Development of Virtual Textile Chemistry Laboratory in Learning Making Cellulose-Based Regeneration Fibers Based on Learning Paradigms in the Industrial Revolution 4.0 Era

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Abstract

This study aims to design and create a virtual chemical textile laboratory model as an effort to improve students' understanding of learning Textile Chemistry, especially on the subject of making cellulose-based regenerative textile fibers that have a high level of abstraction and complexity. Theoretical learning in the form of verbal symbols, empirically is not representative enough to explain the concept of the system that is needed, so that the possibility is not affordable (likely to inaccessible) by students which effected to the lessen of learning experiences. These conditions have implications for the lack of student understanding of these processes which is indicated by the acquisition of low learning outcomes. The specific target of this research is to produce a virtual laboratory device as a simulation medium for learning textile chemistry on the subject of making effective cellulose-based regenerative fibers. Furthermore, the model developed is validated to get input from experts related to the technology used, design and process content in the developed model. The validation results show that this model is suitable for use in the study of textile chemistry and can be used to improve students' understanding of the material for making cellulose-based regenerative textile fibers. In the limited trials that have been carried out, there are some features, image choices, and some simulations that need to be refined to avoid students' misinterpretations of the planned chemical process concept. Students involved in the trials are more motivated to continue learning related concepts that have been learned. In subsequent studies this model will be tested on a broader scale to measure its effect on the mastery of concepts and its ability to improve learning outcomes in textile chemistry courses, on the material for making cellulose-based regenerative fibers.

Keywords: Virtual Laboratory of Textile Chemistry, Learning to Make Cellulose-Based Regeneration Fiber, Industrial Revolution Era 4.0

INTRODUCTION

One problem that is often faced by students in studying Chemistry is because Chemistry has a high degree of difficulty due to the abstract and incremantal characteristics of chemistry. Likewise the study of Textile Chemistry, where in general, students are difficult to digest and master the chemical process and the process of forming fibers that are abstract and complicated. Based on previous research results, the data found that the highest level of difficulty faced by students is in studying material related to chemical processes and the mechanism of cellulose-based regenerative fiber formation which has a high level of abstraction and complexity. Theoretical learning in the form of verbal symbols empirically is not representative enough to explain the concept of the system that is needed, so that the possibility is not affordable (likely to *inaccessible*) by students which effected students' learning experiences. These conditions have implications for the lack of student understanding of these processes which is indicated by the acquisition of low learning outcomes.

Fiber is known for thousands of years BC as in 2,640 BC China has produced silk fiber and 1,540 BC has established the cotton industry in India. One fiber that has a lot of demand is cotton fiber, because of its excellent quality and very comfortable when it is used. The high demand causes the limited availability of cotton fiber, as well as the limited land that can be planted with cotton trees, so we need a replacement fiber that can be produced with a higher level of productivity than cotton fiber, which is regenerative fiber. Regenerative fibers are artificial fibers formed from polymers that come from nature, which are made by polymerizing chemical compounds to form fibers that are sprayed through a *spinneret.*

The first commercially regenerated synthetic fiber was rayon fiber, which was made from cellulose modified from wood pulp, later known as viscose rayon. In subsequent developments, this fiber becomes the most produced regenerative fiber because of its characteristics that are being able to match the quality of cotton fibers. Cellulose-based regenerative fibers were developed into several types, namely viscose rayon, acetate rayon, cuproamonium rayon and hi tenacity rayon (high strength rayon) [13].

The mechanism of regenerative fiber formation from cellulose material to rayon fiber involves a long and quite complicated process, as the following picture shows:

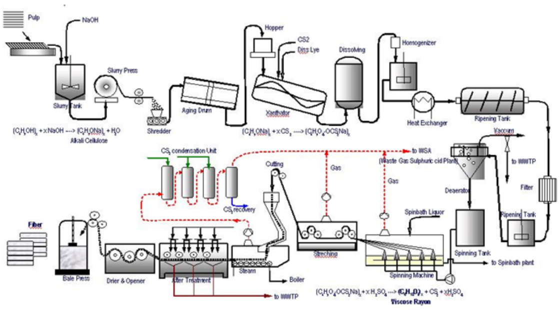

Figure 1. Mechanism of the Rayon Fiber Manufacturing Process
Source: http://texfiber.blogspot.com/p/viscose. html

Based on the facts above, students can master the Chemistry Textile learning, especially in the discussion of cellulose-based regenerative fibers that are considered difficult, efforts should be made to improve their learning activities. This condition is the background of the emergence of new innovations in chemistry learning, one of which is through the development of innovative learning media, by utilizing computer technology, both in the learning process and laboratory activities.

Development of media that can support the effectiveness of the learning process is very urgent to do, not just to improve learning outcomes in the classroom, further there are projections to prepare students to enter and compete in the era of the Industrial Revolution 4.0 based on the ability to explore the digital fields, virtual intelligent and automation. This is in line with the characteristics of the Industrial Revolution 4.0 described by Roblek et al. [12], that the fourth Industrial Revolution Period was marked by full use of the automation and digitalization processes, and the use of information technology and electronics (IT) in manufacturing and services. Other identifications about the characteristics of the Industrial Revolution 4.0 are described by the website of *Sumber Daya Iptek & Dikti*, [14] as an era that emphasizes the patterns of digital economic, artificial intelligence, big data, robotic, etc. or known as the phenomenon of disruptive innovation. While Thai and Anh [15] revealed that the 4.0 Industrial Revolution had made it possible in the development of computers, hardware, software and global networks, as well as creating a premise. This shows that we know the emergence of a comprehensive industrial revolution has changed all aspects of global socio-economic life. This condition is a challenge for LPTK which has a mission in producing qualified educational staff who are ready to compete. This is an urgent mission to do. Biot [2] provides an overview of the mission that universities must carry in entering the Industrial Revolution 4.0 era, namely that the university need to produce and disseminate the latest knowledge for the interests of students, industry and society. This means that the university carries the mandate to produce and disseminate the latest knowledge as a necessity of students, industry and society. Furthermore, Liao et al [9] signaled all University Colleges in the world to take part and contribute to this new challenge (Industrial Revolution 4.0 era), through laboratory experiments or application-oriented industries (for example Digital software development). Therefore, in facing these challenges, teaching in higher education is also required to change, in order to produce quality future generations. Biot [2] identified the qualifications of graduates demanded in the Industrial Revolution 4.0 era, is that they (graduates) have intelligence in solving complex issues involving multiple sciences, and respecting the public interest. This condition is certainly not easy to realize, and requires support from educational resources oriented to the goals achievements. The development of educational resources in the era of digital technology needs to be managed as close as possible together with the anticipation of changes in disruptive innovation that will affect the relevancy between the higher education output and development needs in the industrial era 4.0. In line with this, Xing and Warmala [16] suggested that the Industrial Revolution 4.0 was marked by the convergence of humans and machines, this would reduce the distance between subjects humanities and social sciences or science and technology. This will certainly require more interdisciplinary teaching, research and innovation.

One logical consequence that can be taken in realizing this Industrial Revolution 4.0 oriented teaching is by developing innovative learning tools. This is similar with Biot [2] who argues that in conducting education for our students, involves special efforts in developing new pedagogical tools which aimed to encourage multidisciplinary approaches. Further, educators in this information age should have sequential, sensing, and visual teaching styles. Educators should encourage the students to be an active learners, easy to learn by observing and drawing generalizations in the form of conclusions about what is being learned. Thus, a lecturing method, one-way communication and teacher centered approach will not suit the students. [5] as for this reason Multimedia learning in the form of virtual chemistry textile laboratories on learning to make cellulose-based regenerative fibers was developed.

Gunawan et al. [6] argue that a computer simulation that allows important functions of laboratory experiments to be carried out on a computer is called a virtual laboratory. In practice, virtual laboratories are not defined as leaning units but rather learning space, for virtual experiments. This is important to remind the lecturers that they need to explain the learning objectives to their students. The aim is to enable students to develop skills in problem solving learning and to control themselves according to their professional needs in the future. Virtual laboratories must provide sufficient freedom for individual experiments or experiments outside the limits set by the curriculum.

Virtual laboratories are defined in various literatures in various ways, for example Noor and Wasfy define virtual laboratories as "leverage modeling, simulation, and information technologies to create an immersive, highly interactive virtual environment tailored to the needs of researchers and learners". While Blázquez et al. [3] suggested that a Virtual Laboratory (VLab) is an interactive virtual space that incorporates all the technological, pedagogic and human resources for carrying out practical activities, is adapted to the needs of students and teachers in a virtual learning environment.

METHODOLOGY

The method developed in this study is the Educational Research and Development in the form of developing a Virtual Laboratory of Textile Chemistry at learning making Textile Fibers Cellulose-Based Regenerative. The research was carried out in two stages, starting with a preliminary study to find a form of product needed, then developing it through several stages of assessment (expert validation /*expert judgment* and limited trials), then it was revised until a final product design was deemed ideal.

This research is carried out in two main stages of research, namely:

1. The first stage aims to design and create a *Virtual Laboratory* of Textile Chemistry as a simulation media to learn cellulose-based regenerative textile fibers. The steps taken in this study refer to the research and development approach as the following below:

a. Gathering various information (preliminary studies) relating to the learning model in the Textile Chemistry course, specifically on the subject of Cellulose-Based Regenerative Fiber.
b. Conduct an analysis of the learning model that has been identified at the time of the previous study, which is related to: teaching approaches, teaching methods, instructional media and evaluation systems that are applied
c. Making the planning of Textile Chemistry course learning programs by focusing on optimizing the use of virtual laboratories in learning process
d. Designing learning software that will be developed on the virtual laboratory of textile chemistry device, which includes: a. Making flow-charts, b. Making the Storyboard, and c. Making Manuscript
e. Developing devices of virtual laboratory in the study of Textile Chemistry, which includes activities:

1) Arranging components of Textile Chemistry subject matter in a systematic and structured manner,
2) Processing key elements of design device in the virtual laboratory form of typography, symbolism, illustration and animation in one visual composition interesting and informative.
3) Developing learning tools of virtual laboratory by applying animation components in the form of audio effects, visual effects and the illusion of motion.
4) Editing and rendering the developed Virtual laboratory of Chemical Textile.

5) Developing the initial form of the product using the appropriate application program, for example: Macromedia Flash, Lectora Inspire, Ulead GIF Animator5, Corner-A ArtStudio and etc.

2. The second stage aims to test the result quality of Virtual Laboratory. The activities undertaken are:

a. Validating (*expert judgment*) products from media experts and material experts.
b. Revised the first stage of the results of the validation of the media experts and material experts.
c. Conduct one-on-one trials for prospective students of interactive learning multimedia user.
d. Conduct final revision of software products in the form of virtual laboratories.
e. Produced the product of Virtual Laboratory of textile chemistry that have been validated and are ready to be tested / implemented in learning Textile Chemistry in the subject of Regenerative Textile Fiber Cellulose based, and will be tested for reliability in improving learning outcomes in second year research.

Based on the foregoing, the stages of this study are described in the form of a chart as follows:

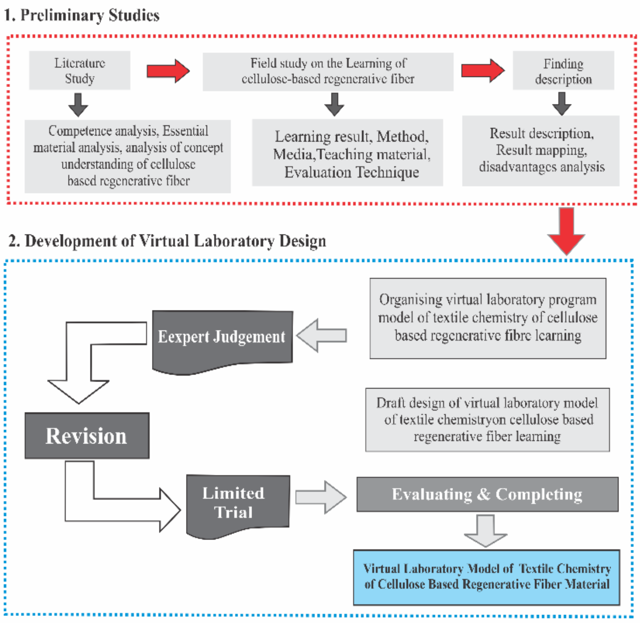

Figure 2. Development Research Stage Using Modification of R&D Research

RESULTS AND DISCUSSION

From the research and development that has been conducted, the results found in each stage in accordance with the research and development procedures described as following:

A. Analysis Phase

1. General Analysis

There are things that must be considered in developing multimedia, especially animation-based interactive multimedia which are: easy navigation, Cognition content, Media integration, Aesthetics, and overall function

Related to the criteria of a multimedia, a field survey was also carried out to the students to analyze the multimedia needs that will be developed in terms of users. Based on the field survey, the following results were found: Multimedia must be interactive, the material in multimedia learning uses language that is easily understood by students, and provides illustrations or images that are commonly seen in daily life, development of navigation in multimedia is expected provide a simple links which make it easier for students to see the material they want and are responsive to commands of the students, multimedia packaging is made by emphasizing the interactive aspect, not boring, using language that is easily understood, and provides intelligent solutions in solving a problem contained in the material, multimedia display is expected to be displayed in a form that is much in demand and favored by students, and it related to the desired experience of the students, multimedia is expected to provide an easier learning experience in understanding the materials.

2. The Software

In the process of developing this textile chemical virtual laboratory media, it requires the support of several softwares, including:

Adobe Flash CS6, as the main software for developing multimedia, **Adobe Photoshop,** is used to do editing and images manipulation that will be used in the textile chemistry virtual laboratory media, **MDM Zinc** is additional software to make adjustments on products made from Adobe Flash. With this software, it is possible for the product from Flash to be packaged into an executable installer to install the product on the computer.

3. The Hardware

Beside of software developers, minimum hardware is also needed to develop multimedia interactive learning. The minimum hardwares needed in this development are as follows: Processor: 2.0 GHz or faster processor tech-nology, Memory: 1 GB, Monitor: 1280 x 720 x 32-bit, Graphics Card: 128 Mb/32 Mb 5, and Hard Drive: 20 Gb

B. Design Phase

This stage is a process of making a multimedia interactive learning design by referring to the results of the needs analysis from the previous analysis stage. Based on the analysis that has been developed, we get a concept of "simple desktop". In this concept, the media is designed with a simple, easy to use, and attractive appearance, with simple animations. With an overview of such concepts and to simplify process of developing a virtual laboratory of textile chemistry media, then a user interface design is made at this stage.

C. Development Phase

After the design or planning stage is completed, the next stage is multimedia development. In the develop-ment of multimedia, it is divided into several small stages, namely the stage of making interfaces, coding, movie test, publishing and finally packaging. Each stage is described as follows:

1. Development of User Interfaces

Some examples of interfaces from multimedia learning that have been developed are as follows:

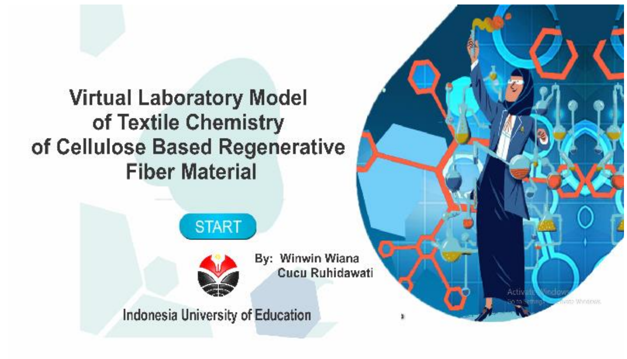

Figure 3. Home of Textile Chemistry Virtual Laboratory

Figure 4. Home Opener Vitur of Textile Chemistry Virtual Laboratory

Figure 5. Main Menu of Textile Chemistry Virtual Laboratory

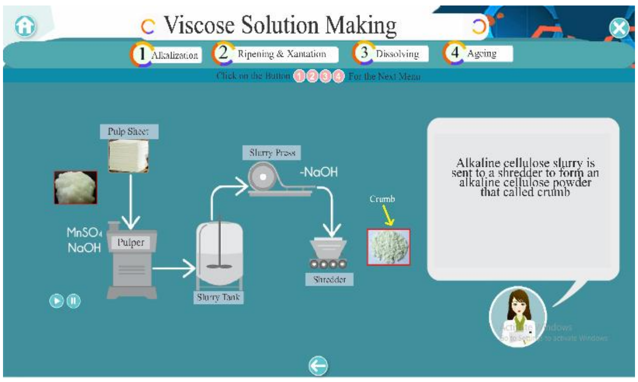

Figure 6. One feature of Textile Chemistry Virtual Laboratory (in the Content of Creation viscose solution on alkali-zation process)

2. Encoding

Objects in the form of buttons or Movie Clip that have been previously made on the interface display cannot perform any function. Therefore, at this stage the code is given to these objects so that the objects function as we wish. Code in Adobe Flash is called ActionScript and this multimedia development used Action Script *3.0.* By giving an ActionScript to the interface that has been made before, it is possible to create interactive and dynamic multimedia, for example giving ActionScript to the button to give the function of switching to another view and ActionScript to create simple animations.

3. *Movie Test*

After the process of *ActionScript* is completed, then the next step is Movie Test on Adobe Flash which will produce a *SWF* file, which is a SWF file extension. The purpose of this movie test is to see whether the objects in multimedia that have been given ActionScript can perform its functions as expected. If there are functions that are not yet suitable, then improvements are made to both the interface and the *ActionScript* of the objects concerned. This stage is done repeatedly until the appropriate function is obtained.

4. *Publishing*

In the previous stage the *SWF* files have been generated. To run this *SWF* file, you need a Flash Player that must be installed on the computer that will run it. Due to the possibility that the computer that will run textile chemistry virtual laboratory media does not yet have a Flash Player which means that this multimedia will not be able to run, then an alternative is needed so that all computers can run it without having to install the Flash Player first. Another alternative to overcome this problem is to package the SWF files into an installer that can be executed directly without having to install Flash Player first.

5. Packaging

This stage is the stage of virtual media packaging textile chemistry laboratory that has been created. At this stage, the SWF files and other related files are packaged into an installer to make it easy to install multimedia on another computer. Packaging or packaging of this multimedia into the installer uses the MDM Zinc program which has a build installer facility. The packaging process continues with the process of writing the installer file onto a CD, this is intended to facilitate the installation process of a textile chemistry virtual laboratory media on another computer.

D. Validation Stage

1. Validation by Media Experts

Validation of the textile chemistry virtual laboratory media is carried out by lecturers whose field of study is related to multimedia. The aspects seen in this validation are the existence of the Navigation Key, Multimedia Display and the easy use of multimedia. The results of multimedia validation by media experts can be seen in the following table:

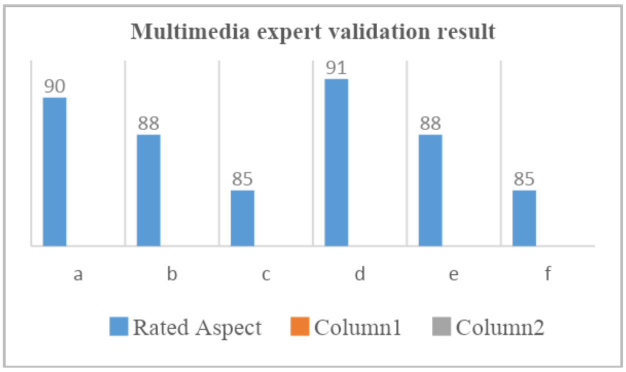

Figure 6. Multimedia Expert Validation Result Diagram

<u>Description</u>:

A: Navigation Keys in Multimedia are easy to operate

B: The illustrations presented make it easy to understand the material

C: Attractive display of learning multimedia

D: Learning media is easy to understand

E: Easy use of multimedia

F: Multimedia interactivity

From the diagram, it can be seen that multimedia validation by multimedia experts obtained an average percentage of eligibility of 87.83% which can be categorized as Very Eligible, because the value obtained is in the range of 81-100%

Virtual laboratory is a visual-based media that functions as a tool in the learning process and is expected to influence and make a better learning environment. Empirically, based on various researches that have been carried out in various parts of the world prove that the use of the learning media in the teaching and learning process is able to arouse the desire and learning interest, increase motivation in learning activities, and even it is able to bring good psychological influence to students, as supported by Levie & Lentz [8], who argue that learning media, especially visual media, are able to attract students' interest and attention to concentrate on the material being discussed. The existence of this interest provides a great possibility in the achievement of learning objectives

2. Validation by Material Experts

Validation of Animation-based Interactive Multi-media material is carried out by lecturers whose field of study is Design Technology. The aspects seen in this validation are general aspects, learning aspects, and material substance aspects. Validation results can be seen in the following table:

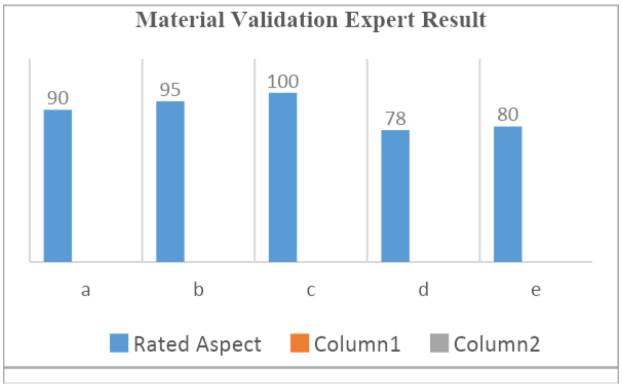

Figure 7. Diagram of Material Expert Validation Results

Description:

A: The suitability of the material with the Core Competencies and learning indicators to be achieved

B: Suitability of the concepts presented

C: The material is presented systematically according to stages of the process of making regenerative fibers

D: The format of presentation of the material is interesting, so that it can motivate students to learn

E: The illustrations used are clear, relevant and support the concepts taught

Graph above shows the results of validation of the virtual laboratory media by material experts, which are obtained on average the percentage of eligibility of 88.60% which can be categorized Very Good, because it is in the range of 81-100%.

The feasibility aspect of the material in the virtual laboratory media generally contains the feasibility of the media developed in terms of the material and the truth of the concepts presented. One of the things that need to be considered in this aspect is the relationship between basic competencies and learning indicators with the material presented. Arsyad [2] revealed that a learning media must have a clear focus on learning objectives. Learning objectives include abilities that are expected to be mastered by students after the learning process is done. In addition to being able to accommodate the learning indicators that will be achieved, the material presented must also contain accurate data, so that it can broaden students' insights and not cause misconceptions.

The illustrations presented in the virtual laboratory-based learning media are designed as closely as possible to the reality, so that they can support the concepts that are presented correctly. Verbal stimulation provides better learning outcomes as for the activities of remembering, recognizing, linking facts and concepts. Further, verbal stimulation provides better learning outcomes as for the learning that involves sequential memories. This statement is supported by Paivio's dual code theory [10] which explains that the human cognitive system consists of two subsystems including visual and verbal systems. An information that is presented visually and verbally will be better remembered then presented in only one way.

Related to the ability of virtual laboratory media in supporting the learning process, Leow & Neo [7] states that besides deepening student understanding, elements in media such as video and animation help students get more detailed information so that the capacity to be stored in brain memory is also increased. In another review, Bruner [4] said that learning occurs more determined by the way a person organizes messages or information, the learning process will occur through enactive, iconic, and symbolic stages. The implication of cognitive theory in virtual laboratory is that it can presents learning material in the form of images or icons, as well as with texts with a varied display so that students' understanding of a concept is more profound that can be stored in memory for a relatively long time [4].

3. Validation by Prospective Users

Validation by prospective users is carried out in the form of device trials, to determine user ratings of the use level of virtual laboratory of Textile Chemistry media, before the products produced are implemented in the field. And the following data are obtained:

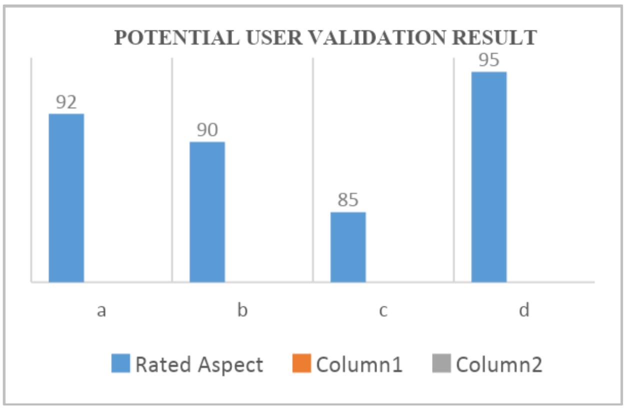

Figure 8. Diagram of Prospective User Validation Results

<u>Description</u>:

A: Easy to operate the navigation button

B: Media Display of virtual textile chemistry laboratory

C: Easy use of virtual textile chemistry laboratory

D: Media interactivity of virtual textile chemistry laboratory

Results of media validation the virtual textile chemistry laboratory by prospective users shown in the table above describes the average percentage of media usage by users, which is 90.50% which is categorized as Very High, because it is in the range of 81-100%. This means that interactive multimedia that is developed is easy to use and operate by the user, so that it can be implemented in further research, to measure the effectiveness of its use.

In terms of easy use of the media, there are still students who feel that virtual laboratory-based learning media are not easy to operate. While in aspects related to the ease of students understanding the material, students generally think that the virtual textile chemistry laboratory media that they operate are able to provide new experiences in learning, and are able to guide them in understanding the material displayed, so they are very enthusiast to do it.

E. Multimedia Revision Phase

There are some improvements that must be made to the virtual textile chemistry laboratory that have been developed including:

1. Specification of the title formulation at the initial interface, should better describe the contents of the multimedia optimally.
2. The user manual aspects of the interface should be more complete, and contain all technical aspects, so that it will be more informative and easier to understand, so that it will be easier for students to operate.
3. An introduction about the purpose of lectures needs to be displayed.
4. One of the multimedia expert validators suggested adding back sounds to each tutorial display, but students as users thought that the addition of back sounds would interfere with concentration when operating the virtual textile chemistry laboratory media.

CONCLUSION

Based on the results of research on the development of virtual laboratory media on the learning of textile chemistry in the production of cellulose-based regenerative fibers, data were found that the learning media developed were suitable to be used. The conclusions are obtained based on the eligibility requirements that have been met, among others; virtual chemistry laboratory media on cellulose-based regenerative fiber manufacturing material which was developed was valid with a very high category, namely by obtaining a validity percentage of 87.83% from media experts and a percentage of validity of 88.60% from textile chemistry experts. Apart from that, the learning media based on virtual textile chemistry laboratory on cellulose-based regenerative fiber manufacturing material that was developed was also declared practical, which was based on the results of observations of students' activities and responses. The results of student activity observations obtained the category of very good/ very practical with a percentage of 90.5%, which shows that the developed media is easy to operate and provides a good stimulus for students to learn.

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