Augmented Reality Eyewear for Assisting in the Preparation and Control of Cancer Therapies: Assessing the Learning Curve and Level of Adoption.

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doi:10.3233/SHTI240793

Augmented Reality Eyewear for Assisting in the Preparation and Control of Cancer Therapies: Assessing the Learning Curve and Level of Adoption

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Abstract. Since March 2022, the centralized cytotoxic preparation unit at the Lille University Hospital (Lille, France) is equipped with augmented reality eyewear for preparation and quality control. The technology enables a user-friendly guided step by step preparation process. It also assists the user by identifying vials through data matrix scan and recording photos at different stages of preparation in order to replace the in-process double visual inspection which will now be carried out *a posteriori* during the release control. In this paper, we evaluate user feedback and model the learning curve for this new tool. The team's feedback was evaluated using the System Usability Scale (SUS) and Short User Experience Questionnaire (S-UEQ). Both questionnaires showed very good acceptance of the tool by our teams, with scores of 79.7 for the SUS and 2.014 for the UEQ. Finally, a learning curve was drawn up according to Wright, showing a learning curve of 91%. This study shows that the tool has been very well integrated into our preparation unit.

Keywords. Drug compounding, Chemotherapy, User experience, Learning curve

1. Introduction

Compounding of injectable cancer drugs is a high-risk activity for both the manipulator and the patient. Each establishment can equip itself according to its needs, by evaluating the advantages and disadvantages of each preparation and control method [1,2]. In the

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case of clinical trials, a great majority of standard control methods cannot be applied because of the lack of information on the active compound. Hence, the most frequent used control method is double visual inspection process, which is considered both unreliable and requires considerable human resources [3]. In response to these challenges, our unit has been developing and implementing since March 2022 a new preparation and control tool through an augmented reality eyewear technology. This tool is based on the AR CHIMIO® application, which generates a visual support providing step-by-step preparation instructions to the user, while also enabling recording photos during preparation. The steps generated by the application vary according to the required final packaging type and dose. This tool is completely voice controlled and instructions can be read on a small screen located near the eye. By scanning the data matrix, the eyewear can verify that the correct components were used compared to the expected ones. A pharmacist will then review the photos and steps that were recorded to validate that the preparation has been carried out correctly. This new preparation method eliminates the need for double visual inspection process, thus reducing the need for human resources during production, while ensuring safe preparation by guiding the operator [4]. Since March 2022, over 4,000 preparations have been prepared using augmented reality eyewear for the compounding of injectable experimental cancer medications in clinical studies.

This work focuses on the adoption of the augmented reality eyewear by the clinical trial compounding team made up of 13 compounders and 3 pharmacists. This article presents the score of two questionnaires designed to assess the perceived usability of the glasses and the user experience, as well as the learning curve associated with the glasses.

2. Methods

2.1. Evaluation of user experience and perceived usability of the tool

Two surveys were set up to more accurately gauge the team's perceived wearability and user experience of the glasses, one for new trainees and one for the entire team.

The French version of the System Usability Scale (F-SUS) was used following user training. This quick questionnaire has the advantage of being applicable to a wide variety of products, is highly sensitive and is generally applied after only few test scenarios have been run [5]. The score is calculated on 10 items rated from 1 to 5 (strongly disagree to strongly agree). Scoring is done on a scale of 0 to 100, ranking from the worst imaginable to the best imaginable experience. The user experience was evaluated on the whole team using the Short User Experience Questionnaire (S-UEQ). This questionnaire was selected due to its ability to gauge the user's subjective experience of the tool [6,7]. The S-UEQ consists of 8 items rated from -3 (very poor) to + 3 (very good), judging the user's feelings about the tool's hedonic and pragmatic qualities. A 95% confidence interval according to Student's law for each item on each form was calculated to determine the potential margin of error of the rating.

2.2. Assessing the learning curve

The CHIMIO® software was used to extract the preparation times for preparations made using the eyewear, from March 2022 to March 2024. Only one sort of preparation—which was already regularly carried out in the unit before to the introduction of the

eyewear—was examined to illustrate the evolution of compounding times. The average time to complete a preparation step was calculated for all operators. The evolution of preparation times was modeled using a scatter plot. Wright's learning percentages were calculated [8]. Learning theory states that repetition of the same operation leads to a reduction in the time or effort devoted to that operation. If the rate of improvement is 20% between each doubled quantities, the factor called learning percentage will be 80% (100-20 = 80). A high learning percentage means that the tool is quickly mastered.

3. Results

3.1. Evaluation of user experience and perceived usability of the tool

At the end of each training session, new trainees were asked to complete the F-SUS questionnaire in order to provide feedback on how well they had adapted to the tool. Eight operators answered the survey.

Table 1. F-SUS form answer

Question	Mean [CI95%]
I thought the system was easy to use	4,5 [3,87 ; 5,13]
I found the various functions in this system were well integrated	4,5 [4,05 ; 4,95]
I would imagine that most people would learn to use this system very quickly	4,25 [3,38 ; 5,12]
I felt very confident using the system	4 [3,37 ; 4,63]
I think that I would like to use this system frequently	3,5 [2,73 ; 4,27]
I think that I would need the support of a technical person to be able to use this system	2,25 [1,66 ; 2,84]
I needed to learn a lot of things before I could get going with this system	2,125 [1,43 ; 2,82]
I found the system very cumbersome to use	1,75 [1,16 ; 2,34]
I found the system unnecessarily complex	1,625 [0,86 ; 2,39]
I thought there was too much inconsistency in this system	1,125 [0,83 ; 1,42]

The mean score calculated for acceptability was 79.7/100 (CI95= [70.3;89.6], α=5%).

To assess the team's user experience on the use of the eyewear, the S-UEQ form was sent to all team members who had performed at least 10 autonomous preparations. Nine operators responded to the survey.

Table 2. S-UEQ form answer

Related item	Mean	CI 95%
Pragmatic qualities		
Obstructive / Supportive	1,6	[0,893 ; 2,218]
Complicated / Easy	2,1	[1,505 ; 2,717]
Inefficient / Efficient	1,9	[1,200 ; 2,578]
Confusing / Clear	2,3	[1,871 ; 2,795]
Hedonic qualities		
Boring / Exciting	1,8	[0,993 ; 2,563]
Not interesting / Interesting	2,2	[1,678 ; 2,767]
Conventional / Inventive	2,3	[1,871 ; 2,795]
Usual / Leading edge	1,9	[0,998 ; 2,780]

On average, Pragmatic qualities were rated 1.972 (CI95= [1.522;2.423], α=5%) against 2.056 for hedonic qualities (CI95= [1.509;2.602], α=5%) making an overall rating of 2.014 (CI95= [1.581;2.447], α=5%) for the tool. The estimated precision of these ratings is 0.5, with a relative error of 0.1 due to the small sample size.

3.2. Assessing the learning curve

Preparation times were extracted for the period 03/03/2022 to 03/03/2024. Isatuximab is the clinical trial drug selected for time analysis. During the study period, 13 different operators prepared 734 preparations. The operators carried out between 13 and 134 preparations, each comprising 7 to 14 steps, depending on the dose manufactured. Preparation times ranged from 1 to 17 minutes. This wide array of time is due to events that may occur during production but are not related to the preparation itself (i.e. need for material input). The average time taken to complete a step was calculated for each preparation, for all operators combined, and ranged from 0.31 to 0.87 minutes. The evolution of step completion times follows a logarithmic progression as the manipulations progress.

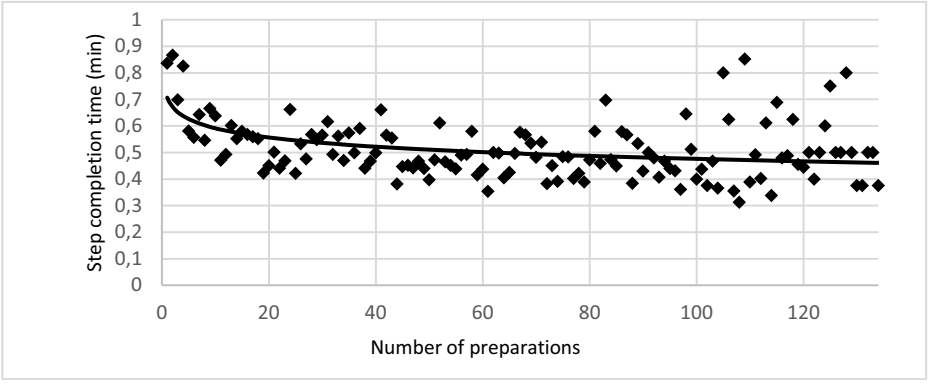

Figure 1. Average time taken to complete a preparation step as each manipulation is carried out

Analysis of the Wright learning curve allowed us to estimate a learning rate of 9%, which means that each doubling of the number of repetitions reduces the completion time by 9%.

4. Discussion

In order to ensure clinical trial compounding, our team uses augmented reality eyewear on a routine basis. Although this type of preparation only accounts for 9% of our total production, it requires more control and often involves complex handling instructions from sponsors. This device is designed to reduce the risk of error by guiding the operator step by step, but further investigations are needed to evaluate its impact on the error rate. The F-SUS post-training results show overall satisfaction, with some reservations about the time required for tool adoption. Augmented reality eyewear is ranked as excellent by the S-UEQ, which offers an internal benchmark for comparing the product against a database of 452 other products. Regarding the hedonic qualities, the tool is perceived as highly stimulating and innovative, attracting the attention of users and making them want to use it. Regarding pragmatic qualities, the tool is perceived as relatively efficient and can be mastered quickly. The limited number of participants in this monocentric study could lead to bias in the results of the F-SUS and S-UEQ questionnaires and require more data, which will be collected as recruitment progresses. The learning curve, described by Wright as 91%, demonstrates a rapid grasp of the tool. Aside from training purpose, this

model is scarcely described in the pharmaceutical field [9]. To our knowledge, there are no other studies on the pragmatic use of the augmented reality technology in a pharmaceutical production unit. However, it is widely used in industry, where its adoption is considered to be around 80% [10]. Moreover, the technology is also used in the medical field to assess the learning curve for procedures with more variable proportions [11,12].

5. Conclusions

In addition to safety and traceability benefits, this study highlights the augmented reality eyewear tool's ease of adoption by pharmaceutical teams, and a short learning curve. In the future, this innovative technology will be carried out to other field of hospital pharmacy compounding such as reception and thawing of CAR-T Cells.

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