

# Visual Feedback from a Virtual Coxswain to Improve Engagement

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## ABSTRACT

During the pandemic training on your own has become the norm. This research will look at a system that helps improve the engagement of rowers on the ergometer. This research contains 3 main steps. The first is to identify the needs of the rowers by using a survey and doing interviews. The second step is to gain knowledge about the impact of visual and auditory feedback. This is done by a literature study. The last step is to combine these findings into a prototype and evaluate this. From the interviews and the survey, the most important finding was to keep it simple and clear. The rowers would like to get visuals as well as textual feedback and have the opportunity to look into previously done trainings. The literature study acknowledges these findings. Feedback has a positive effect as long as it is simple and clear. The prototype was made with almost all the requirements from these findings, only the voice was left out. The Evaluation was done with the User Engagement Scale-Short Form. The system overall scored a 3.6 out of 5. The Focused Attention scored the lowest with a 2.8 followed by the Aesthetic Appeal with a 3.7. The Perceived Usability and Reward Factor scored the highest with a 3.9. These results indicate that the system would engage well with the user. The low score of Focused Attention can be influenced by the environment that the evaluation was done in. Therefore, future studies must be done. These studies should evaluate the system while using it during an ergometer workout.

## Keywords

Rowing, Coxswain, Virtual Feedback, Ergometer

## 1. INTRODUCTION

Rowing has been a popular sport for a long time. In 1839 the first Henley Regatta<sup>1</sup> was held and in 1878 the first Varsity<sup>2</sup>. Both regattas, one in the United Kingdom and one in the Netherlands, are very popular and highly visited. Last year both races were cancelled and indoor rowing became much more popular. Every year the Dutch royal ergometer championships (NKIR)<sup>3</sup> are held. In 2020 the events were completely online and a lot of rowers had trained for this individually. Due to the pandemic, the need for individual training has grown exponential. This change has caused a higher demand for virtual help whilst training. This paper will focus on the proposal for research that will focus on helping rowers during trainings on the ergometer.

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<sup>1</sup> <https://www.hrr.co.uk/about/history/>

<sup>2</sup> <https://knsrb.nl/varsity/historie/>

During the past 3 years, I have been active in the rowing community. All of these years I have been a rower as well as a coxswain. Being a coxswain started in a freshman boat for fun, but evolved into being a coxswain in a competitive boat and getting training from other coxswains. During these years I have noticed the influence of a coxswain in and outside the boat. A coxswain has a much larger influence than just telling the rowers what to do. For example, they help with motivation and the atmosphere of the crew.

There has been done quite extensive research on rowing. Most of them have focused on virtual rowing [1, 9, 14, 15, 18, 22-24, 27]. But none of them have looked at it from the view of a coxswain. There has been research about the influence of auditory feedback. However, none of these papers have looked at what rowers need and want [6, 19-21]. This research will focus on the needs of rowers and will take the experience as a coxswain into account. These focus points will make this research essential for the development of a virtual feedback system.

In the end, this research will have contributed in multiple ways to the development of a virtual feedback system. The first way is the discovery and formulation of the needs of a rower for a visual feedback system. This will be done by a survey and interviews with rowers with different levels of experience. A literature study will help to understand the influence of visual feedback. Secondly, a system will be designed that tries to maximize engagement. The result will be in the shape of a prototype that will be evaluated. Following the evaluation, the design can be rated on a scale of engagement.

This research will first contain the basics of rowing. Here the basics of the stroke will be discussed as well as often made mistakes. The job and influence of a coxswain will also be discussed and the ergometer will be explained. Furthermore, the needs of the rowers are discussed, which can be found in the survey and the interview. The known influence of visual feedback is discussed followed by the design and evaluation.

## 2. BASICS OF ROWING

It is important to understand and establish the rowing stroke and the mistakes made before reading this research. This research does not only focus on the rower but also on the coxswain. The calls that are often used are gathered and the most important ones are discussed. This research will focus on the use of the ergometer and therefore the focus will be mostly on the stroke made on the ergometer. For this research, the Dutch rowing stroke is kept in mind. The rowing stroke is explained by the help of the local rowing association D.R.V. Euros [10], the national rowing association KNRB [16] and the student rowing association from Wageningen W.S.R. Argo [4].

<sup>3</sup> <https://www.nkindoorroeien.nl/>

## 2.1 The rowing stroke

A single rowing stroke consists of 4 main steps. The Finish, the Recovery, the Catch and the Drive. To explain the rowing stroke correctly we will explain every step with the guidance of Figure 1.

**The Finish:** This is often used as a starting position for the training. The arms are close to the chest and at the height of your midriff. The legs are straight. In this position, it is important to keep your abdominal muscles flexed such that your back is straight and your shoulders are behind the bench. It is important to keep your elbows pointed outwards and your shoulder blades pushed together.

**The Recovery:** This stage is used to prepare for the Catch. From the Finish position, you will straighten your arms and then bend your back forward from the hip. The position of your back and hips will not change after this moment. These 3 steps are called the steps or in Dutch “stopjes”. The first step is the Finish position, the second with only the arms straight and the third with the back bend as well. After you bend your back, you bend your knees and slide towards the Catch. When your shins are vertical and your heels just left the footplate, you are ready for the Catch.

**The Catch:** This stage is the spot you end the Recovery in and is used to start the Drive. It is important to keep your shoulders a little bit before your bench and your arms fully stretched. Your core should be flexed. Your chest is allowed to touch your legs as long as it is the position that you keep during the stroke.

**The Drive:** The Drive consists of the same steps as the Recovery, but in reversed sequence, so this stage consists of a leg push, after this your hips bend back and your arms follow. To start the legs push off on the footplate, your posture should not change. Your bench and shoulders should move at the same speed, but your shoulders should stay before the bench. When your legs are about  $\frac{3}{4}$  done the hip can be used again. The bend of the hips and the legs should be done at the same time. After this, the arms can come back to the Finish.



Figure 1 The rowing stroke by A. Bond [3].

## 2.2 Common mistakes

The rowing stroke can be quite complex and a lot of problems can be made. For this research, it is important to identify them and link them to a stage. The information about often made mistakes come from own experience, the KNRB [16] and interviews with a rowing coach that were done by Sascha Bergsma [2].

**The Finish:** It is important to keep your core straight, this is commonly forgotten. People will sit slouched or won't engage their core enough. This can cause pain in the lower back, which is a common place for injuries. This mistake is not only made during the Finish but can be made during the entire stroke. Furthermore, the height of the handlebar is not high enough. The handlebar needs to be at the height of your midriff.

**The Recovery:** A common mistake in the recovery is that people speed towards the Catch. The Recovery should be twice as long as the Drive. This mistake can cause other mistakes such as catching more length in the Catch. It can also cause that the rower does not go through all the steps of the Recovery well enough. This means that the hip swing and the arms are not done in the correct order or not done at all. This leads to the wrong position to start the Catch.

**The Catch:** In this stage, there are two main issues. The first one is about catching more length in the front. This can be done in two ways. The first is bending you back more once you have arrived in the Catch and the other is moving your shoulders further forward than necessary. Furthermore, a common mistake is to not have the shins vertical at the Catch. This makes it harder to push at the start of the drive.

**The Drive:** It is important to always keep pushing on the legs in this stage. At the start of the Drive, it is important to push directly. It needs to feel like you are pushing yourself off the ground, this is also why it is called to jump. Not only pushing in the beginning of the stroke, but throughout the entire stroke is important. During the Drive, the back is often done too early or not at all. The strong core as already mentioned is important during the whole stroke, but when this is not done properly during the Drive you can push and you will fly off your bench.

These are the most important mistakes that are made when people start rowing. The rowing stroke can always be optimized and will never be perfect. For this research, it is important to keep these errors in mind and focus on how to improve them. We will use these points to build a system that could help the rower to improve their technique and increase engagement. These Points of Interest will form the basis of the information that will be in the system and they will be the basic form of the feedback in the system.

## 2.3 The coxswain

The previous part has been more focused on the rowers themselves, but in this research, the coxswain is just as important. The information about a coxswain was gathered by using autoethnography.

A coxswain sits in the boat and guides the rowers. The job of a coxswain is to keep the boat straight and guide it over the water. More important is that the coxswain has to keep track of the surroundings. Making sure the boat does not bother others. In a race, this also includes the competitors. The coxswain is also responsible for keeping track of time and making the race plan. Furthermore, the coxswain is the coach in the boat and often the mental support for the crew.

A coxswain can help the crew by giving different calls. A call can be an exercise, like a push, or can be the support to help rowers perform better. In this research, we will focus on the second type. There are two ways to communicate with rowers. A call can be short or long. Short calls, calls that use 2 words, are used in the Catch and Finish. Longer calls can be given at any time. Furthermore, calls can be further divided into 3 categories, focusing on technique, focusing on power or general encouragement and rhythm guidance. The ones focusing on technique can be further divided by the stages of the rowing stroke. This will however create a lot of overlap. All the calls are connected to some of the technical phases, power or rhythm and encouragement. For this research, the focus will be on the technical calls. The most important ones for this research are directly translated and discussed. The short calls will be used as a text in the design and the long calls will be translated to pictures.

As discussed in the previous section common mistakes are made. To prevent these types of mistakes or to fix them, calls are made in the boat. The calls are for the part of the technique that is linked to one of the 4 stages of the stroke.

A mistake that can be made during the entire rowing stroke is to forget to flex your core. For this specific mistake, multiple calls are often made. The most used one is “core strong”. This call is easy to understand and embodies the essence of the job for the rower.

To help improve the height of the handle in the finish “bring high” is often used call. This call is short and can often be used to bring the attention back at the Finish.

During the Recovery often longer calls are made. Calls about the Recovery can be made during the Drive or during the Recovery itself. Most of the calls will be about the speed driving up, an example is “slow to the Catch” these calls will mostly be said during the Recovery. If the order of the Recovery is not done properly calls such as “behind your arms” or “together to step 3” can be made.

Calls for the Catch can be made during the Recovery or during the Drive. “Shoulders relaxed” can be made during the Drive to prevent catching more length in the front. Often calls “do not reach further” will be made at the moment of the Catch.

“Legs straight” is often used during the Drive to indicate to keep pushing, but also “jump in the front” and “long with” are used to indicate to jump in the front and keep pushing in the back.

The power category has calls that give a push, which is an exercise to increase power and speed or can be used as a reminder to push through the pain. The pushes are not considered in this research and we will focus on the rest.

A call can be anything a coxswain wants to say, but a good call is harder to make. A good call needs to be short and easy to understand for the rowers. Coxswains often use words that indicate where the improvement needs to be and how. Calls are often repeated and are focused on the focal point of that training.

## 2.4 The ergometer

There are different types of ergometers. The two most important ones are a static ergometer and a dynamic ergometer. A dynamic ergometer has a bench that stays still and the machine moves. A brand that makes this kind of ergometers is RP3. For this research, we will focus on the static ergometer, which is often called ergometer or erg. The most important brand for this is Concept 2. We chose to focus on this ergometer. This choice is made because Concept 2 is most commonly used. Furthermore, the RP3 requires a lot more previous knowledge of rowing.

The Concept 2 rowing machine is static, this means that the machine stays in the same place and only the bench moves. Concept 2 consists of a screen that can show you different information. The information that can be shown is the pace, the distance, the expired time, the speed, burned calories and the wattage [5]. The pace is the number of strokes done per minute and the speed is measured in time that it will take to do 500 m, which is also called the split time. In Figure 2 all of the possible screens are shown.

The first screen shows all the data that is mentioned above. The second screen shows a curve to display how much a person pushes during a stroke. It is important that it goes up quickly but goes down slower. This screen can always be seen during training and more experienced rowers can use this to improve their technique.



Figure 2 The concept2 Screens [5].

## 3. PROBLEM STATEMENT

Rowing has been a popular research topic. There has been a lot of research on integrating intelligent interaction in rowing. However, all of these did not identify the need of the rowers. Most of these papers were focused on rowing and improving performance. Some of them looked at the engagement, but none did this in a way of a virtual coxswain. In this research, the focus will be on identifying the features that are important for rowers. The features will contain the functionalities (physical aspects) and the design aspects. Furthermore, the impact of visual as well as auditory feedback will be discussed. These will help to understand the influence of a visual coxswain. These findings will help to develop a prototype, whose goal is to improve engagement.

### 3.1 Research Question

This problem statement can be solved by answering the following research question:

How will a system look like that uses visual feedback in the form of a virtual coxswain to help rowers engage more on the ergometer?

This research question has the following sub-questions:

1. What are some physical and design factors that affect the engagement of a rower on the ergometer?
2. How does visual and auditory feedback impact the rowers and what are their impacts?
3. How will these findings be combined into a prototype and how do users react to this system?

### 3.2 The Approach

To answer the research, question the following approach will be followed, to answer the first question a survey will be done to gain features. Furthermore, 5 interviews will be done with rowers with different experience levels to gain more features. The second question will be answered by reviewing literature about auditory and visual feedback. The features and factors will be combined into a system. This system will be evaluated by the User Engagement Scale – Short Form. The design will be rated on a score of 1-5 by using the evaluation.

## 4. IDENTIFYING ROWERS' NEEDS

To gain information about what rowers will need in this system qualitative research was done by a survey and an interview. The survey was answered by 30 participants and 5 interviews were held. All of the participants are members of the local rowing association D.R.V. Euros. The survey focused on the overall opinions about the system. The interviews were held to gain a little bit more insight. The survey was analysed and from this a list of features rose. The same steps were used for the interviews.

### 4.1 The survey and responses

The survey consists of four different sections. The first was about their rowing experience, for this the participants were divided into 3 groups. The first group was the group with the

least amount of rowing experience. People who just started recreative rowing or 1-year recreative rowing experience. The second group were people who have 2 or 3 years of experience in rowing. This can be multiple years of recreative rowing or one-year of competitive rowing. The last group consisted of people who have done multiple years of competitive rowing. Or have more than 4 years of recreative rowing experience. For this research, the main focus will be on group 2 because they will benefit the most from the proposed system.

The second section is about their experience with erg training. It focuses on the likes and dislikes of an ergometer training. The most favourable aspect of a training on an ergometer is that it gives direct feedback of how well you're performing and that they like doing sprints. The dislike is mostly about a long session that focuses on technique. During erg training, they mostly focus on performance or technique and performance.

The third section is about the use of the proposed system. The results are summarized below.

- 70% of all participants are interested in this system, in group 2 that number is 60%.
- 5 people are unsure if they would use the system and wanted more explanation.
- Feedback is wanted by the participants on technique, rhythm and power. One person wanted feedback on posture and another on stroke length.
- The step that needs the most improvement according to the participants is the catch, followed by the drive and finish. One person wanted to improve their hipswing.
- The participants think that their technique would be most influenced followed by rhythm.
- Stamina, power and likeability will be less influenced according to the participants.
- 27% of group 2 believe the system would increase their use of the ergometer and 47% is unsure.

Overall, the system was well received. There were no results that were very different from the other answers. Most of the results were clear and the preferences were clear to see.

The last section focused on the design of the system. First, a small explanation is given and then a choice could be made out of 3 options. Only text, only picture or both. The used example can be seen in Figure 3. 90% wanted a combination of text and picture. In group 2, 87% wanted a combination of both. When asked to explain their answer most answered that it helps to visualize and understand. One answer that clearly explained it said that the picture helps you visualize it and the text should represent how it should feel. Besides text and visual, another design point that should be kept in mind is that it should be easy to understand and not too much on the screen. Another suggestion was adding a voice. In the system, there should be an option to elaborate on the point and set specific focus points.



Figure 3 Design examples given in survey[4]

#### 4.1.1 Features found from the survey

From the results as explained before we can conclude that most are willing to try the proposed system and the focus should be primarily on technique and rhythm. They are not yet convinced that the system will get them to do more ergometer workouts. The focus on Catch, Drive and Recovery is most relevant to the

participant, but the Finish is also important. For the design, a combination of text and visual is preferred, but it should not be overdone. From the results, we can make a list of requirements that would need to be implemented in the proposed system. In table 1 a list of the requirements is made. These requirements are taken from the survey results. They include the feature and explanation of the requirement. The third column shows how important a feature is. How frequent something is mentioned, the more important it is. The importance is measured on a scale from 1-5, where 5 is the most important and 1 the least.

Table 1 Founded Features from Survey

Feature	Explanation	Importance
Textual feedback	Represent the feel, easy to understand, short	5
Visual feedback	represent how it looks, simple, easy to understand, colours	5
Focus on technique	focus on technique and most on the Catch	4
Adaptive	Adaptive focus point to personalize	4
Focus on Rhythm	focus on the rhythm of the stroke.	3
Elaboration on feedback	elaborate on points during breaks	3
Storage of training	Ability to see past trainings	2
A voice	A voice that repeats the text, like a coxswain	1

#### 4.2 The interviews with rowers

In total five interviews were held. The interviews are used to get more information about how the system should look like according to the rowers. The interviews were held to gain more insight into the survey results. Each interview is held with someone with a different experience level. During each interview, their experience is established and their opinion on rowing and ergometer is discussed. The system is explained, after this their opinion on the system is discussed. For each interviewee, a summary will be given. All of the participants will remain anonymous and will be called gender-neutral pronouns to preserve their identity.

The experience of the first year recreative rower is one year of "comproeier", which is the specific field for first-year student rowers. The interviewee has trained about 1 or 2 times a week. In the winter they did some ergometer training but now are mostly training in the boat. They want to start rowing more on the ergometer again. They actually like the ergometer because they can let go and push to the max. The ergometer also discards the distraction of the boat such as clipping the blades or disbalance. The interviewee would use the system because it gives more insights. For them, it should focus most on the technique specific to the Finish and Recovery. They like the idea of visual and text and saw the system using a green and red picture to easy indicate right or wrong. They believe this system would make it more likeable to use the erg but also would improve their technique. For the system to work they believe to keep it simple and only use one screen next to the screen that is already there. If this is kept in mind, they believe the ergometer would become more accessible and more fun.

The next interview was done with a recreative rower. They have rowed for 3 years. They train 3 times a week on the RP3. In the boat, they train 2 or 3 times a week. They have spent about 50 hours on the ergometer this year. And all of them without a coach. They like that they train their conditions but think it is a bit boring. They would like to get feedback on their technique and especially the correct execution of the stages. They would like to see the visual aid on their technique during the whole stroke. This needs to be clear and still be able to see the screen of the ergometer. The system should be added to the original system and not replace it. The screen should be small.

This interview was with a person who did one year of competitive rowing. They did one year of “comporeicien” and one year of club rowing. In their second year at Euros, they did lightweight rowing. They now train 4 times in the boat and 3 times on an RP3. All of these hours are without a coach but they have a training schema from the RP3. They like that you see feedback quickly, but they think it is boring. They would like to see visual feedback, a picture and text. This should be focused on the technique, especially their hip swing and their position. They would like to see their data and recommendations. It should be done with sensors. The feedback should be given constantly and simple. Furthermore, they think it should be easy to use and understand. This would make the system more accessible for inexperienced rowers.

The fourth interview was with a competitive rower with multiple years of experience. They started with 2 years of recreative rowing, followed by 3 years of competitive rowing. They train about 9 times a week, which consists of 7 times in the boat and 2 times strength training. They have spent about half a year, three times a week for 1,5 hours per session on the ergometer without a coach. They mostly train their performance and do not focus much on technique. They believe the erg is nice to train technique when the boat is not working. They believe that it would not add to their training, but could be interesting for starting rowers. They believe visual aid would help the most but it should be clear and simple.

The last interview was with the coach of a freshman competitive crew. They have rowing experience; they were a freshman competitive rower and have done recreative rowing for a year. They train once a week and have done one erg training this year. This interview was more focused on the performance of rowers they coach rather than their own experience. They believe it would help with the technique and make it more fun. Most important is that the system should be readable during the training. Furthermore, it should be quite simple and repeatable. They would like to see past trainings and what their feedback was.

#### 4.2.1 Features found from the interviews

From all the interviews we can conclude that a variety of rowers believe that the system would help group 2. Overall, they believe the system should be simple and easy to use. The focus should lie on the technique and use that to improve the engagement. During the interviews, we focused on how the system would look like and what needs to be in the system to get the ideal outcome. Some physical features include that the system needs to be small and can be added to the existing screen. This leads towards the idea of a smartphone and an app design. These are summarized in table 2. From these requirements, we can get features for the system and their importance. In the second column, the features are explained and additional information and specific requirements.

**Table 2 Founded Features from Interviews**

Feature	Explanation	Importance
Textual feedback	Easy, Short sentences	5
Visual feedback	Simple, Easy to understand, colours, Numbers, View the ideal stroke	5
Focus on technique	focus on technique to increase performance	4
Adaptive	Adaptive focus point to personalize	4
Repeatable	reproduce feedback in different ways	3
Elaboration on feedback	Elaborate on focus point when not training	3
Storage of training	Past training point can be seen	3
Recommendations	Give recommended training	2

## 5. INFLUENCE OF FEEDBACK

To understand more about what will impact the needs of rowers and how this will impact them, a literature review is done. This review was focused on getting a quick idea about how feedback affects engagement and performance. There is already a lot of research on the effect of feedback on rowers [1, 6, 7, 9, 11-15, 17-27]. Overall, the performance is positively affected. There are different types of feedback, each type has a different influence.

One type of feedback is auditory [3, 19-21]. The impact of the natural sounds of a rowing boat is essential to rowing. The lack of sound in the boat can negatively affect the rower and its performance [21]. Sonification can help the rowers perform better in the Recovery [19, 20]. Not only auditory feedback but also visual feedback can help rowers.

In this study, we will mainly focus on visual feedback. In a study by Kojic et al [12], it is found that too much visual information can be distracting, but simple visuals can help a rower improve their technique. The focus of this study was on breathing. When the focus was on breathing the technique was less accurate. Overall, the visual feedback helped by positively impacting the performance of the participants. Not only this study gave positive results on the use of feedback. In a different study, a comparison was done between a traditional workout and one with VR. The VR improved the rhythm and breathing during the stroke, which is essential to rowing. The participant mentioned that their concentration on the traditional workout was higher. They felt that they were able to concentrate more on the technique, however, the technique metrics did not show any difference. In another study, the focus was on haptic and visual feedback. The haptic feedback increased the synchronicity of the rower, the visual feedback was not able to do this. However, the visual feedback was rated higher in almost every aspect of the User experience. Furthermore, the visuals also decreased the workload according to the participant. Overall the visual was rated very high, but the complexity made synchronizing harder [7].

In the following study the focus was less on their performance, but more on the engagement. In this study, a comparison between rowing on an ergometer with and without Virtual

Environment (VE) was made. There were two ways to create the VE, one was the Head-Mounted Display (HMD) or the Cave Automatic Virtual Environment (CAVE). Participants rowed for 3 minutes and were asked to fill in a questionnaire. From this questionnaire the results were clear. Both of the systems showed that their use results in a richer overall experience and more engagement. This came from the increased flow and presence that the user experienced. All the participants would recommend the systems and had an increase in motivation, which was caused by the increased sense of presence [22].

Overall, the virtual system has a positive effect on the rowers' performance as well as their engagement and experience. There are some downfalls of the system that should be kept in mind. The system should not have too much information as it can be hard to process. This can lead to distraction of the tasks. This does not necessarily lead to a negative impact on the performance, but it can lower the experience rate. The most important takeaway for the design is to keep it simple.

## 6. THE DESIGN

From the previous results, a design was made. The design was made as an app that would be able to connect to sensors on the ergometer. The app consists of 3 main screens, which can be seen in Appendix A. The home screen, the profile screen and the past training screen. Under the home screen, the focus of the training can be found. The choice is on Recovery, Catch or Finish. When the training is in the middle of the screen it is chosen and the start button can be pushed. A get ready screen is shown to tell you to follow the red and has an indicator for the sensors. After this, one of three calls is shown. This can be "arms first", "shoulders relaxed" or "arms higher". These screens will go blank after 2 seconds and will reappear after 1 second. This is to represent that it only shows in the Recovery. Under past training, the trainings are shown with the given feedback. On the profile page personal information can be found as well as Points of Interest and a recommended focus based on the Points of Interest. The Points of Interest are parts of the technique that can be improved, for example, strong core.

### 6.1 The evaluation

This design was evaluated by using the User Experience Scale Short form (UES-SF) [8]. This form consists of 12 questions that can be divided into four categories. Each question gets rated on a scale that rates from 1-5 and have the following description: strongly disagree, disagree, neither disagree nor agree, agree, strongly agree. The four categories can be explained as:

- FA: Focused Attention, which rates if the person feels lost in the experience and as if time is slipping away
- PU: Perceived Usability, which rates the negatively affected experience caused by using the system
- AE: Aesthetic Appeal, which rates the visual appeal of the system
- RW: Reward Factor, which rate the Endurability, novelty and the felt involvement

Each category has 3 questions that are made to get an overview of the overall system. The questions are derived from the proposed short form made by H.L. O'Brien et al [8] and can be found below.

FA-S.1	I lost myself in this experience.
FA-S.2	The time I spent using the feedback system just slipped away.
FA-S.3	I was absorbed in this experience.
PU-S.1	I felt frustrated while using the feedback system.
PU-S.2	I found the feedback system confusing to use.
PU-S.3	Using the feedback system was taxing.
AE-S.1	The feedback system was attractive.
AE-S.2	The feedback system was aesthetically appealing.
AE-S.3	The feedback system appealed to my senses.
RW-S.1	Using The feedback system was worthwhile.
RW-S.2	My experience was rewarding.
RW-S.3	I felt interested in this experience.

### 6.2 The results

The evaluation was done by a questionnaire that consisted of the UES-SF and two other questions that focused on what the participant would like to see to improve the system. In total fourteen participants participated and twelve of them had the right rowing experience. To get the results the rates were added per question and were divided by the number of participants which was 12 for this study. For the category PU, the answers are reversed, this is because the statements are negative. Below the results per question are shown.

FA-S.1	2.4	Disagree (2)
FA-S.2	2.8	Neither disagree nor agree (3)
FA-S.3	2.9	Neither disagree nor agree (3)
PU-S.1	4.2	Agree (4)
PU-S.2	3.8	Agree (4)
PU-S.3	3.9	Agree (4)
AE-S.1	3.8	Agree (4)
AE-S.2	3.6	Agree (4)
AE-S.3	3.7	Agree (4)
RW-S.1	4.0	Agree (4)
RW-S.2	3.7	Agree (4)
RW-S.3	4.1	Agree (4)

From these results, we can see that the first question was rated the lowest. When a result is rounded to a 4, the system is doing well. "Neither disagree not agree" means it is not acceptable yet and "disagree" means that it need to be improved. The highest rate is 4.2 for PU-S1.

For each category, the total of the rates was divided by the number of questions, which is 3 for each category. To get the final result the scores are divided by the number of participants. The results are summarized below.

FA	2.8	Neither disagree nor agree (3)
PU	3.9	Agree (4)
AE	3.7	Agree (4)
RW	3.9	Agree (4)

The results show that the Focused Attention still needs work, the other categories are performing well. Overall, the system scored a 3.6, which means that overall, the system would get an "agree" which indicates that the system does engage with the user.

The first open-ended question focused on the effect the system had on using the erg. Most of the participants believed that the system would help to keep them focused on the points that they were working on. One participant liked the system because they could accept the feedback better as it did not feel if they were in the wrong. The second question focused on how the system could be improved. Most of the participants wanted to have more focus points to choose from. Furthermore, an idea of a voice was mentioned several times. Another answer was that the background colour could change to indicate how the user was doing.

## 7. DISCUSSION

To understand the final results, it is important to know some choices and assumptions that were made. From the first survey and interview, the choice was made to focus on group 2. Which does not contain rowers with one year of experience. However, during the evaluation of the design, they were kept in mind. This choice was made because in the time span between the survey and evaluation most of the first years at D.R.V. Euros have passed their first rowing exam. Another way the results can be influenced is by the time of the year that this research was held. The winter is normally the ergometer season. This can cause that fewer people thought about using the erg and that could have influenced the likeliness that they would use this system. In the results of the survey and interview, no outliers were found. The choice to focus on group 2 was made from these results as the first-year rowers had too little experience with the ergometer due to the coronavirus and more experienced rowers did not believe it would help as they have the knowledge themselves already. However, their interview is used to gain knowledge about rowing and what may help the less experienced rowers.

During the literature review, a lot of researches were found. Most of these researches were done in a controlled environment. It should be kept in mind that the effects of virtual feedback will differ in a busy workout room. The results of the literature review were compatible with the results of this research. From the literature review, it was expected that a system would get a relatively high score. The most important takeaway was to keep it easy to understand and simple. The perceived usability was quite high. From this, we can see that the usability was scored high. There are no significant differences between the literature results and the result of this research.

All of these results were taken into account to make the design. It was important to first gain the features and requirements from the rowers and previous research to get a design that would have an effect, but also fit the needs of rowers. The design was made with Figma<sup>4</sup>. The colors were based on multiple rowing organizations, such as world rowing<sup>5</sup>. The design was influenced by other sporting apps and rowing apps. The pictures from the feedback were made by using RowAnimation<sup>6</sup>. During the design phase, constant changes were made and these changes were discussed with colleagues and rowers.

The evaluation was done by using the short UES-SF instead of the normal UES. This choice was made to keep the evaluation short to keep people from stopping halfway. The Short Form still gave a good first indication of engagement. From these results, we can see that the FA, Focused Attention, scored low.

This category was influenced by how the engagement was done. The participants got a link to the design and were able to look through the system in their own time. Normally the design would be used during a heavy workout and distractions would be lower. The participants said in the open questions that the system would help them focus more, which is interesting as they scored the FA a 2.4. The score could also be influenced by the type of questions asked.

### 7.1 Future work

To gain a better view of the design it is important to gain more knowledge. The first step would be to improve the recommendation that came from this research. This would include using the voice of a coxswain to add a voice to the system. The system needs to be extended and add all of the possible improvement points. Furthermore, the feedback screens can be improved by making the figure red and green, such that when you are doing it right you see a green figure. In the future, it is important to gain more insight into why and how the focused attention score low. This can be done by first improving the system and taking an engagement test after using the system while rowing. The evaluation can then be done by using the UES to have more questions about focused attention. The questions that might be unclear will have less influence. Furthermore, it is important to look at how the system would influence the performance of the rower. To get this information a study towards the use of sensors to gain the full stroke should be done and the system should be made. After this, a study can be done where inexperienced rowers train with a coach, without a coach and with the system. This study can be done by doing a test at the beginning of the study. The recommendation is to do a 2k and 20-minute test and compare the split times. During the study, it is important to keep track of the progress by doing multiple tests and making sure that they do not do other activities. Between these studies, it is important to keep updating the system to get the best design in the end.

## 8. CONCLUSION

In this research, the first goal was to identify what features rowers would like to see in the system. By using a survey and conducting interviews, a list of features could be established. The most important feature was to add visual as well as textual feedback. The feedback should be kept simple and clear. The system should be able to adapt to the user. Furthermore, it is important that past usage can be seen and that recommendations can be given. From the literature review, we can conclude that feedback has a positive impact on the engagement of rowers as well as their performance, as long as the system is simple. These findings were added to the design. The design scored pretty well overall on the UES-SF. It scored the best on the Reward Factor and the Perceived Usability. The Aesthetic Appeal also scores okay. These three categories score 'agree', which indicates that the system would be used. The category Focused Attention scores the lowest with a 2.8, which is towards the negative side. Overall, the system scored a 3.6. This indicates that the system engages with the user.

<sup>4</sup> <https://www.figma.com/>

<sup>5</sup> <https://worldrowing.com/>

<sup>6</sup> <http://www.rowanimation.zalmstra.nl/>

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# 11. APPENDIX

## A. The design

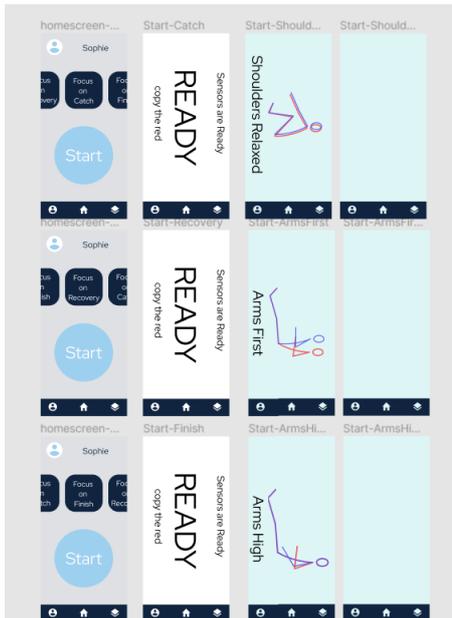


Figure 4 Home Screens and Feedback Screens

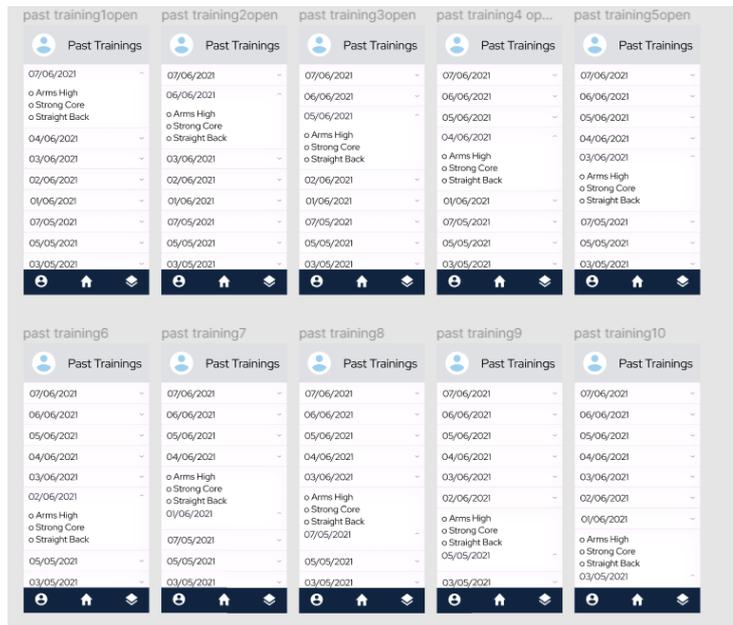


Figure 5 Past Trainings opened

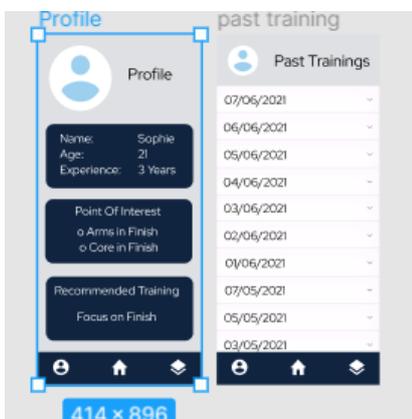


Figure 6 Profile and Past Training Screen

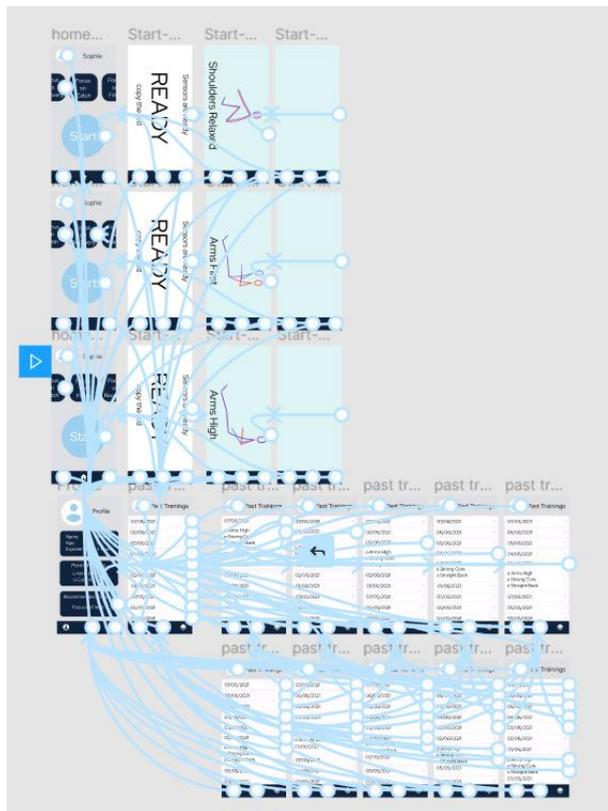


Figure 7 all the Connection of the Prototype