Digital Videos of Experiments Produced by Students: Learning Possibilities

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Introduction

The relevance of practical activities in science education seems to be undeniable. At the same time, a simple inclusion of experiments has been insufficient to ensure learning science, and thus the role of lab work is not self-evident (Hofstein and Lunetta 2004). Hodson (1993) describes that the emphasis in procedural aspects has interfered in work lab quality in terms of learning. In this manner, reflection, which has been frequently stated as more significant than interaction with materials, can become secondary. Additionally, the practical work needs to go beyond experiments that merely require following a "cookbook" recipe and move toward critical thinking about the results obtained during lab work, including the unexpected results.

Hence, it would be important to establish connections between practical work and discussion, analysis, interpretation, and social interactions as well as social validation and communication of the results. These elements serve to forge pathways for the production of science, including its processes and products. Moreover, the role of language as a way to learn science should be considered (Mortimer and Scott 2003).

In this context, digital technologies arise as additional tools for the inclusion of practical activities in the learning process. Some studies have pointed out positive aspects of audiovisual language such as pleasure, creativity, and social engagement (Pereira et al. 2012). Digital videos enable detailed observations of experiments or daily life events, which can make science more relevant to students. Besides, videos can also be used to improve experimental skills, encouraging students' engagement in different activities, both instrumental (i.e., hands on) and cognitive (i.e., minds on) (Rodrigues et al. 2001; Erdmann and March 2014).

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Movies have been used in many ways in chemistry education. For instance, back in 1973, Rouda recorded some experiments (e.g., the vacuum technique, determination of vapor pressure, and the kinetics of a hydrolysis reaction) performed by students themselves. Students who actively participated in these videos became familiarized with the experiments in different aspects including the apparatus, theories, calculations, and communication skills. Similar findings were described by Lichter (2012), who investigated a general chemistry course in which students created and uploaded (to the video-sharing website YouTube) videos about solubility. According to Lichter, the students who produced videos achieved significantly better learning than the rest of their classmates. However, most of these studies have not focused on the process of video production in order to evaluate the students' engagement.

The concept of school or student engagement has attracted growing interest in different realms. Some studies have investigated how the social contexts and school climate can interfere with students' learning (Vedder-Weiss and Fortus 2013; Sha et al. 2016) or cause dropping out of school (Connell et al. 1995). The relationship between instruction, teacher performance, and intellectual engagement has been also studied (Polman and Hope 2014). On account of this wide set of factors, student engagement is a complex construct that can be identified from different perspectives. In spite of these differences, there are some characteristics that allow classifying student engagement in three major groups: behavioral, emotional, and cognitive engagement (Fredricks et al. 2004).

Behavioral engagement is usually associated with commitment to learning and academic tasks, unveiling attitudes such as effort, persistence, concentration, and attention (Birch and Ladd 1997). The capability to work autonomously, the self-directed academic behaviors, and the collaborative actions are also some characteristics of behavioral engagement (Birch and Ladd 1997; Buhs and Ladd 2001). This engagement is considered essential for achieving positive academic outcomes (Fredricks et al. 2004).

The emotional engagement is associated with students' feelings and their affective reactions, such as interest, boredom, happiness, sadness, and anxiety (Fredricks et al. 2004). In general, this type of engagement involves positive and negative reactions toward teachers, classmates, and educational institutions that influence their willingness to do a specific task. Finn and Voelkl (1993) described it as identification with the school.

In turn, the cognitive engagement can be conceptualized as a psychological investment in learning that promotes improvements in comprehension by using self-regulated strategies (Fredricks et al. 2004). In a theoretical view, this engagement is possible when it involves problem solving, hard work, and ways of coping with perceived failure. At the same time, it is important to highlight the integration of "doing the work," which primarily involves behavioral and mental efforts to deeply understand some theoretical aspect. Students exerting more mental effort create more connections among ideas and may achieve greater understanding of concepts.

Engagement is fundamental to achieve learning. Thus, students need to be actively involved in a meaning-making process wherein they interpret, create, and act on reality. Learning is seen herein as an action by which language (or languages) is transformed (Kress et al. 2001). This perspective is in agreement with the social semiotic background.

This chapter reports on an exploratory study that examines some contributions of video production to chemistry teaching based on the evaluation of videos produced by students and their opinions about the production process. The research question that guided this inquiry was: How can the production of digital videos of experiments foster the undergraduates' engagement and chemistry learning?

Methods

This study involved 31 students enrolled in a general chemistry course at a Brazilian Federal University. The students were divided into groups of two to four members, and each group selected a general chemistry topic for the experiment. The groups subsequently planned, set up, and tested the experimental situation. Each experiment was first presented to the teacher and then videotaped without prompting. A total of 11 videos were produced. The content of the videos and the process of production were analyzed under the students' point of view for this investigation.

The analysis of the videos took into account a research-based analysis model based on the tetrahedron chemistry by Mahaffy (2004) and modified by Sjöström (2013). The analysis model consists basically of four fields: pure chemistry (includes formulae/symbols and safety procedures), applied chemistry (comprises applications and everyday-life aspects), socio-chemistry (involves historical context, risks, and benefits of chemistry, larger cultural milieu), and nature of chemistry (encompasses descriptions, explanations, analysis, synthesis, and knowledge uncertainties). In this perspective, chemistry education includes not only content knowledge in chemistry but also knowledge about chemistry, the nature of chemistry, and its role in society.

Structural components related to aesthetic characteristics were also evaluated based on the film analysis (Vanoye and Goliot-Lété 2013). Film analysis allows interpreting the video production as a cultural production from two different steps: deconstruction and reconstruction. Basically, deconstruction represents a description of the video components, whereas reconstruction presents the interpretation of these components within the video context and its production.

Information about the production process was obtained through a Likert-type questionnaire containing ten items, which also required explanatory answers. The questionnaire was structured following the Technology Acceptance Model, which aims to understand the system's acceptability to users. This model is based on the perceived usefulness, perceived ease of use, and real use of the technology (Davis 1989). Perceived usefulness is related to the users' beliefs in using a technology system to improve their performance in a task. People tend to use or ignore an application to the extent that they believe it can enhance their job/academic quality. Furthermore, even if the potential is recognized by the users, their beliefs about the degree of difficulty can contrast with the usefulness. Accordingly, the perceived ease of use is also a determinant factor in user behavior to accept or not accept a technology. Therefore, the decision of acceptance is concerned with the possibility for the real use of the technology.

Following these statements, the questionnaire items were constructed in order to attend to these definitions and to include questions about perceived usefulness (five questions), perceived ease of use (two questions), and real use (three questions). Explanatory questions were asked to evaluate which aspects of the video production plan were important (from the students' point of view), either in a positive or negative sense. Likert-type questions were counted and the percentage for each one was calculated. Explanatory answers were gathered by similarity generating excerpts that could be associated with engagement's characteristics. This analysis followed qualitative content analysis principles (Bardin 2011).

Results

Video Analysis

The audiovisual production showed a flexible structure in terms of filmic composition. For instance, the videos were filmed in different setups (i.e., six were produced at the university's laboratory, three of them at a home set laboratory, and two were recorded in both places). Movie length varied from 3 min 50 s to 6 min 32 s, and a soundtrack was employed in nine of the 11 videos. Video editing was carried out both linearly and nonlinearly. The videos included narration (except for one video), with two cases having been done in a voice-over. Credits and legends were inserted in ten videos and a making-of in two of them. The making-of exhibited not only a playful environment characterized by happiness and relaxation but seriousness and interest as well. These examples demonstrate both freedom and commitment during video creation.

It is worth noting that two videos produced in the laboratory also employed dramatization resources simulating a chemistry class in which a teacher discussed the experiment with the students. In these videos, jokes, laughs, and a relaxed situation (all elements of emotional engagement) were also identified. One video presented a film scene followed by a problem situation introduced to discuss some chemical aspects. In addition to these results, aesthetic elements (e.g., music, dramatization, picture/image, movie scenes, animation, and paintings, among others) were spontaneously inserted in all video productions. These resources enriched the videos and are related to diverse cultural dimensions. Considering that these elements were included by the students themselves, the variety of cultural aspects demonstrated creativity in that students created situations to present their experiments. These characteristics refer to positive reactions in academic tasks, revealing attitudes like effort and collaborative actions in order to produce material concatenated with students' desires and expectations.

With regard to chemistry aspects, students' concerns were mostly related to pure chemistry and to the nature of chemistry. The main results are summarized in Table 1.

Social issues including historical aspects, risks, and benefits of chemistry and cultural milieu were observed in two situations. For instance, in video 5, the context of the Second World War was presented to discuss chemical ethics, especially the employment of chemical weapons. In the same video, risks versus benefits were highlighted. The dark history of chemical weapons was contrasted with the advances in medicine. In turn, video 1 dealt with the pharmaceutical treatment of stomach acidity by using sodium bicarbonate or calcium hydroxide (milk of magnesia).

Materials found in our everyday life were presented in three of the videos. Examples included electricity generation by means of cells and batteries, food preservation (mainly the role of temperature control in chemical reactions), cooking process, refrigerator use, and the utilization of sodium chloride use to conserve meat in the past. Potassium permanganate application as a chicken pox medicine was also described.

The students mostly failed to explain phenomenological changes in terms of atomic-molecular theory. Most of them described experimental evidences without establishing a correlation with chemical phenomena as the following illustrates:

> This (phenomenological evidence) occurred due to a neutralization reaction between the acid (carbonic gas) and the alkaline (calcium hydroxide) substances.
>
> First, a little naphthalene ball stayed between honey and water. Then, we put a piece of paraffin that was between oil and alcohol. Afterward, we added a coin that was on the bottom because it is more dense than all liquids.

Table 1 Conceptual aspects assessed in the videos

Items analyzed	Video										
	1	2	3	4	5	6	7	8	9	10	11
Presentation of chemistry applications		X			X				X		
Presentation of social and cultural issues	P				X				X		
Correct description of the chemical process	X	X	X	X	X	X	P	X	X	X	P
Correct explanation of the chemical process					X				P		
Adequate use of chemistry nomenclature	X	X		X	X	X		P	X	X	
Correct presentation of experimental procedures	X		X	X	X	X		X	X		X
Correct presentation of chemistry equations		X						P			
Correct use of chemistry formulas		X			X			P			X
Safety recommendations		P									
Presentation of proper waste disposal											

"X" indicates the presence of the item analyzed. "Blank" indicates absence. "P" indicates partial presence

Although the videos offered descriptions, which are an important step in understanding chemistry, explanations were only given in one video (Table 1).

Students' Points of View

The analysis of students' viewpoints demonstrated a positive acceptance on the video production (Table 2). The answers about the usefulness of videos for learning and for stimulating creativity (items 1 and 7) revealed that all the students agreed "partially" or "totally" with the contributions afforded by video production. The positive statements were based on three aspects: the intensive work involved while producing the videos, the cooperative learning atmosphere, and the pleasure:

> This activity was important to foster a closer relationship. We had a lot of fun on our mistakes during the recording and (…) the video production was a new experience. We were free to choose what to do and this enabled us to use our creativity.

Table 2 Students' answers to the questionnaire ($N = 31$) on the video production activity

Statements	I totally agree	I partially agree	I'm un-decided	I partially disagree	I totally disagree
[1] Producing the video has helped me to understand chemistry concepts	10 (32.3%)	21 (67.7%)	0	0	0
[2] Producing the video has helped me to develop my technical skills	10 (32.2%)	19 (61.3%)	0	2 (6.5%)	0
[3] Producing the video has helped me to understand chemistry concepts applied to daily life	6 (19.3%)	21 (67.7%)	4 (13.0%)	0	0
[4] Producing the video was very difficult	0	23 (74.2%)	0	8 (25.8%)	0
[5] Producing the video was a pleasurable activity	21 (67.7%)	8 (25.8%)	2 (6.5%)	0	0
[6] My ability to explain a chemistry phenomenon has improved	6 (19.3%)	21 (67.7%)	0	2 (6.5%)	2 (6.5%)
[7] Producing the video stimulated my creativity	16 (51.6%)	15 (48.4%)	0	0	0
[8] I would like to participate in another activity like this one	15 (48.4%)	15 (48.4%)	1 (3.2%)	0	0
[9] I think video production may be an important teaching tool	16 (51.6%)	15 (48.4%)	0	0	0
[10] I would like using video production in my future pedagogical practice	12 (38.7%)	16 (51.6%)	3 (16.7%)	0	0

> We had to search for a lot of information about the experiment in order to explain what happened. This was a little hard in the beginning but doing it collaboratively helped us in our video.

Freedom and creativity appeared in 11 students' comments. These findings are in concordance to the video analysis that also showed playfulness, commitment, and collaboration actions during video production.

With respect to items 2 (improvement of technical skills), 3 (chemistry application concepts in everyday life), and 6 (explanations of concepts), which focus on usefulness as well, most of the students presented favorable answers, although some restrictions were mentioned regarding the need for someone to help them in technical abilities and chemical explanations:

> Difficulties to edit because my ICT knowledge was restricted. Recording was also hard because we had to combine the camera position, experimental control, time, and light. Sometimes the recording did not meet our expectations. So, we had to repeat it. Even so, we tried to do the best we could. On account of this, we had an enjoyable experience.
>
> The ability to explain a chemical phenomenon requires high cognitive skills. Although I have had other experiences, I was not able to explain some simple phenomena. We can just explain this one because we worked hard, together, and we sought out other sources. Perhaps if I was alone I wouldn't be able to explain the experiment at all.

Concerning the potential for the real use (8, 9, and 10), all the students were in agreement about the usefulness of video production as a teaching tool. Almost all students (96.8%) partially or totally agreed to participate in activities like this one again, and 83.3% of them would use video production as a teaching strategy. The students' justifications were often associated with playful, stimulating atmosphere, and social interaction:

> Video production was a playful activity that motivated me, giving me autonomy, stimulating me to know chemistry concepts, helping me to develop communicative synthesis skills, and promoting chemistry learning.
>
> It was quite interesting to participate, mainly because it was developed in a group in which we can interact more deeply with each other and to learn chemistry in a different and entertaining way. So, we could develop other skills, both social and technical.

Regarding the ease of video production (statements 4 and 5), most students (73%) had difficulties related to editing and recording techniques. In this sense, they suggested courses and specific attendance to solve these issues. Nevertheless, 93.5% of the participants stated that they had fun producing the videos.

Discussion and Conclusions

Video Analysis: Engagement and Learning Possibilities

The flexible filmic structure can be pointed out as an important magnitude of the audiovisual productions, given that such manifestations are concerned with the comprehension by students about the role of videos as a cultural expression. The flexible filmic structure, as can be seen by the different aesthetic elements included in the videos, and the presence of making-of and "bloopers" are related to autonomy, self-directed, and collaborative actions, which are characteristics of behavioral engagement (Fredricks et al. 2004). The climate of video production has also demonstrated interest and happiness, exhibited mainly in the making of the video and from the audio present in some videos.

The interest of students in searching and including cultural elements (e.g., music, photos, slow motion, and painting images) in their videos is related to willingness to do the task. The involvement in schoolwork such as pursuing one activity out of interest or for the pleasure of doing so has been positively associated with behavioral (e.g., participation and work involvement) and emotional (Fredricks et al. 2004) engagements. It can be understood as a psychological investment in learning, unveiling a desire to go beyond the requirements and a preference for challenge. These features are also included in the set of definitions of cognitive engagement (Connell et al. 1995; Newmann et al. 1992).

Considering the science as culture, videos would be a vehicle to converge different scientific dimensions. In different historic times, people have tried to use the knowledge about nature to make artistic representations of the reality or use art to represent scientific knowledge. Art deals with aesthetics, ideas of beauty, feelings, imagination, values, and so forth. Each one of those aspects may be relevant to learning science by performing an abstract idea in a somewhat concrete and even in a pleasing manner. Furthermore, it is possible to bridge the gap between science teaching and art with the aim to provide different dimensions of human knowledge. Meaning and appearance can be combined within an affective appeal, provoking a special feeling of pleasure of understanding (Galili 2013).

Video is not only a product, but it is a part of the process that drives a cultural and didactic production, a result from an action in which a dialogical relationship between product and process is established. The development of critical thinking relies on respecting and encouraging the curious, free, and creative action. This relationship between creativity, freedom, and playfulness can be noted in video production which reveals the three typologies of engagement (i.e., behavior, emotional, and cognitive). However, it is important to underline the importance of mental efforts to create connections among ideas and to achieve a greater understanding of the concepts.

In agreement with the comprehension of the learning as a transformative sign-making process, students should be capable of transforming the concrete world into a different notation. Cultural and aesthetic elements within the videos worked together to form a coherent text through a range of linguistic aspects that is the product from sign-making transformation.

Some videos tried to connect to everyday life, technology, society, chemical research, and history of chemistry, featuring aspects of applied chemistry and debating on the risks and benefits of chemistry. Concerning the perspective of the present work, these aspects can be considered important in the learning process, as videos contextualize chemistry by providing a broader perspective. By doing so, students demonstrated transformative sign-making by which learning can be achieved by the expression of a narrative that includes different dimensions of the tetrahedron, each one contributing to the whole communicative event. However, only three videos included this kind of discussion. A broader and problematized socio-perspective was missing.

In addition, the absence of discussions about safety, proper waste disposal, and its reduction is another aspect in which students need support. Although simple and low-risk materials were used in the experiments, the discussion about this issue cannot be secondary. Vilches and Gil-Pérez (2013: 1869) state that “chemical education is an ethically laden activity that can and must incorporate sustainability as an essential dimension.”

Although the videos offered descriptions about the experiments, explanations in terms of atomic-molecular aspects, and chemical representations including reaction equations, were scarce. Chemistry knowledge can be considered multidimensional, and the tangible world (even applied and socio-chemistry) cannot be the only way to capture it. Thus, chemistry learning involves establishing links between macroscopic phenomena and theoretical models, mediated by a specific language (Mortimer and Scott 2003). However, other aims of chemistry, such as analyzing and synthesizing, were present in a significantly lower number of videos.

The acknowledgment of the meanings attributed to the chemical atomic-molecular level is of central importance from a pedagogical perspective. Therefore, focusing solely on descriptions is not enough to develop an understanding on what happens during an experiment. The phenomenon needs to be reinterpreted from a suitable theoretical model, mostly beyond the tangible and visible. Previous studies (Gabel 1999; Talanquer 2011) reported problems faced by students in building bridges between the phenomena and the intellectual tools used in chemistry to describe or explain them.

Chemistry knowledge should be shaped by rhetorical transformation of everyday entities into scientific entities. The teacher’s actions need to provide the rhetorical construction of the entities and request the students to see the world in a particular way, through the representations, equations, and formulas. Teacher’s action has a central role to shape a dialogical process in which students should participate actively. Taking advantage of the videos as a dialogical product and expressive of the students’ interests, the teacher can use them to open the way of seeing the chemistry world.

Just as the audiovisual material, learning is a sort of a flame in which ideas are in constant movement and transformation. This can be seen as potential that has been afforded by video production in a learning process, especially when the video is seen like a cultural production. From this perspective, it is necessary to keep in mind that video production is a complex process through which students discuss, argue, select, (re)descript, construct, and integrate different effects (e.g., sound, image, speech, and feelings, among others) that allows to combine various communicative modes.

Precisely on account of this convergence of features, some difficulties are presented to the measurement and to the development of chemistry learning exclusively from the videos. On the one hand, cultural and aesthetic elements gave evidence of different learning and types of engagement. On the other hand, a requirement for specific chemistry aspects that need to be included in a video by students can hinder freedom, creativity, and, furthermore, engagement. Hence, the discussion of the chemistry aspects, particularly at the atomic level, can be a way to contrast what students have explored (i.e., positive aspects) and what they need to explore and identify gaps in learning. This is the teacher's role in terms of chemistry teaching.

Students' Points of View: Engagement Characteristics

The answers about the usefulness of videos showed that all students "agreed" or "partially agreed" about the contribution of videos for learning and for stimulating creativity. According to students' comments, the approach promoted collaborative engagement during the activities (i.e., experiments and recording), as well as individual organization, in a way which fosters autonomy, playfulness, and as a consequential behavioral, emotional, and cognitive engagement. Especially in the case of comments related to the usefulness and real use, the students attributed importance to the role of peers (e.g., "this activity was important to foster a closer relationship"; "we can interact more deeply").

Some studies have shown that engagement (or disengagement) is linked with peers and interpersonal relationships in classrooms (Marks 2000; Turner et al. 2014). Engagement is enhanced when class members actively discuss ideas, debate points of view, and critique each other's work. Other studies have showed that contexts in which autonomy is stimulated can favor engagement (Connell et al. 1995). In this study, the video production has created happiness and a relaxed environment, both being elements of emotional engagement. These results were corroborated by videos that have also demonstrated the same characteristics in making-of and audio. A possible reason may be associated with the nature of the task, since that video production created opportunities for students to work collaboratively and to freely introduce their ideas. These outcomes are in concordance with previous studies for which engagement can be enhanced in classrooms when the tasks (a) are authentic; (b) provide opportunities for students to assume ownership of their conception, execution, and evaluation; (c) provide opportunities for collaboration; (d) permit diverse forms of talents; and (e) provide opportunities for fun (Fredricks et al. 2004).

In addition to these results, persistence and dedication were identified as behavioral engagement categories in students' comments (e.g., "We had to search for a lot of information about experiments;" "We had to repeat it"). Emotional engagement has also been identified in students' comments when they referred to happiness while recording and, mainly, to identification with the school activity. The acceptance of video production seemed to be influenced by those characteristics of engagement. However, as in all experimental work, learning success is not ensured by simply performing the task, which was revealed by video analysis. In this regard, some aspects of content knowledge in chemistry (especially explanations, analysis, synthesis, and knowledge uncertainties) but also human elements from tetrahedron by Sjöström (2013) need more attention in video discussion. Thus, postproduction activities offer a way to overcome some of these learning difficulties that have been identified during video analysis.

Negative aspects were not identified in explanatory answers. Some students reported technical difficulties while recording and editing, as well as in chemistry comprehension, pointing out the role of collaborative work. Likewise, the results for the perceived ease of use and real use of the technology reinforced those aspects earlier presented. Again, the collaborative work and challenges faced during production operated in a positive way for the emotional (e.g., "it was funny"), behavioral (e.g., "we tried to do the best we could;" "we have repeated it"), and cognitive engagement (e.g., "we worked hard"; "we sought out other sources to explain the experiment"). As ascertained in other studies (Confrey 1996; Pereira et al. 2012), the participants stated that they had fun while producing the videos, which underscores the importance of freedom and social interaction.

Intellectual engagement and creativity have been pointed out as positive characteristics in video production (Goldman 2004). Other trends observed in raising engagement are flexibility and fair tasks (Finn and Voelkl 1993). Feelings of autonomy and competence seem to be strongly connected to engagement (Ryan and Deci 2000). This suggests an important support from social relationships, creativity, and entertaining in fostering the engagement. Social relationships and entertaining can be also related to the feeling of belonging. As described by Polman and Hope (2014), creations based on personally meaningful topics open opportunities for developing identities while fostering participation in critical thinking about science. As earlier mentioned, the students had freedom to choose and set up their experiments and videos. Thus, these aspects may have provided a deep identification with the task.

Some Final Considerations

Although student engagement cannot be seen as a guarantee for learning, it can result in a commitment or investment and, consequently, may be a key factor to decrease student apathy and enhance learning. In this manner, a positive correlation between video production and engagement was observed. The video analysis results were in concordance with the Technology Acceptance Model, and both demonstrated the presence of the three typologies of engagement. A few technical and conceptual difficulties were reported. At the same time, those difficulties worked like an additional incentive for the intellectual engagement. The recording and prerecording activities demonstrated an important role in student engagement during video production. These aspects require further investigations, mainly because they may play an important role during ongoing engagement and consequently in providing bridges between the phenomena and the intellectual tools used in chemistry.

Hence, the creation of a learning environment particularly involving the discussion of misconceptions related to chemistry in the videos would be desirable. This discussion is possible during each step in video production and is essential after its conclusion. Having this in mind, it is possible to connect initial engagement in promoting reflections that can continue over a long time. It will probably improve the learning process by addressing new perspectives for science classrooms.

Overall, the students' engagement has been an important first step. The video can be seen like a cultural production by which students can express different actions and a tangle of effects, resulting in a complex sign-making process. On the other hand, the nature of chemistry knowledge requires ongoing engagement with the aim to achieve links between macroscopic phenomena and theoretical models, as well as applied and socio-chemistry. In this way, students' understanding of chemistry may be improved through a cooperative learning environment after video presentations followed by discursive interactions.

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References

Bardin, L. (2011). Análise de conteúdo [Content analysis] (Vol. 70). Lisbon: Edições.

Birch, S., & Ladd, G. (1997). The teacher-child relationship and children's early school adjustment. *Journal of School Psychology, 35*(1), 61–79.

Buhs, E. S., & Ladd, G. W. (2001). Peer rejection as an antecedent of young children's school adjustment: An examination of mediating process. *Developmental Psychology, 37*(4), 550–560.

Confrey, J. F. (1996). Focus on science concepts: Student-made videos zoom in on key ideas. *The Science Teacher, 63*, 16–19.

Connell, J. P., Halpern-Felsher, B. L., Clifford, E., Crichlow, W., & Usinger, P. (1995). Hanging in there: Behavioral, psychological, and contextual factors affecting whether African American adolescents stay in school. *Journal of Adolescent Research, 10*(1), 41–63.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–339.

Erdmann, M. A., & March, J. L. (2014). Video reports as a novel alternate assessment in the undergraduate chemistry laboratory. *Chemistry Education Research and Practice, 15*(4), 650–657.

Finn, J. D., & Voelkl, K. E. (1993). School characteristics related to school engagement. *The Journal of Negro Education, 62*(3), 249–268.

Fredricks, J. A., Blumenfeld, P. B., & Paris, A. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109.

Gabel, D. (1999). Improving teaching and learning through chemistry education research: A look to the future. *Journal of Chemical Education, 76*(4), 548–554.

Galili, I. (2013). On the power of fine arts pictorial imagery in science education in science education. *Science & Education, 22*(8), 1911–1938.

Goldman, R. (2004). Video perspective meets wild and crazy teens: A design ethnography. *Cambridge Journal of Education, 34*(2), 157–178.

Hodson, D. (1993). Re-thinking old ways: Towards a more critical approach to practical work in school science. *Studies in Science Education, 22*(1), 85–142.

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundation for the 21st century. *Science Education, 88*(1), 28–54.

Kress, G., Jewitt, C., Ogborn, J., & Tsatsarelis, C. (2001). *Multimodal teaching and learning: The rhetorics of the science classroom*. London: Continuum.

Lichter, J. (2012). Using YouTube as a platform for teaching and learning solubility rules. *Journal of Chemical Education, 89*(9), 1133–1137.

Mahaffy, P. (2004). The future shape of chemistry education. *Chemistry Education: Research and Practice, 5*(3), 229–245.

Marks, H. M. (2000). Student engagement in instructional activity: Patterns in the elementary, middle, and high school years. *American Educational Research Journal, 37*(1), 153–184.

Mortimer, E. F., & Scott, P. H. (2003). *Meaning making in secondary science classroom*. Maidenhead: Open University Press/McGraw Hill.

Newmann, F., Wehlage, G. G., & Lamborn, S. D. (1992). The significance and sources of student engagement. In F. Newmann (Ed.), *Student engagement and achievement in American secondary schools* (pp. 11–39). New York: Teachers College Press.

Pereira, M. V., Barros, S. S., Rezende Filho, L. A. C., & Fauth, L. H. A. (2012). Audiovisual physics reports: Students' video production as a strategy for the didactic laboratory. *Physics Education, 47*(1), 44–51.

Polman, J. L., & Hope, J. M. G. (2014). Science news stories as boundary objects affecting engagement with science. *Journal of Research in Science Teaching, 51*(3), 315–341.

Rodrigues, S., Pearce, J., & Livett, M. (2001). Using video analysis or data loggers during practical work first year physics. *Educational Studies, 27*(1), 41–43.

Rouda, R. H. (1973). Student-produced videotapes in a physical chemistry laboratory course. *Journal of Chemical Education, 50*(2), 126–127.

Ryan, R., & Deci, E. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development and well being. *American Psychologist, 55*(1), 68–78.

Sha, L., Shunn, C., Bathgate, M., & Ben-Eliyahu, A. (2016). Families support their children's success in science learning by influencing interest and self-efficacy. *Journal of Research in Science Teaching, 53*(3), 450–472.

Sjöström, J. (2013). Towards *Bildung*-oriented chemistry education. *Science & Education, 22*(7), 1873–1890.

Talanquer, V. (2011). Macro, submicro, and symbolic: the many faces of the chemistry "triplet". *International Journal of Science Education, 33*(2), 179–195.

Turner, J. C., Christensen, A., Kackar-Cam, H. Z., Trucano, M., & Fulmer, S. M. (2014). Enhancing students' engagement: Report of a 3-year intervention with middle school teachers. *American Educational Research Journal, 53*(3), 450–472.

Vanoye, F., & Goliot-Lété, A. (2013). *Ensaio sobre análise fílmica* [*Essay on the film analysis 7th Ed.*]. Campinas: Papirus Editora.

Vedder-Weiss, D., & Fortus, D. (2013). School, teacher, peers, and parents' goals emphases and adolescents' motivation to learn science in and out of school. *Journal of Research in Science Teaching, 50*(8), 953–988.

Vilches, A., & Gil-Pérez, D. (2013). Creating a sustainable future: Some philosophical and educational considerations for chemistry teaching. *Science & Education, 22*(7), 1857–1872.