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Development of Learning Videos for Simple Chemistry Practicum with Acid-Base based on Green Chemistry Topic for Students of Class XI

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Abstract. Practicum is critical for students to develop their abilities and comprehension of the subject being studied. The lack of a laboratory and a laboratory assistant, as well as limited instruments and practicum materials, are the primary reasons why practicum activities are not performed in schools. Therefore, the use of instruments and materials which are available in everyday life can be an alternative to keep carrying the practicum out. This study aimed to develop a simple chemistry practicum video on green chemistry- based acid-base solutions and determine the quality of the developed video. The research method employed was development research (R & D) which adapted the 4-D models (define, design, development, and disseminate), although it was limited to the stage of development in this study. The research instruments used were the product quality assessment sheets for material expert, media expert, reviewers (senior high school chemistry teachers), and student response sheets. The developed product was a video containing determining the best indicators, making pH routes, determining the pH of acid-base, and acid-base titrations. A quality assessment on the product by material expert was 95% with the very good category; from media expert, it got a percentage of 95% with the very good category; and from reviewers, a percentage of 95% with the very good category was obtained. Furthermore, based on student responses to the product, a percentage of 98% with a very good response category was also obtained. Based on the results, the developed product was appropriate to be used as an alternative media to replace acid-base chemistry practicum in schools.
Keywords: Practicum video, green chemistry, Acid-Base

Introduction

The development of technology and information in the era of the industrial revolution 4.0 has led to the significant changes in the various sectors of life. One of which is in the education sector (Lubis & Ikhsan, 2015). The advancement of technology has a positive impact on the educational paradigm shift, specifically the change from traditional (face-to-face) learning to virtual learning (Cholil, 2019). Technology-based learning can facilitate teachers to deliver the material. Therefore, teachers are required to make innovations related to the use of technology in learning activities (Putra et al., 2019). Information and communication technology (ICT) in the learning process is considered effective to help students create interesting learning styles (Meidyanti et al., 2021). However, many Indonesian teachers are still not proficient in using technology for educational purposes (Afrida et al., 2018). Teachers' mastery of ICT is still low, at 40.48 percent (Marzal, 2013). Teachers' stuttering with technology is caused by a lack of skill in using technology (Husain, 2014). Many teachers, particularly those who are elderly, are still unable to use technology-based learning media (Winda & Dafit, 2021).

Video learning media can be used to create the effective learning (Aswana, 2021). Learning using video has advantages, including: (1) the learning process is more interactive, (2) the abstract material can be packaged to be more concrete, and (3) media can connect students and teachers flexibly and is not limited to space and time (Herani, 2021). Learning videos can be utilized as an independent learning resource because they can be played repeatedly to ensure that the material is understood (Ningtiyas & Aningtyas, 2020). Videos can also improve students' scientific processes (Wilujeng et al., 2020), affective and psychomotor (Pölloth et al., 2020). In addition, learning videos can also increase learning efficiency, learning skills, and student innovation (Indrawati, 2021; Yip et al., 2019). Yunita & Wijayanti (2017) stated that learning videos can improve student learning outcomes because the use of videos can stimulate students' interest in learning (Monalia et al., 2021). Unfortunately, the videos are still rarely used in chemistry classes and has not been widely used in schools (Asmara et al., 2017). Therefore, this medium needs to be developed so that students can easily understand a material (Riyanto & Asmara, 2018).

The problem that typically emerges in chemistry learning is a failure in the learning process Because chemistry is abstract and contains sequential concepts (Irawati, 2019). The abstractness of chemistry makes it difficult for students to imagine the material that cannot be directly observed (Hemayanti et al., 2020). Acid-base material is one of the chemistry materials that has sequential concepts and is abstract. The acid base is a prerequisite material before entering the materials of buffer solution and hydrolysis solution (Amry et al., 2017). The majority of acid-base matter is directly tied to everyday phenomena such as fruit sourness, the use of alkaline properties in gastric medicine, the use of lime to neutralize agricultural land, and others (Andriani et al., 2019). The research conducted by Paristiowati et al. (2017) stated that 87% of students find it difficult to understand acid-base material. Many students have not known the role of chemistry in everyday life (Putri, 2014). as a result of learning chemistry that is not based on the facts of everyday life, students prefer shortcuts to memorize the material rather than to understand concepts. Therefore, the material that has been studied is easy to forget (Sanjiwani et al., 2018).

In senior high school, chemistry is taught in two ways: in the classroom and in the practicum (Jelita et al., 2021). Practicum allows students to test a theory in a real-world setting, build critical thinking abilities, and develop basic experimental skills (Sasongko et al., 2020). Furthermore, practicum activities might help students understand abstract chemistry concepts by simplifying them (Syifaunnida & Kamaludin, 2022). Thus, the practicum is an important activity to be carried out in learning (Mamlok-naaman & Barnea, 2012). However, reality revealed that in Indonesia, teachers still do not use practicum activities as one of the learning activities (Junaidi et al., 2017). This occurs because there are several obstacles to bringing practicum activities into the classroom, including; (1) practicum tools and materials are limited because they are expensive; (2) the preparation and implementation of the practicum takes a long time; and (3) teachers have difficulty dealing with crowded students when conducting the practicum (Tüysüz, 2010). Practicum activities in schools are sometimes canceled due to a lack of laboratory equipment and materials (Sariati et al., 2020). It's also possible that practicum will be eliminated because there are no simple practicum activities that students can do (Astuti & Marzuki, 2017). The problems above can be solved by making a simple chemistry practicum-based learning video. However, based on the research conducted by Maulida et al. (2016), simple chemistry practicum-based learning video has not yet widely implemented in schools. As a result, schools that have issues in implementing practicums end up changing their learning models in the classroom such as giving assignments to do questions.

Chemistry practicums in senior high school often use hazardous chemicals. Some of the harmful chemicals used in chemistry practicums in senior high school are, HCl and magnesium ribbon for reaction rate practicum, $FeCl_3$ and KSCN for chemical equilibrium test practicum, $AgNO_3$ and $CuSO_4$ for glucose test practicum (Redhana, 2013). n addition, synthesis indicators are often used in the chemistry practicum on acid-base (Nuryanti et al., 2010). The use of these chemicals in the long term will harm the environment and adversely affect health (Kadek et al., 2014). The usage of methyl orange indicators, for example, can cause eye and skin irritation, as well as be possibly carcinogenic and lower oxygen demand and total organic carbon in water. The use of phenolphthalein indicators at a level of 25-50 g/mL can cause cytotoxicity in liver cells, leading to reducing cell growth (Jain et al., 2013). These chemicals can be replaced with environmentally friendly materials by integrating the principles of green chemistry in practicum (Harta et al., 2020).

Green chemistry is a concept that encourages the creation of a product to minimize harmful substances (Mannahan, 2005). The green chemistry approach is able to train students to become an environmentally caring generation in the 21st century (Mitarlis et al., 2017). Students' opinions of chemistry subjects that study hazardous chemicals can be changed by using ecologically friendly materials (Redhana et al., 2020). Green chemistry practicum tends to make students feel safer than synthetic chemistry practicum. Green chemistry practicum can also stimulate students' interest by demonstrating reactions that occur in the natural materials used (Redhana & Merta, 2017). In schools with limited laboratory infrastructure, this approach is also considered effective to provide an understanding of the concept of chemistry material in the form of a practicum (Redhana et al., 2020). Green chemistry practicum can improve student learning outcomes (Redhana & Suardana, 2021).

Based on the explanation of this problem, this research aims to develop a simple chemistry practicum video on green chemistry- charged acid-base solutions and determine the quality of the developed. Hopefully, this learning media can help students increase their understanding and knowledge of green chemistry-based acid-base practicum. Teachers can also use this learning media as an alternative media for teaching and performing acid-base practicum in schools.

Methods

This study used a type of research and development (R&D) to develop a video with a simple chemistry practicum on green chemistry-charged acid-base material. This study also used the 4-D model adapted from Thiagarajan and Semmel. The 4D model included the stage of defining, designing, developing, and disseminating (Sugiyono, 2017). However, this study was limited to the stage of developing.

The stage of definition was conducted to analyze the condition of the chemistry practicum in schools. This stage's goal was to define the needs that could be applied to the developed product. The definition stage included three main steps, namely, needs analysis, concept analysis, and goal formulation. The stage of designing was the stage in which a practicum video was made with steps: media selection, format selection, reference collection, instrument creation, and initial product design creation. The stage of development was the stage in which product's revision and assessment were conducted in order to produce a high-quality product.

The instruments used in this study were product validation sheets, product quality assessment sheets with the Likert scale, and student response sheets with the Gultman scale. Product validation data was obtained from product validation sheets, in the form of advice and input from a material expert, media expert, and reviewers. Product quality data was gained from product quality assessment sheets from a material expert, media expert, and reviewers. Student response data was determined based on the student response sheet after the developed product was responded to students of class XI.

The results of product assessment were analyzed by converting qualitative data into quantitative data. Quantitative data was then converted again into qualitative data using criteria for the ideal assessment category (Sukardjo, 2012) which can be seen in Table 1.

Table 1. Criteria for the Ideal Assessment Category

Quantitative (i) Score Range	Qualitative Category
$Xi + 1{,}80\ SBi < X$	Very Good
$Xi + 0{,}60\ SBi < X \leq Xi + 1{,}80\ SBi$	Good
$Xi - 0{,}60\ SBi < X \leq Xi + 0{,}60\ SBi$	Fair
$Xi - 1{,}80\ SBi < X \leq Xi - 0{,}60\ SBi$	Poor
$X \leq Xi - 1{,}80\ SBi$	Very Poor

Student response data were converted into quantitative data using the Gultman scale with a yes score of 1 and a no score of 0. The score obtained is then calculated for the ideal percentage using the achieved score formula divided by the ideal maximum score.

Results and Discussion

The developed product was a video-based learning media about simple chemical practicum on green chemistry-charged acid-base material. The Capcut application was used to edit the video. The application was selected based on the number of features that can be utilized to create the interesting learning media such as precision editing, multiple layers, color adjustment, and audio features (Fitrianingtyas et al., 2021). Furthermore, Capcut was a free application which was easy to be used (Choirun et al., 2021). The video display was made as attractive as possible by using the Ibis Paint X application to display animated pictures. Ibis Paint X was an application for drawing design in detail. This application was picked because it had several advantages such as a complete ruler feature, many font types, 325 brush types, and video feature (Hasanuddin et al., 2021). The use of animation in the learning process can increase students' learning enthusiasm. Animated images can help simplify abstract chemistry concepts so that students can easily understand the material (Sandi et al., 2016). The research conducted by Ardiman et al. (2021) showed that chemistry practicum video can attract students' attention to learning so that student learning outcomes can be improved eventually.

This study adapted the 4-D research model. The definition stage consisted of three main steps. The first was needs analysis. At this step, interviews were conducted with chemistry teachers and students at SMAN Darmaraja, SMA PGRI Situraja, and SMAN Situraja. Based on the interviews with the chemistry teachers at SMAN Darmaraja, the chemistry practicum has not been carried out properly because much laboratory equipment was damaged by the landslide disaster and the laboratory feasible to be used. The same problem was also delivered by chemistry teachers of SMA PGRI Situraja. The teachers complained that the cost of chemicals were expensive. Furthermore, chemistry teachers at SMAN Situraja said that the reduction of the learning time due to the impact of COVID-19 was a significant problem. Practicum at SMAN Situraja cannot be performed yet. Teachers, on the other hand, replaced it by assigning students to make chemistry practicum videos using simple tools and materials. Furthermore, based on interviews with students, it was discovered that due to the COVID-19 pandemic, students had never performed a direct practicum in the laboratory. The next step was the analysis of the curriculum which was adapted to the material in the developed product. Based on the applicable curriculum, then the concept of the practicum was compiled using the specified material. The final stage was the formulation of goals. After the material has been systematically conceptualized, the boundaries of the material were created according to the focus of the goals to be achieved.

The design stage was carried out by selecting media, selecting formats, collecting references, making instruments, and initial designs. The first step was media selection. This study developed a video with a simple chemistry practicum on green chemistry-charged acid-base. The video format design consisted of opening, material, practicum, results and discussions, and closing. The next step was the collection of acid-base material references. In the product development, there were four practicum videos, namely, determining the best natural indicators, making pH routes, determining pH and acid-base titration. The material references were obtained from literature studies and YouTube videos. The application used for editing videos was Capcut and the application for creating animated images was Ibis Paint X.

The next step was to make the instrument of product quality assessment using the Likert scale and the instrument of student response analysis using the Guttman scale. The instrument, which was in the form of a questionnaire, with several aspects was used as a tool to assess the product. Product quality assessment instruments were used to assess product quality by material expert, media expert, and reviewers. Student response questionnaires were used to find out how students felt about the product. The instrument above was then reviewed by the supervisor. After that, it was also validated by the instrument validator.

There were several steps in making practicum videos. The first step was pre-production. This step was done by creating video script and storyboard. The video script served to describe the scenes and dialogues in the video while the storyboard, in the form of sketches, was used to describe the sequence of scenes to be recorded (Sari & Risnani, 2021). The second step was production. This step was carried out by video recording and sound recording activities based on the storyline outlined in the storyboard. Video recording was done by using the Canon EOS M3 camera.

The third step was post-production. This step became the final step in video production before the video was distributed. The footage video was then edited by using the Capcut application. The editing process can be seen in Figure 1.

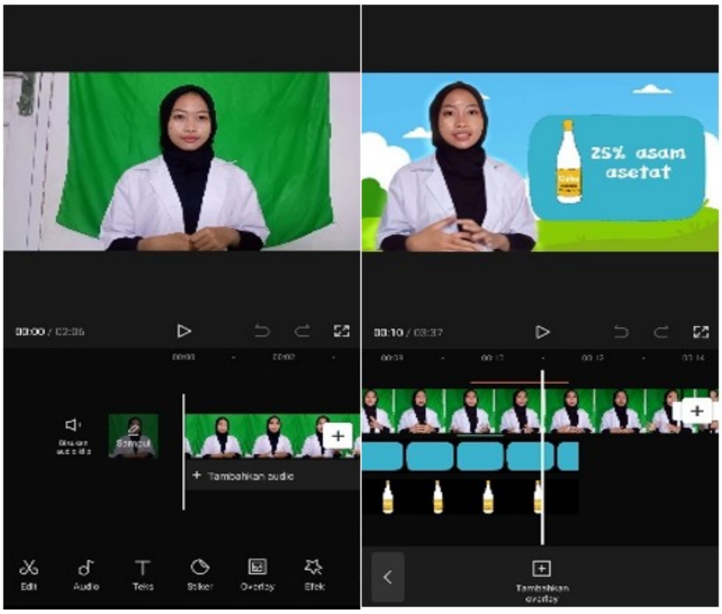

Figure 1. The video editing process with Capcut Application

The video editing process, especially in the material delivery scene, was carried out by background removal, cutting, mixing, transitions, adding animations, and adding sounds. The same procedure was also done when editing the practicum scene. However, to edit the practicum scene, the background removal was skipped. The editing process can be seen in Figure 2.

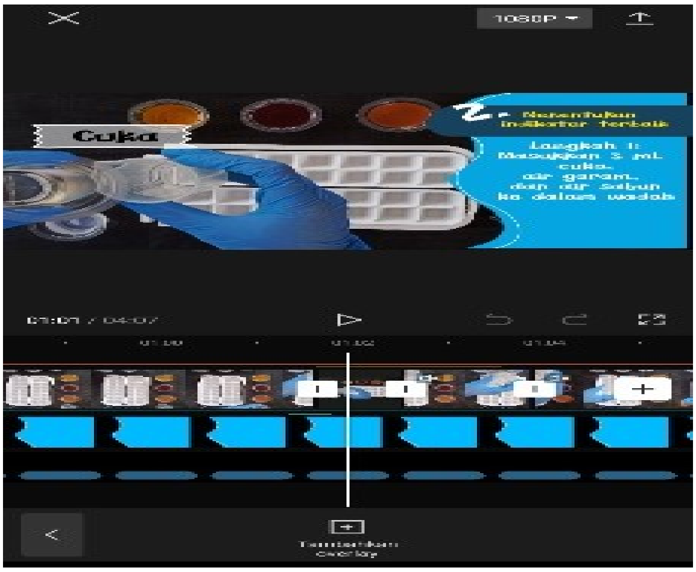

Figure 2. The editing process of the practicum scene with Capcut application

Furthermore, the Ibis Paint X application was used to create animated pictures. Figure 3 depicts the procedure.

Figure 3. The creation of animated pictures with Ibis Paint X application

In the last step, an animation effect was added to the images and the motion direction of images was made as needed by using the Capcut application. The final result of this study was a practicum video on how to determine the best indicators, make pH routes, and determine pH and acid-base titration with a duration of ±10 minutes each. Overall, the practicum video consisted of opening, content, and closing.

The opening video contained an introduction, the opening narration of the video such as the intro (synopsis of the content), the opening footage, and the learning goals. The writing layouts, transition effects, and font types were made as attractive as possible in order to draw interest students' attention. The opening video can be seen in Figure 4.

Figure 4. The opening video

The video's content was divided into four scenes: discussion of materials, introduction to practicum tools and materials, practicum procedures, and results and discussions. The materials shown in the video included acid-base indicators related to determining the best indicators; universal indicators related to making pH routes from natural indicators; acid-base pH related to pH determination; and acid-base titrations related to determining the acidity of vinegar in practical activities.

An acid-base indicator is a chemical that can give different colors to the acidic environment and the alkaline environment. There are several types of acid-base indicators namely, litmus paper, universal indicators, pH meters, as well as natural indicators and synthesis indicators such as bromothymol blue, phenolphthalein, methyl orange, and methyl red (Chang & Jason, 2011). Natural indicators are plant-derived materials having natural colors (roots, flowers, leaves, fruit, or seeds) that can be extracted using proper solvents (Rusiani & Lazulva, 2017). The subject matter of acid-base indicator can be seen in Figure 5.

Figure 5. Subject Matter of acid-base indicators

A universal indicator is a paper that contains particular organic compounds that changes color in the pH range of 0 to 14. . By dipping the indicator paper into the sample, universal indicators can be used to determine pH. The resulting color is then compared with the pH standard on the packaging. Universal indicators with natural materials can be an alternative for synthetic indicators in practical activities in schools (Priyanto et al., 2021). The subject matter of universal indicator can be seen in Figure 6.

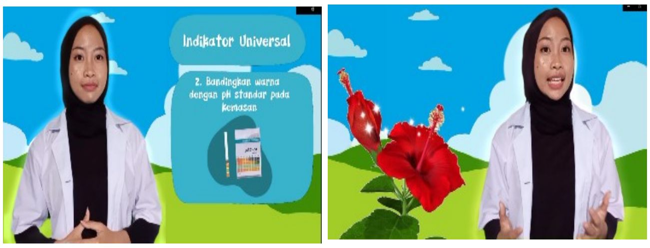

Figure 6. The subject matter of universal indicators

pH is an acidity level used to measure the acidity or alkalinity of a solution (Jespersen et al., 2015). The pH value of a substance determines whether it is acidic or alkaline. According to Soren Sorensen, a substance with a pH more than 7 is alkaline, a substance with a pH equal to 7 is neutral, and a substance with a pH less than 7 is acidic (Hewit et al., 2007).

Titration is a method to determine the concentration of a solution using another solution whose concentration is already known (Khopkar, 1990). The elements that need to be considered in titration are titrant, titration, indicator, titration endpoint and equivalent point (Chang, 2003). Titration endpoint and equivalence point are two different conditions (Jespersen et al., 2015). However, the two are often considered the same. The discoloration at the titration endpoint is actually an approximation of the achievement of the equivalent point. As a result, the titration endpoint is regarded as identical to the equivalent point. Titration of acids and bases can be made at home using instruments and materials found in the environment. Hibiscus extract can be used as an indicator of acid-base titration. The discoloration of the natural indicator of hibiscus extract in an acidic condition is red while the alkaline condition is green (Riniati et al., 2019).

The second scene contained an introduction to the tools and materials required for practicum. It can be seen in Figure 7. In addition, the third scene showed in Figure 8 was the work procedures in the practicum. The fourth scene was the results and discussions of the practicum. It can be seen in Figure 9.

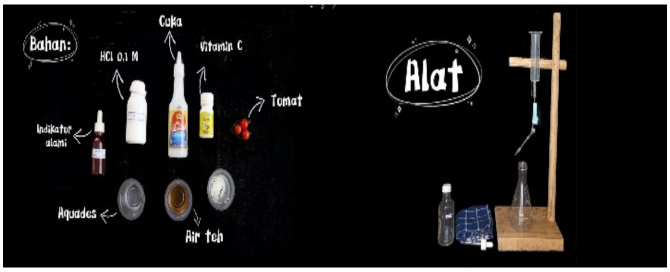

Figure 7. The introduction to the tools and materials required for practicum

Figure 8. The work procedures in the practicum

Figure 9. The results and discussions of the practicum

In the closing of the video, there was a scene that presented the end of the video with a few closing sentences. The closing scene consisted of the closing sentence, video ending footage, and credits. It can be seen in Figure 10.

Figure 10. The closing of the video

The development stage was the stage in which the final format of the chemistry practicum video was created. The developed product was then validated and assessed by material expert and media expert. Material expert assessed material aspects and green chemistry. A media expert in this study assessed the video based on the video aspects which included opening, visual, audio, and closing. Throughout product validation on a material expert and media expert, suggestions and inputs were collected for product quality improvement. The revised video was further assessed by four reviewers. Reviewers assessed the product based on the aspects of material, green chemistry & video. The following results gained after the developed product has been assessed by material, media experts, reviewers, and student responses can be seen in Table 2.

Tabel 2. Data on the results of assessments by material, media experts, reviewers, and student responses

Assessment /response	Assessment Aspect	Σ Score	Σ Ideal Maximum Score	Ideal (%)	Category
Material expert	Material	14	15	95	Very Good
	Green chemistry	5	5		
Media expert	Video	19	20	95	Very Good
Reviewer	Material	57	60	95	Very Good
	Green chemistry	20	20		
	Video	75	80		
Student	Presentation	20	20	98	Very Good
	Benefits of video	20	20		
	Practicum	19	20		
	Green chemistry	20	20		
	Material	19	20		

Based on Table 2, the video on a simple chemistry practicum of the acid-base charged with green chemistry had excellent quality with an ideal percentage of 95% according assessment by the material expert. It was appropriate for learning acid-base material. It was in line with the research conducted by Redhana & Suardana (2021). The research stated that green chemistry-based chemistry practicum is effective in improving student learning outcomes. According media expert's assessment, the developed product had excellent media quality with an ideal percentage of 95% so it was feasible for learning acid-base material. This was in line with the research, conducted by Muchtar et al. (2022), which stated that the qulity of chemistry practicum video was 86,87% with the very good category. Therefore, the developed video was feasible for learning how to perform the chemistry practicum. The use of media based on green chemistry can increase student literacy about the environment (Dewi & Listyarini, 2022). The video of simple chemistry practicum on green chemistry-charged acid-base could be categorized as media with excellent quality with ideal percentage 95% according to assessment conducted by the reviewers. Thus, the practicum video is feasible to be used in the learning process by both teachers and students. The fact above was endorsed by the research, conducted by Putri et al. (2021) which stated that the practicum video can be used by both teachers and students flexibly if it is required. Learning using videos can also increase student motivation and learning outcomes (Halmuniati et al., 2022; Pradilasari et al, 2019). The next stage was a limited trial towards 10 students. Presentation, the benefits of video, practicum, green chemistry, and material were the elements which were considered in the term of assessment. Table 2 contains the results of students' responses to a simple chemistry practicum video of acid-base charged with green chemistry. Overall, it can be concluded that based on student responses, the video of simple chemistry practicum on acid-base material based on green chemistry obtained very good category with a percentage of 98%. The positive response was realized because students were interested in the developed product and they also more easily understood the subject matter presented in the video. Thus, the practicum video was feasible to be used as alternative learning media. This was in line with the research, conducted by Erniwati et al. (2014) which stated that practicum video can be used as alternative media in the learning process because it can improve student learning outcomes and knowledge. The green chemistry-based practicum video has not been widely used in the learning process in schools. Furthermore, there were several benefits of green chemistry-based practicum video. They were (1) the tools and materials used were safe and affordable; (2) the video could be played repeatedly and applied independently at home, (3) it might be used as an alternative medium for practicum learning in class, (4) It could increase students' learning motivation and curiosity. This study is still limited to chemistry practicum on acid-base so that other materials can be carried out in the subsequent research. The restricted reference that discussed chemistry practicum on acid-base based on green chemistry was an obstacle in this study.

Conclusion

Based on the findings, it can be concluded that the video of a simple chemistry practicum on acid-base based on green chemistry consists of the opening, content, and closing sections. The developed video demonstrates how to determine the best natural indicators, create pH routes, determine pH and acid-base titration. The result obtained from the assessment conducted by a material expert is 95% with very good category; from media expert, a score of 95% with very good category is also obtained; and the reviewers yield a score of 95 percent in the very good category. The responses from 10 senior high school students show that the practicum video is very feasible to use with an ideal percentage of 98% and is categorized as very good. Thus, a video of a simple chemistry practicum on green chemistry-charged acid-base can be used as an alternative medium in practical learning at school.

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