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# Development of Computed Tomography Quality Control Training Application Model Based on the American College of Radiology Phantom Integrated Website

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**Abstract:- The use of Viewdex as a radiographic image evaluation tool has limited flexibility for students, especially in the complicated process of installation and input of DICOM ACR image results. These limitations can slow down the learning process and reduce the effectiveness of education on radiological image evaluation. This research aims to develop a web-integrated ACR Phantom-based CT quality control training application, which can overcome the weaknesses of Viewdex and improve efficiency and user experience. The research method used is Research and Development (R&D), which consists of several stages: literature study, product development, field testing, evaluation, and product revision. The application developed simplifies the process of DICOM data import, question coding, and automatic evaluation, improving operational efficiency. Validation of information technology and QA/QC experts shows that the application meets high standards in various aspects with 100% validity. Performance evaluation through pre-test and post-test showed a significant improvement in participants' knowledge and skills, with the Wilcoxon test showing a p-value of 0.005. The developed application has proven to be effective and efficient in improving the usability and learning experience of students, overcoming the weaknesses of Viewdex. Its advanced features enable efficient storage, retrieval, and management of medical images, as well as access and analysis of medical data.**

***Keywords:-*** *Viewdex, radiographic image evaluation, ACR Phantom, CT quality control, web application, DICOM, PACS, Research and Development.*

## I. INTRODUCTION

Technological developments in the field of radiology are currently getting more rapid. This is marked by the emergence of various cutting-edge technologies for the diagnosis of a type of disease in humans. An example of such technology is Computed Tomography (CT) [1]. Computed Tomography (CT) is an imaging modality that produces a cut of anatomical structures so that it can help improve diagnosis. Computed Tomography (CT) is the first medical imaging modality using a computer. CT Scan images are generated by passing the patient's body on x-rays that are rotated at various angles. CT Scan is a transmission technique that produces images of each body piece. The advantage of CT Scan lies in its ability to display three-dimensional (3D) anatomical slices, eliminating the superposition of anatomical structures so that it can display any unobstructed images of the anatomy to the doctor [2].

Computed Tomography (CT Scan) is a diagnostic imaging modality used to produce various anatomical structures in the form of slices to help improve diagnosis. The quality of the images obtained with these two modalities is very important because it also determines the quality of the examination or the results of the diagnostic image readings carried out by radiologists. Therefore, it is very necessary to test the quality of the image on both modalities [1]. According to Middleton (2017) the American College of Radiology (ACR) has published a performance testing protocol for CT Scan modalities in 2012, then ACR also published a performance testing protocol for MRI modalities in 2015. The principle of these two protocols is the same, namely for accreditation guidelines for the feasibility of CT Scan and MRI modalities used for radiology quality control programs. The quality control program in radiodiagnostic service facilities needs to be carried out to determine the work achievements of the radiology section in accordance with the Decree of the Minister of Health Number 1014/Menkes SK/XI/2008 concerning Standards for Diagnostic Radiology Services in Health Service Facilities. The quality control program in a hospital consists of a team that includes specialist doctors, medical physicists, radiographer coordinators, quality control (QC) radiographers, and technician representatives. A QC radiographer is a radiographer who is trained and has a certificate in the field of QC who is considered skilled and capable of quality assurance and quality control of conventional modalities radiology as well as CT Scan and MRI. A certificate of competence in the field of QC, CT Scan and MRI is a must-have for an expert radiographer who has studied Bachelor of Imaging Radiology Technology.

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The Imaging Radiology Technology Study Program (TRP) of the Department of Radiodiagnostic Engineering and Radiotherapy, Semarang Health Polytechnic is an education and training institution to equip prospective graduates with education and training in quality assurance and quality control (QC) CT Scan and MRI in order to provide added value for radiologist education graduates. In line with the quality control program in the radiodiagnostic service facility, an education and training program (diklat) is needed considering that not all radiographers can take part in the training activity because of the limited time they have for service, while the activity is very important. So far, educational institutions that have provided QC CT Scan are only the Imaging Radiology Technology (TRP) study program by providing training for prospective graduates, offline training requires more resources such as location, facilities, infrastructure, and most importantly participants must be present at the training location [3]. The education and training is expected to provide competency certification in the field of QC, especially in the CT Scan modality. In accordance with this QC CT Scan training program, it has been carried out in accordance with the functions of education and training management.

The management or management of education and training is related to the trident of activities, namely planning, implementation, and evaluation. According to Notoatmodjo (2018), this training cycle broadly includes Training Needs Assessment, Determination of Training Objectives, Curriculum Development, Preparation for Training Implementation, Training Implementation, and Evaluation [4].

Although training activities have been planned in accordance with the management function of the training mentioned above, there are still obstacles in the implementation of the training program. The obstacle is that the training programs have not been integrated with each other using an application. Several processes are still being carried out, starting from inputs, processes, and outputs from one training place for the training program. Therefore, an application system is needed that is able to integrate the entire process in the training program.

## II. RESEARCH METHODS AND SAMPLE

The research model used is Research and Development (R&D) which is a process used to develop and validate products. This process consists of several stages. First, study research findings related to the product to be developed. Second, the product was developed based on these findings. Third, field testing is carried out where the product will be used eventually. During the field testing phase, the product is evaluated to identify any deficiencies and problems that may arise. Based on the results of the evaluation, the product is revised and improved to ensure optimal quality and performance. These methods are the most relevant used and this research has reached the stage of developing the ViewDex Administrator application which has been used for CT and MRI quality control training.

The research design used is one group pretest-posttest. Data analysis uses a paired t-test. The sample of this study was divided into two groups. The first sample is product validation by experts, namely information technology experts. The second sample was a lecturer majoring in radiodiagnostics and radiotherapy and students of the imaging radiology technology program.

## III. RESULTS AND DISCUSSION

### *A. Evaluation of ViewDex-based CT-Scan Training Training Application*

The use of Viewdex as a radiographic image evaluation tool does not provide optimal flexibility to students for several reasons. The process of installing the application and inputting the results of the DICOM ACR image is quite complicated, requiring a sufficient understanding of the settings and configuration of the application, including handling questions related to the use of Viewdex that requires basic knowledge of coding. This limitation can hinder students from using the application effectively, as the process can be slower and take longer to provide adequate education about the use of Viewdex in radiological image evaluation.

Table 1. Overall Process Description of ViewDex-based Applications

| Process | Description | Debilitation |
|---|---|---|
| Download ViewDex | Download the app installer through https://www.sahlgrenska.se/ website. The selection of installers should be tailored to the specifications of the device being used, whether Windows, Linux, or macOS. | It requires a basic understanding to choose the right installer. |
| Install ViewDex | Installs the app on the user's device. | The installation process can be complicated and requires knowledge of software settings. |
| Import DICOM Image | Manually import DICOM data into the Image Database folder that Viewdex has provided. | The manual import process is not automatically integrated, requiring longer time and an understanding of directory settings. |
| Course LMS | Manually determine exam questions and answer choices by using a text editor application such as Notepad or Visual Code. | Requires basic programming knowledge to configure questions and answers manually. |
| Result | Carry out exams and produce data recaps in the form of manual .txt files. | The resulting recapitulation is not automatic and is only presented in the form of text files that require manual interpretation. |

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| Process | Description | Debilitation |
|---|---|---|
| Evaluation of Radiographic Imagery with ViewDex | Users can perform basic reconstructions of DICOM images, such as brightness and contrast adjustments for medical image analysis and assessment. | Visual settings have to be done manually and can take longer. |
| Value Recapitulation | Displays assessment results in the form of text files (.txt) opened with a simple application such as Notepad, without automatic recapitulation features such as passing grades. | There are no automation features for participant performance evaluation, reducing efficiency and requiring manual assessment by instructors. |
| The Whole Process | The ACR Phantom-based CT quality control training process with Viewdex offers some basic features, but there are significant drawbacks that reduce efficiency, such as manual data import, manual question coding, and non-automatic value recapitulation. | The process is manual and poorly integrated, requiring technical understanding and additional time to complete each stage, which can be an obstacle for participants and instructors in the implementation of training. |

This CT Scan Training Training has several important benefits for prospective students who graduate from Applied Bachelor (D4) Imaging Radiology Technology at the Semarang Ministry of Health Polytechnic. Students gain knowledge and practical skills in performing QA/QC on CT Scan devices. They learn how to operate the tool correctly, calibrate it, and ensure the quality of the images produced is up to standard. This training provides an in-depth understanding of the importance of QA/QC in radiology imaging. Students learn about the quality standards that must be met and how to conduct evaluations to ensure that CT Scan tools are functioning properly [5].

Through hands-on practice using the ACR phantom program, students gain invaluable practical experience. This experience helps them prepare themselves to face challenges in the real world of work. With the competencies gained from this training, students become better prepared to work in various health facilities [6]. They can work with high professionalism and work ethics, and are able to adapt quickly to the development of medical technology. Graduates who have good QA/QC skills can contribute significantly to improving the quality of health services. They are able to ensure that the CT Scan devices in their place produce high-quality images, which is essential for accurate diagnosis and patient care [7].

The results of the evaluation of the test using Phantom ACR will then be assessed on the results of the image. In practice today, the assessment is carried out using an application called Viewdex. The application serves as an image assessment medium that utilizes the Likert scale and option selection to provide value to various aspects of image quality. The use of Viewdex provides useful features in the simple image reconstruction process, such as brightness, contrast, and panning settings. These features allow for a more in-depth and thorough evaluation of the images generated by the CT Scan [8].

Fig 1. The Process of Using Viewdex Application in ACR Phantom Based CT Scan Quality Control Training

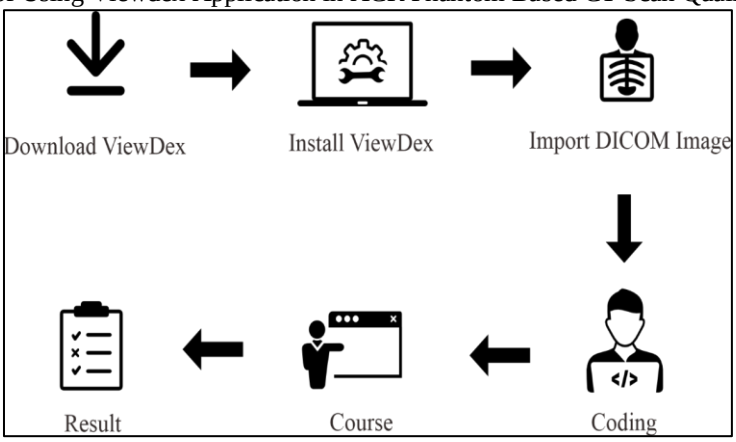


Figure 1 shows the process of using the Viewdex Application in ACR Phantom-based CT Scan Quality Control training. This process begins by downloading the app installer through https://www.sahlgrenska.se/ website. The selection of installers should be tailored to the specifications of the device being used, whether Windows, Linux, or macOS. After that, the installer is installed on the user's device. The next step is to manually import the DICOM data into the Image Database folder that Viewdex has provided. At the stage of determining exam questions and answer choices, the process is done manually using an application that can edit files with .txt extensions such as Notepad, Visual Code, and so on. Finally, an exam to answer training questions can be carried out. The results of this exam are in the form of data recaps in the form of manual .txt files.

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*B. Development of a Web-Integrated ACR Phantom-based CT Quality Control Training Application.*

The development of a web-integrated ACR Phantom-based CT quality control training application, critical steps are taken to ensure that the process runs efficiently and produces a quality final product. First of all, the creation of use cases is an important starting point to define the interaction between the application and the user and establish essential functions such as automatic DICOM data import, automatic question coding, and evaluation of results with a passing grade system. Activity diagrams are then used to visualize the sequence of steps in executing those functions, providing a clear understanding of the system's behavior during development.

The next development process involves the detailed implementation of each feature that has been defined in the use case and activity diagram, as well as continuous testing to ensure the application works according to the set standards. Once the development phase is complete, the app will be validated by experts in the field to thoroughly evaluate the security, functionality, and quality of the user experience. The feedback from this validation becomes the basis for making necessary revisions and improvements before producing the final product [9]. Thus, the final product of this development is expected to provide a more efficient, integrated, and responsive training experience to the needs of participants and teachers in ACR Phantom-based CT quality control.

Web-integrated ACR Phantom-based CT quality control training application. The system is designed to allow participants to view the quiz questions along with their answer options, with support for DICOM-based question displays integrated through Orthanc's PACS server. The main advantage of this page is its ability to display DICOM images directly in the quiz questions. DICOM images, which are the standard format for medical images, are stored and managed through Orthanc's PACS server, allowing participants to access high-quality, uncompressed images. This ensures that the displayed medical images remain accurate and detailed, in accordance with the needs of CT quality control evaluation and training [10].

The DICOM integration through Orthanc's PACS server allows participants to perform basic manipulations on the image, such as brightness, contrast, and measurement adjustments, which are critical in CT quality control training. With this feature, participants get a more realistic and immersive learning experience, as they can directly interact with relevant medical data in the context of assessment. This quiz display page is designed to ensure that participants have all the necessary tools to better evaluate and understand the training material, thereby improving their learning effectiveness and practical skills. This approach not only strengthens participants' technical abilities but also improves their understanding of the practical applications of the learned theories in real-life clinical situations [11].

The application system has been validated by involving three expert validators in the fields of Information Technology (IT) and Quality Control and Quality Assurance (QA/QC). This assessment process covers various important aspects of the application, namely General Functionality, Security, Compatibility, Performance, Usability, Dashboard, and User Interface. These experts provide in-depth evaluations to ensure that applications meet high standards in each category assessed.

The Assessment of General Functionality ensures that all application features operate in accordance with the specifications that have been specified. Security Evaluation focuses on user data protection and system integrity, ensuring applications are not vulnerable to cyber threats. The Compatibility aspect checks the app's ability to run on a variety of devices and operating systems [12]. Performance is tested to ensure the application is responsive and efficient in resource usage. Usability assesses the ease of use of the application by the end user, while the Dashboard and User Interface assessment ensures that the app's interface is intuitive and easy to navigate. The results of this validation provide confidence that the application is ready for use with high quality standards

*C. Expert Validation*

The results of the validation test by experts using the Blackbox method show that the entire test including General Functionality, Security, Compatibility, Performance, Usability, Dashboard, and User Interface received a validity score of 100%. This means that three expert validators in their fields consider that this training system is valid and runs well according to expectations. This evaluation reflects that the application meets all the criteria that have been set without any significant errors or shortcomings. With the results of this validation, the application is declared ready to be tested further on potential users to evaluate the effectiveness and acceptance of the application in real use. This 100% validation gives confidence that the application has been developed to high quality standards and is ready to support optimal CT quality control training

*D. Performance Effectiveness of the Web-Integrated ACR Phantom-Based CT Quality Control Training Application*

This stage is to test the effectiveness of the performance of the quality control training application *CT* Based *ACR* Integrated phantom *Web*. The evaluation is carried out through a limited test with the *Pre-test* and *post-test*, using a single variable to assess the effectiveness of the application. It is hoped that the results of this evaluation can provide an overview of the extent to which this application is effective in the context of usability. Method *Pre-test* and *post-test* allows for a comprehensive assessment of changes in participants' knowledge and skills before and after using the app. The results of this evaluation are expected to provide a solid foundation for understanding the positive impact of the development of this application, as well as be the basis for further refinement. Thus, this study not only measures the effectiveness of the application in supporting quality control training *CT*, but also assessed its contribution to improving the overall competence of participants [13].

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To meet the requirements of a valid and reliable questionnaire instrument, 7 variables as the main dimension and 14 question items as indicators are examined for the findings of r values$_{count}$ must $\geq r_{table}$ at $\alpha = 0.632$ and the average value of *Cronbach's alpha* must > 0.632. The variable in question includes the aspect of measuring *Learnability, Efficiency, Effectiveness, Errors, Satisfaction, privacy,* and *design.*

Based on the results of the validity test using the *Pearson Correlation* Average $R_{count}$ 0.81 $\geq r_{Table}$ at $\alpha = 0.632$. Meanwhile, Cronbach's alpha value of 0.779 is > 0.632 which is relative, so it can be concluded that the questionnaire instrument has met the requirements for validity and reliability as a suitable data collection tool to be used to measure all aspects of the variables in this research design.

In this evaluation stage, a quasi-experiment was carried out with a one-group design *Pre-test* and *post-test* to measure the impact of quality control training applications *CT* Based *ACR* Integrated phantom *Web.* A total of 10 stakeholders in the quality control training *CT Scan, X-ray*and *MRI* in the D4 Imaging Radiology Technology Study Program, Department of Radiodiagnostic Engineering and Radiotherapy, Poltekkes of the Ministry of Health, Semarang, participated in this experiment. This experimental approach is designed to provide a deeper understanding of the system's performance changes and effectiveness after application implementation.

Using a one-group design *Pre-test* and *post-test*, this study can identify significant changes in participants' knowledge and skills before and after using the application. This approach allows for a comprehensive assessment of the impact of the application on participants' understanding of quality control *CT*, X-ray, and *MRI.* The results of this evaluation are expected to provide valuable insights into the effectiveness of the application in improving the competence of participants and become the basis for further development, to ensure that this application can provide maximum benefits in the context of radiology education and training.

Table 2. Statistical Test Results of Each Usability Accompanying Indicator

| Indicators | p-value (Mann Whitney) | Mean Rank | |
|---|---|---|---|
| | | Pre | Post |
| **Learnability** | 0.000 | 55.00 | 155.00 |
| **Efficiency** | 0.000 | 55.00 | 155.00 |
| **Effectiveness** | 0.000 | 55.00 | 155.00 |
| **Errors** | 0.000 | 55.00 | 155.00 |
| **Satisfaction** | 0.000 | 55.00 | 155.00 |
| **Privacy** | 0.000 | 55.00 | 155.00 |
| **Design** | 0.000 | 55.00 | 155.00 |

To ensure that there were further significant changes, a Mann-Whitney non-parametric differential test was performed on each of the accompanying indicators *Usability* namely Learnability, Efficiency, Effe*CTiveness*, Errors, Satisfa*CTion*, Privacy, and Design. The results of the statistical test show that there is a significant difference between the conditions before and after using the application. Average p-value*Roleh* is 0.000, which is well below the significance threshold of 0.05, indicating a significant change. In addition, the average mean rank in the condition of *Pre-test* is 55.00, while in the *post-test* increased to 155.00. This indicates that after the use of the app, there is a significant improvement in the *Usability* assessed, reflecting an overall improvement in user experience and application effectiveness in quality control training *CT.*

The qualitative findings of each user's impression of this application show a very positive impression. Some users stated that this application has excellent features and follows the latest technology, such as integration into the system *PACS* (Pi*CTure* Archiving and Communication System). This integration allows for efficient storage, retrieval, and management of medical images, making it easy to access and analyze medical data. Users also appreciate the image-based question feature *DICOM* (Digital Imaging and Communications in Medicine), which allows them to perform simple reconstructions of the resulting images of medical images. This feature allows for adjustments to brightness, contrast, and measurement on the image, providing a more interactive and immersive learning experience. With this ability, participants can practice and better understand medical image analysis in the context of quality control *CT*, improving their practical skills in an environment that is close to real situations [14].

## IV. CONCLUSION

This research resulted in a web-integrated ACR Phantom-based CT quality control training application, overcoming the weaknesses of previous applications such as Viewdex. This application simplifies the process of DICOM data import, question coding, and automatic evaluation, improving operational efficiency and user experience. Validation by IT and QA/QC experts shows that the app meets high standards in functionality, security, compatibility, performance, usability, dashboard, and user interface, with 100% validity.

Integration with the Hospital Information System (SIR) will improve data coordination between training and clinical practice. The development of training modules for other medical imaging technologies such as MRI and Ultrasound will expand the scope of training. Research on the economic impact of the application of this application in educational institutions and hospitals is needed for the evaluation of cost efficiency and productivity improvement.

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