

The Use of Video Annotation in Education: A Review

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<https://doi.org/10.24191/ajue.v17i4.16208>

Received: 4 April 2021

Accepted: 29 September 2021

Date Published Online: 31 October 2021

Published: 31 October 2021

Abstract: Video annotation (VA), a tool which allows commentaries to be synchronized with video content has recently received significant research attention in education. However, the application contexts of these studies are varied and fragmented. A review was therefore undertaken with the objectives to find out the extent to which the use of VA has been explored for different instructional purposes and summarize the potential affordances of VA in supporting student learning. Articles related to the use of VA in education context were searched from 2011 to 2020 (Nov). Of the final 32 eligible studies, it was found that VA tools were used predominantly to develop teaching practices, enhance learners' conceptual understanding of video content and develop workplace skills as well as clinical practices. Five most dominant educational affordances of VA tools were summarized as follows: (1) facilitating learners' reflection (2) facilitating feedback process (3) enhancing comprehension of video content (4) promoting students' learning satisfaction and positive attitude and (5) convenience and ease. With the outstanding weight of research evidence gained on educational affordances offered by VA, it is convincing that advancing the use of VA in education can further expand the learning opportunities in 21st century classrooms.

Keywords: Affordances, Education, Feedback, Learners' reflection, Video annotation

1. Introduction

In this post-web 2.0 era where accessibility to ever increasing free and high-quality digital resources is made practicably easy, video which can shape a rich visual learning environment, has been lauded as a powerful pedagogical tool. This is particularly relevant as visual learning style was found to have the greatest influence on student engagement (Halif et al., 2020). Furthermore, the global shutdown of many educational activities during covid-19 outbreak has evidenced the high growth and adoption of remote teaching. The rise of video-assisted online learning was also observed and will continue to grow as a strategic teaching approach during this post-pandemic recovery phase. However, with regards to online learning, difficulty in understanding the subject content remained one of the main challenges (Chung et al., 2020). To effectively exploit the use of video technology in any online learning environment, there is a need to explore more effective means to use videos in a more pedagogically meaningful way. Video annotation (VA) tool with anchored commentary can transform video viewing from a passive learning experience to active consumption of video content (Jayawardana et al., 2001) and thus, it is anticipated to provide opportunities for learners' active and focused engagement. Hence, the use of VA will remain an interesting research domain in education and reviewing the relevant studies

will help to sketch a more comprehensive landscape depicting the use and affordances of using VA in varied education contexts. Therefore, the objectives of this review are to: (1) find out the extent to which the use of VA has been explored for different instructional purposes and (2) summarize the potential affordances of VA in supporting student learning.

2. Background

As defined by Rich and Trip (2011), VA tools refer to either online or offline programs, which can be used to do clipping, segmentation or marking on the portions of a video with anchored textual, spoken or visual comments. A wide range of terminologies, such as ‘video annotation tool’ (Mirriahi et al., 2018), ‘multimedia annotation tool’ (Moya et al., 2015), ‘audio-visual annotation tool’ (Marcal et al., 2020), ‘online collaborative video annotation’ (OCVA) (Aguillon & Monterola, 2020), ‘video annotation technology’ (Zhang & Wu, 2016), ‘video annotation device’ (Tessier & Tremion, 2020), ‘video annotation platform’ (Lee & List, 2018), ‘video annotation program’ (Baepler & Reynolds, 2014), ‘video annotation learning system’ (Chiu et al., 2016), ‘video annotation system’ (Lai et al., 2020; Nishihara & Yonemura, 2018) and ‘video annotation software’ (McFadden et al., 2014; Van der Westhuizen & Golightly, 2015) were observed. In another study (Van der Westhuizen & Golightly, 2015), VideoAnt was also referred to as a ‘Web 2.0 application tool’. Putting all the key terms together, in educational context, VA can be best understood as a tool, a learning system, a Web 2.0 application, a platform, a device, a software, a program or simply an application of technology associated with feature which enables individuals to annotate audio-visual content, either with textual or multimedia annotations. Most of the VA platforms are characterized with the feature for segmentation or clipping of particular segments of a video with the comments which are synchronized with video timeline. Some web-based platforms also have the advantage of allowing users of different expertise to work on a video-annotated project collaboratively.

Taking *youtube* annotation as example, Rolf et al. (2014) highlighted that there are three types of annotation, namely, isochronic, spatial and structural annotations. Isochronic annotations are the time-based annotations with the content linked to a specific time. Annotations with the content linked to a point or area of the video are called spatial annotations while structural annotations are normally the general comments which appear below a *youtube* video. Mirriahi et al. (2018) also differentiated between time-stamped and general annotations in which the former refers to annotations which are associated with a particular part of a video while the latter is concerned with the summary of the entire video. Meanwhile, Dawson et. al (2016) talked about point-based and text annotations. The former is seen as a flag on the video timeline while the latter is in the form of description in words.

A variety of VA platforms have been explored in education context. Apart from time-marked text annotations, some VA tools also offer advanced annotation features. It is worth noting that VideoANT, Media Annotation Tool (MAT) and Collaborative Lecture Annotation System (CLAS) have received a considerable amount of research attention. VideoANT, which was developed at University of Minnesota, is a free annotation tool which allows users to add time-marked text annotations to web-hosted videos (see Aguillon & Monterola, 2020; Baepler & Reynolds, 2014; Lee & List, 2018; McFadden et al., 2014; Van der Westhuizen & Golightly, 2015). Not only anchored commentaries and collaborative threaded discussion, MAT also offers ‘coloured markers’ for users to categorize content (see Colasante, 2011; Colasante & Douglas, 2016; Colasante & Leedham, 2013; Douglas et al., 2015; Lemon et al., 2013). Meanwhile, CLAS allows users to do both point-based and text annotations on a variety of multimedia content, such as podcasts, lecture capture and PowerPoint. It also has other features such as visualisation of convergence and divergence areas and inclusion of video-to-video annotations (see Dawson et al., 2016).

Annotated video technology in education has a growing research base that presently demonstrates its potential role in supporting student learning. As addressed by Bossewitch and Preston (2011), there is a need for educators to “foster the culture of serious scholarship through deep concentration and focus” (p.177) by encouraging analogous practices around video in student learning. This review thus adds to the body of knowledge on educational affordances of annotation tools and provides a starting point for educators who wish to contemplate the use of VA in their classrooms.

3. Method

Drawing upon the review methodology outlined by Moher et al. (2009), steps of the review process included: identification, screening, eligibility, data abstraction and analysis, as illustrated in Figure 1.

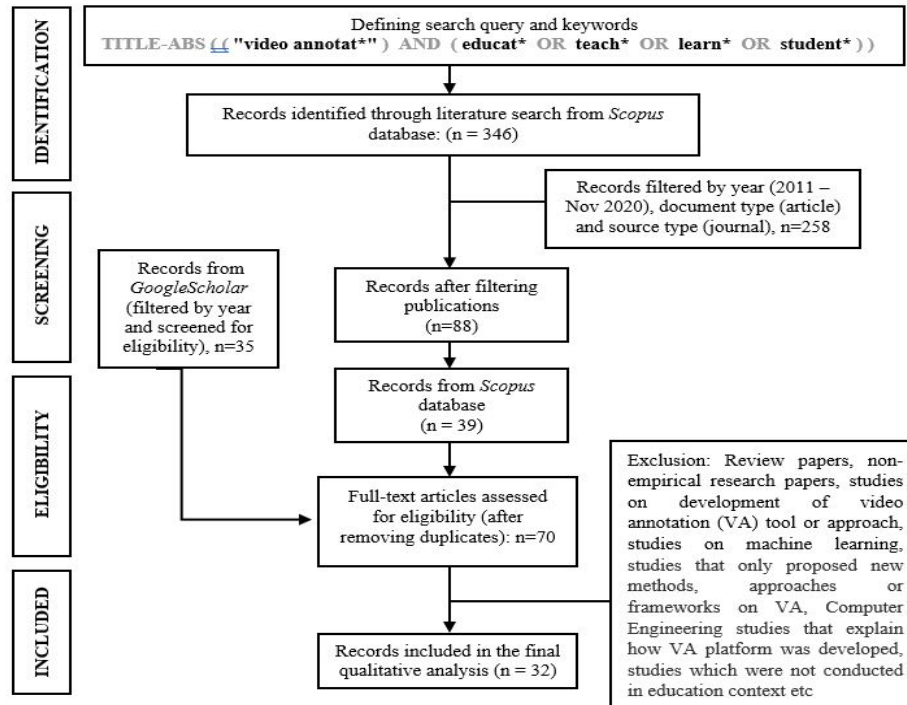


Fig. 1 Review method

To narrow down the research topic and formulate research questions which are sufficiently specific, a pre-review mapping was first constructed to outline the subtopics within the predefined scope. Next, a review protocol which maps out the methods to be used in the review was developed. This includes defining search strategies and formulation of criteria for inclusion. Research articles were searched using two sets of key terms: (("video annotate*") AND (educat* OR teach* OR learn* OR student*)). Four inclusion criteria were formulated. For studies to be included in this review, they need to: (1) present empirical data, (2) focus on using VA for instructional purposes, (3) explicitly describe one or more educational affordances of video annotation tools (4) be studies published between 2011 and 2020 (so as to provide an insight into recent scientific literature). Non-empirical research papers, studies which were not conducted in education context, studies on machine learning, studies that only proposed new methods, approaches or frameworks on VA and Computer Engineering studies that explain how a VA platform was developed were excluded. As a result, 346 potentially relevant items were initially yielded from Scopus database following the literature search conducted in November 2020. After the initial screening, 39 publications from Scopus database and 35 publications from Google Scholar (the second database) were retained for a closer inspection. After removing duplicates, at eligibility stage, the full texts of 70 research articles which were flagged as potentially relevant for a further review were retrieved. After a detailed reading, a total of 32 research articles were finally retained for coding and data extraction.

4. Findings and Discussion

The findings are presented in two sections: (1) the instructional use of video annotation across varied contexts and (2) the educational affordances of video annotation in supporting student learning.

4.1 The Instructional Use of VA Tools Across Varied Contexts

Table 1 summarizes the instructional use of VA in selected studies. Of all the 32 VA studies, nine (9) were conducted in the context of teacher education while eight (8) were found to focus on learners' conceptual understanding of video content. VA tools were also used to develop learners' workplace skills, clinical practices, listening comprehension skills and to explore students' self-reflection, learners' engagement in transmedia navigation and self-regulated learning. To sum up, these VA studies, were conducted predominantly to develop teaching practices, either among pre-service or in-service teachers, learners' conceptual understanding of educational, lecture or content-based videos, work practices among vocational students and clinical practices.

Table 1. An overview of instructional use of video annotation tools in the selected studies

Study focus	Studies	No. of studies
Development of teaching practices (teacher education / teacher training)	Anderson et al., 2012; Ardley & Hallare, 2020; Ardley & Johnson, 2018; Colasante, 2011; McFadden et al., 2014; Nilsson & Karlsson, 2018; Nishihara & Yonemura, 2018; Sherry et al., 2018; Van der Westhuizen & Golightly, 2015	9
Conceptual understanding of video content (educational/ lecture videos/ content-based videos)	Aguillon & Monterola, 2020; Grunewald & Meinel, 2015; Hong et al, 2012; Lee & List, 2018; Marcal et al., 2020; Moya et al., 2015; Tessier & Tremion, 2020; Zhang & Wu, 2016	8
Workplace skills/ work-practices/employment skills development	Colasante & Douglas, 2016; Colasante & Leedham, 2013; Douglas et al., 2015; Lemon et al., 2013; Perini, et al., 2019	5
Development of clinical practices	Cattaneo et al., 2020; Chiu et al., 2016; Hulsman & Vloodt, 2015; Lai et al., 2020	4
Performing arts students' self-reflection	Joksimovic et al., 2018; Mirriahi et al., 2018	2
Development of listening comprehension skills (EFL)	Chen & Chen, 2018; Chen et al., 2020	2
Learners' engagement in transmedia navigation	Baepler & Reynolds, 2014	1
Development of students' self-regulated learning	Dawson et al., 2016	1
	Total	32

It was observed that VA was commonly used as a tool to develop practical skills among learners in teacher and medical education as well as work practices in vocational contexts. One of the reasons could be attributed to heavy adoption of video resources in helping learners to observe, take note of and remember observable aspects of practical tasks. For instance, annotations were focused on the main steps and the significant positions in performing CPR (Chiu et al., 2016), how workplace skill such as communicating with clients or conducting a meeting was demonstrated (Colasante & Douglas, 2016), court advocacy, possible diagnoses in chiropractic clinical encounters or image evaluation in simulated eventual practice related to medical radiations (Lemon, et al., 2013). In comparing VideoANT and MS Word annotations, it was highlighted that the former which allows individuals to pin an annotation to an exact moment in the video timeline makes it easier for commenting at micro, mezzo and macro levels (Baepler & Reynold, 2014). In other words, VA offers valuable opportunities for users to analyze the observable behaviour in the video and most importantly, to get a closer look at the selected details and concentrate on the specifics.

Another critical observation is that the target area in which VA has received considerable attention is development of learners' communication. For instance, in teaching practices,

communication was one of the main focus of annotations apart from pedagogy, classroom management, and student behavior (McFadden et al., 2014). Similarly, in Lai et al.'s (2020) study, video-annotated peer review was conducted to help nursing students in assessing their peers' communication. The same was observed in one of the case studies in another paper (Douglas et al., 2015), as the video-annotated project was meant to develop Juris Doctor students' communication skills in advocacy. Eventhough several studies were found to focus on development of listening comprehension skills among EFL learners (Chen & Chen, 2018; Chen et al., 2020), the potential of using VA to develop ESL/EFL learners' communication skills in speaking has not been fully exploited. Furthermore, as it was revealed that video-annotated project could help pre-service teachers to improve their presentation skills (Anderson et al., 2012), it is thus anticipated that similar video-annotated project could also be adapted for use in ESL/EFL classroom owing to the fact that most of the student annotations which were focused on aspects of presentation skills, such as pace, clarity, posture, voice modulation, confidence and questioning techniques are, in fact, the essential components of oral presentation. Though video-based peer feedback practices are commonly employed in the teaching of public speaking (see Chekol, 2020; Liu, 2016; Luo, 2016), there is little attempt which involves the use of VA, thereby leaving ample room for further exploration in these contexts.

4.2 The Educational Affordances of VA Tools in Supporting Student Learning

From the review, it was unveiled that VA can support student learning in many ways. In particular, it was found to facilitate learners' reflection and feedback process, enhance learners' comprehension of video content, promote students' learning satisfaction and positive attitude and was also considered as a convenient and easy-to-use learning platform. Other affordances are concerned with opportunities for enhanced classroom interaction and video analysis.

First, many studies have demonstrated that VA is a powerful reflection tool. Markers which are used in MAT were found to support students' reflection on learning tasks (Lemon et al., 2013). Similarly, MAT was found to help students to reflect on their knowledge and understanding of customer service (60%), relationship building and networking (60%), facilitation of meetings (more than 80%) as well as arrangements for minute taking (more than 70%) (Colasante & Douglas, 2016). With CLAS, students were found to extend beyond mere observation and engage in motive/effect self-reflections which involved deeper explanation (Joksimovic et al., 2018). Students were found to engage in a higher level of self- reflection in graded conditions while more concrete self-reflections were produced among those with prior experience with the tool. Similarly, students with prior experience with reflection and summative assessment with feedback were found to produce more higher-order reflections (motive/effect and goals) (Mirriahi et al., 2018). In another study (Perini et al., 2019), students who used VA were found to pay more attention to reflection activities while students who did not use the VA focused more on descriptions. As there is no need to textually reproduce the content of the video when using HV, students could articulate and connect what they have learnt in theory with what they have observed in the videos. The same was echoed when feedback with no self-assessment indicators was found to predominate the session without the use of VA (Cattaneo et al., 2020). In another study, the potential of MAT in developing students' employability skills and reflection on important professional practice concepts was expressed by the teachers and industry representative (Douglas et al., 2015). Students also appreciated the opportunities provided for them to identify mistakes and develop a more thorough understanding on the do's and don'ts of the practices. Students' suggestion of filming their own critiques of x-ray images for peer review in future has further confirmed the vital role of MAT in facilitating students' reflection.

Also, a plethora of studies have highlighted the vital role of VA in scaffolding and fostering student teachers' reflection on their teaching practices (Anderson et al., 2012; Colasante, 2011; Nilsson & Karlsson, 2019). This is echoed by findings in Van der Westhuizen & Golightly's (2015) study in which students expressed their satisfaction on the number of assessments and reflections which were made possible via VideoANT over a short period of time. Student teachers' annotations were found to center on what a teacher should do, expectations of the teacher's role and positive comments on what the teachers have practiced (Sherry et al., 2018). Moreover, most of them were found to evaluate the teaching practices from the perspective of the students. Not only student teachers, beginning Science teachers were also found to produce annotations with a focus on themselves (69 %) and many have

moved beyond the level of simply describing and explaining teaching events to include evaluation and interpretation of their own practices (McFadden et al., 2014). Similarly, in another study (Nishihara & Yonemura, 2018), it was found that the use of VA can enhance the awareness of the teachers, leading to their concrete improvements in teaching.

Secondly, VA was also found to facilitate feedback process. Students reported that VA made it easier for them to make specific recommendations (Baepler & Reynolds, 2014). Assessing micro-teaching in annotation platform was perceived positively as assessing the session live might run the risk of missing out important details (Van der Westhuizen & Golightly, 2015). Other prominent advantages included opportunities for watching and assessing more micro-lessons, numerous watching and making comparisons. GoReact was also reported as a potential tool to promote feedback cycle and support a VA software-based online learning community as it allows information to be shared to multiple parties in an efficient manner (Ardley & Hallare, 2020). Furthermore, improved feedback quality was also reported in numerous studies. For instance, 'better and more meaningful comments' (Baepler & Reynolds, 2014), 'more dialogical and student-driven feedback' (Cattaneo, Boldrinia, Lubinu, 2020), more 'suggestion' and 'goal' categories of comments which were concerned with 'finding new solutions' (Lai et al., 2020) and 'feedback that referenced specific moments during the surgery' (Cattaneo et al., 2020) were observed. As more contextual notes could be anticipated with the use of VA, it is not surprising that the feedback provided will be of higher quality.

Besides, a higher acceptance level of feedback was also observed with the use of VA (Cattaneo et al., 2020). An enhanced validity of peer scores and student performances was also observed (Lai et al., 2020). It was highlighted that VA tool has provided more opportunities for students to practise their assessment skills and this in turn has resulted in significant improvement of their assessment skills. In addition, when using VA to provide peer feedback, students need to constantly re-watch the videos so as to relate their comments with the scenes in the videos. Hence, repeatedly watching the videos will somehow help them in giving suggestive feedback, just like the experts. Besides, it is also worth noting that structuring of analysis categories within MAT plays a role in breaking down students' thinking and helping them to model an expert's thinking process (Douglas et al., 2015). Also, VA system was claimed to reduce students' extraneous cognitive load, thus enabling them to provide beneficial feedback (Lai et al., 2020). As effective feedback practices are significant in enhancing student learning in 21st century classrooms (Chan & Nazamud-din, 2017) and feedback is most effective when it takes place as a conversation, with other factors such as immediacy and adequacy of feedback well taken care of (Singh, 2019), VA can thus be viewed as a potential pedagogical tool to boost learning in the 21st century, as far as effective classroom feedback practices are concerned.

Thirdly, a bulk of evidence suggested that using VA can lead to students' enhanced comprehension of video content. Dawson et al. (2016) found that Engineering students who used VA software obtained significantly higher grades compared to students who did not use the software. This is echoed by Lee and List's (2019) finding that students demonstrated enhanced comprehension when assigned to video condition with VideoANT compared to text condition. In another study (Colasante & Douglas, 2016), students (80%) reported that MAT has helped them to understand key concepts in customer service, relationship building and networking. Also, it was found that low performing students using VA have better understanding of the topics compared to those from conventional video-based lesson (Aguillon & Monterola, 2020). Not only that, students who used VALR were also found to have better listening comprehension performance (Chen & Chen, 2018). With VALRS-VLM, Chen et al. (2020) found that students did better in both English listening and vocabulary retention as well as the overall English listening comprehension. Eye-tracking analysis revealed that students working with VA demonstrated better concentration and learning performance (Chiu et al., 2016). In fact, they had lower cognitive load and higher fixation frequency while for control group, their gaze movements were found to distribute around the video screen and the scan paths showed that animations and actions were their main focus. More time was spent on processing information and identifying important video content. Also, markers in MAT were reported to aid students' learning focus (Colasante, 2011) while VALS was reported as an effective tool in helping students to capture key points (Chiu et al., 2016). Similarly, digital writing while watching lecture video was reported by students as having a positive effect on their concentration (Grunewald & Meinel, 2015). Besides, students in Marcal et al.'s (2020) study responded that time-based annotations can augment their study by enabling them to watch summarized versions of the content. Similarly, being able to see what others do and having a good summary of the lecture

were two advantages highlighted by majority of positively attuned students in Grunewald and Meinel's (2015) study. Meanwhile, Chiropractic students responded that VA was helpful as they allowed them to see real life examples and the link between these examples and the theory (Lemon et al., 2013). With Zhang and Wu's (2016) findings that the proportion of student speaking with the support of VA learning platform was 51.2 % compared to only 3.2 % in the traditional lecture classroom have somehow suggested that VA can promote student engagement with the intended content as students were found to speak more and express their ideas more. Besides, Lai et al. (2020) also highlighted that VA can assist students in creating a permanent store of knowledge or schemas via germane or learning-related cognitive load.

In general, students have positive attitude and learning satisfaction towards the use of VA in their learning. Student satisfaction is playing an important role here as it is an essential indicator of overall academic experiences and achievement (Virtanen et al. 2017). VALS has resulted in students' enhanced learning satisfaction as students felt that VALS could help them in enhancing their CPR knowledge, learning the right CPR skill and performing CPR correctly (Chiu et al., 2016). Similarly, vocational students also expressed their learning satisfaction with VA, particularly in enabling them to do video notations at relevant spots, reflect on their knowledge and understanding and obtain teacher feedback (Colasante & Douglas, 2016). Satisfaction among vocational students was again noted when all of them responded positively that MAT activities have helped them to achieve the specific intended learning outcomes (Colasante & Leedham, 2013). The same finding was echoed in Van der Westhuizen and Golightly's (2015) study in which students expressed their satisfaction and most of them felt that the use of VideoANT has improved their micro-lessons. In another study (Grunewald & Meinel, 2015), most of the MOOC students held a very positive attitude towards the use of digital VA. Students highlighted that the approach with online VA could be an interesting complementary study method which can help them to consolidate the subject and acquire knowledge (Marcal et al., 2020). Besides, MAT was also acknowledged as a helpful tool to students, especially in providing the opportunities to watch/re-watch videos, use markers and read the comments and feedback of others (Lemon et al., 2013). Significant correlations were found between students' liking of MAT and recommending its use to others. Not only that, it was noted that some students were intrinsically motivated to learn more on their own with OCVA as they were not only curious about the topic discussed, but were also made to be responsible for their own learning (Aguillon & Monterola, 2020).

Also, VA is a well-recognized convenient and easy-to-use tool. With VideoANT, comments such as 'easy to learn' and 'easy to leave comments on videos' (Baepler & Reynolds, 2014), 'easy to operate' and 'easy to access' (Van der Westhuizen & Golightly, 2015) were reported. As for Annotation, it was 'very simple to use' and 'easy to find the correct annotations to use' (Hong et al, 2012). OVA was considered as an 'easy, useful and innovative' tool (Moya et al., 2015). The ease of MAT use was also reported in Colasante and Leedham's (2013) study. Go-React was perceived as a comfortable form of evaluation (Ardley & Johnson, 2018). In another study (Anderson et al., 2012), EVA was perceived by 68% of students as 'easy or very easy to use'. The writing of digital notes with collaborative educational VA was described as 'fast and easy' (Grunewald & Meinel, 2015).

VA also provides opportunities for enhanced classroom interaction. This is evident when students reported that there was an appropriate amount of interaction with their peers in VA platform (Colasante, 2011). In another study (Colasante & Douglas, 2016), comfort in communicating through MAT was reported by more than 60% of Audiovisual Technology students, 100% of property service Diploma students and near to 90% of Property Service Certificate students. These findings are somewhat expected owing to the fact that most of the VA tools allow each anchored notation to be extended into multiple convergent conversations so as to prompt more meaningful interaction among learners. As addressed by Colasante et al. (2014), threaded peer discussion which is made possible by extending anchored notation can lead to focused classroom discourse. Majority of the students considered VA as a platform to exchange their views (Tessier & Tremion, 2020). The same was echoed in another study (Lemon et al., 2013) in which significant correlations were found between 'liking MAT' and 'using MAT to communicate and collaborate with others'. Some of the university supervisors of a video-annotated project in a student teaching internship program acknowledged that the technology is a great way for them to get connected with student teachers (Ardley & Hallare, 2020). Also, VA was found to facilitate learners in doing video analysis, particularly in unpacking key content or during peer review. It was found that VA has helped students to analyze customer service skills,

relationship building and networking skills in property services and leadership characteristics in meetings (Colasante & Douglas, 2016). In another study (Hulsman & Vloodt, 2015), students were found to pay more attention to performance which needed improvement, as reflected in both the number of annotated events and annotated texts with a negative valence. As highlighted, ‘granular analysis of content’ is made possible as VA allows content data to be segmented into discrete chunks for further analysis (Colasante et al., 2014).

5. Conclusion

This review found that video annotation (VA) tools were used predominantly in the context of teacher education. It was also used for other instructional purposes, such as to enhance learners’ conceptual understanding of video content, develop learners’ workplace skills or clinical practices. Besides, framing our analysis through the lens of educational affordances, it was found that there is accumulating evidence from studies foregrounding VA in education which highlights that VA can be used effectively to support student learning, in particular, to facilitate learners’ reflection and feedback process, enhance comprehension of video content, promote students’ learning satisfaction and positive attitude and convenience and ease. Eventhough it was noted that there are a few VA studies which focused on development of learners’ communication (Douglas et al., 2015; Lai et al., 2020; McFadden et al., 2014) and presentation skills (Anderson et al., 2012), they were conducted in the context of teacher education and clinical practices. The potential of using VA to develop these skills, however, has not been fully exploited in ESL/EFL classroom. As VA has been found to facilitate feedback process and learners’ reflection of their performance, it is thus recommended for future researchers to explore how adoption of VA tools can be advanced for development of communication skills in ESL/EFL classrooms, particularly in speaking context.

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