	Data Collection Method	Research Design	Outcomes			Issues
			Cognitive	Social	Annotations	
McFadden et al., 2014	Mixed method (quant: text-based entries in digital database, qual: reflective annotations)	No comparison	Professional vision		Quality	Reflection-on-action does not necessarily infer quality teaching
Ellis et al., 2015	Qualitative: response annotations	No comparison		Social recognition		Meer presence of online video clubs is not enough to encourage reflection
Mirriahi et al., 2018a	Quantitative: reflective annotations	Natural experiment, comparison: assessed vs. non-assessed			Quantity	Reflection influenced by prior experience and instructional condition
Mirriahi et al., 2018b	Quantitative: log data	No comparison	Learning strategies			Quality of video annotations was not considered
Boldrini et al., 2019	Qualitative: questionnaire	Comparison: video + annotation vs. direct observation + notes		Positive peer influence		Both groups were greatly appreciated
Karlsson & Nilsson, 2019	Mixed method (quant: questionnaire qual: written comments, summary)	No comparison	Self-reflection		Connect theory/practice	Educator only had access to written comments and summary but did not know the real situation
Nilsson & Karlsson, 2019	Qualitative: video vignettes	No comparison	Structured reflection			-
Perini et al., 2019	Qualitative: text analysis	Comparison: annotations vs. no annotations			Quality	Group without annotations paid more attention to describing events
Aguillon & Monterola, 2020	Mixed method (quant: questionnaire, qual: journal, class observations, transcribed audio recordings, field notes)	Comparison: annotation tool vs. no annotation tool	Content knowledge			No significant difference on reflective thinking collectively

Ardley & Hallare, 2020	Quantitative: log data	No comparison	Professional vision			Students not consistent with uploading, technical issues with software, more training needed
Tessier & Tremion, 2020	Qualitative: video projects	No comparison		Social integration	Quantity	Teacher had to help out students working alone, technical issues
Zaier et al., 2020	Qualitative: video recordings, peer evaluation report, self-evaluation report, online discussion forum	No comparison		Social recognition	Quality	Did not use annotation to provide evidence
Blau & Shamir-Inbal, 2021	Qualitative: comments from the most interactive lecture per group, semi-structured interview	No comparison			Quality	Low participation, only 10% active
Cavanagh, 2021	Mixed method (quant: video annotations, qual: written questionnaire, interviews)	Comparison: pre-service teachers vs. experienced teachers vs. university supervisors	Reflection		Quality	Feedback considered to be impersonal, comments posted too late
Cebrián-de-la-Serna et al., 2021	Mixed method: annotations	No comparison			Quantity and quality	Logistical issues
Leung & Shek, 2021	Quantitative: surveys, self-reflective journals	No comparison	Reflection		Quality	No control group
Nagel & Engeness, 2021	Qualitative: written feedback	No comparison			Quality	Giving feedback is uncomfortable
Shek et al., 2021	Qualitative: peer comments, journal entries, questionnaire	Comparison: annotations vs. no annotations	Reflection			Maximum level of reflective thinking showed no effect

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