Programming a Web App for Patients Suffering from Fatigue

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Abstract

Fatigue patients often keep track of their energy level on a paper chart to plan their day and schedule enough rest time. The goal of this project was to find out whether I can create a web app that makes it more comfortable to use than the chart on paper. My web app allows users to enter their energy level after every activity and to display different charts showing the energy level throughout the day, week, month, or year. Additionally, the web app rates the activities based on their impact on the energy level which is calculated using all the user's entered data from the past month. The web app was tested by about 15 therapists who were referred to me by my therapist and about as many patients who found my web app on social media. The few feedbacks I received from therapists and patients, as well as my own experience, show that the web app offers a more efficient and practical way of tracking one's energy.

Preface

Motivation

I have suffered from chronic fatigue syndrome caused by COVID-19 since November 2020. In therapy, I had to fill out charts on a piece of paper to learn the pacing method. I wanted to get rid of the growing stack of paper and provide a better-organized solution. Nowadays, I think there should be a way to do that digitally. So, I wanted to create a web app as an alternative to those charts. It was also my intention to use the entered data to provide a better analysis than just one chart.

Acknowledgment

I thank Kathrin Hofer (dipl. occupational therapist at the Bürgerspital Solothurn) for connecting me with therapists and patients who tested the web app, Thomas Jampen for providing me with a web server, Noe Emch and Tobias Yoong for testing my web app for bugs, and everyone else who tested the web app and sent me feedback. I also thank Ralf Kretzschmar for supervising my project.

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1. Introduction

1.1 Fatigue

Fatigue is a symptom that appears in several illnesses, however, there are two types of fatigue: the one that improves with training and the one that gets worse if a patient is physically or mentally active. The former form appears for example in cancer patients whereas the latter version is common in illnesses like chronic fatigue syndrome or multiple sclerosis. There is no treatment or cure for the second form of fatigue. Every exertion can make it worse therefore pacing (see Chapter 1.3) is a big part of minimizing symptoms. For this paper, I am going to focus on chronic fatigue syndrome (CFS).

Fatigue is often used as a synonym for tiredness however those two terms are significantly different. Tiredness is something that everyone feels after an exhausting activity or day, but it is relieved by sleep. On the other hand, fatigue is constantly present and does not go away with sleep. [1]

1.2 Chronic Fatigue Syndrome

The Centers for Disease Control and Prevention (CDC) [2] describe CFS as an illness with no cure. People living with it are often extremely limited in what they are able to do compared to before getting CFS. Managing their day-to-day life can be incredibly challenging since any physical or cognitive activity can worsen one's symptoms. This worsening of symptoms is known as post-exertional malaise (PEM) or often called a "crash". Sometimes symptoms worsen immediately after the activity but occasionally it takes up to 48 hours. PEM can cause people to become housebound or even bedridden. Even though fatigue will not go away completely, resting is important to improve the symptoms and prevent a crash.

Apart from severe fatigue and PEM other symptoms might be sleep problems, difficulties with thinking (often called "brain fog"), headaches, muscle pain, and many more.

According to the CDC, it is not yet clear what causes CFS, but some assumptions are that it could be caused by a viral infection (like the Epstein-Barr or SARS-CoV-2 virus) or a change in the immune system. Scientists suppose that it could be genetically inheritable.

1.3 Pacing

Pacing is a strategy that fatigue patients use to manage their symptoms. The goal of pacing is to plan the day in a way that does not result in a crash. This means that patients need to

learn how to spend their energy so that it lasts for the entire day. To achieve that patients must plan a lot of rest time to recover. Making rest time as effective as possible is of essence, therefore one should understand what activities can help with gaining energy. However, that is just one of many aspects of pacing. Additionally, it is important to shorten activities or split them into several smaller parts. Furthermore, activities that drain a lot of energy must be avoided.

To teach this technique therapists often use printed charts (like the one created by H. Lorenzen [3], see Appendix 8.1). The idea of the chart is for the patients to write down what they have done and how bad their fatigue is afterward. The y-axis describes the energy level while the x-axis represents time. The energy level shows how much energy one has left on a scale from 1 to 10, therefore if the fatigue is bad, the energy level is low. Under the time axis, there is space to write down what activities one has done at a certain time. The patients should now fill out this chart after every activity. This can help with understanding what activities drain a lot of energy and which activities help to regain some energy. Additionally, one may see that certain activities are better at one time of the day than another or that at a certain time the energy is always quite low. With this information, one can then plan the day better.

1.4 Project Idea

The idea of this project is to create a digital and enhanced version of Lorenzen's chart used in therapy. I decided to do it as a web app. That presents the following advantages. For one, the patients do not have to write everything down on paper but can do it on their phones that they have on them all the time. Furthermore, the entered data can be automatically analyzed and used for more than just one chart: It can be used to compare different days or months, or an algorithm can calculate what activities help with gaining energy and which drain energy. Furthermore, a goal was for me to be able to use the digital version for myself to track my fatigue as well as let therapists try it out. If possible, I even wanted to get feedback from fatigue patients.

This leads to the question: Can a self-programmed web app provide better support for fatigue patients than the paper forms currently used in therapy?

2. Process

I started with sketching simple mockups (see Appendix 8.2) using Figma [4] to find out what elements I needed and how the users should be able to enter their data. I then programmed the basic functionality, which was signing up and logging in, creating activities, adding entries with an energy level and activities, and generating a chart displaying the energy levels throughout the day.

At this point, I started learning about designing conventions like material design [5] so I can focus on a good-looking user interface. This helped me for example with choosing a primary and secondary color and made it easier to decide where to use which color. Afterward, I created new designs (see Appendix 8.3) based on what was working well and what was not, and I improved my code. Based on feedback from others, I additionally created a light theme which should be a bit more positive compared to the dark theme. I also implemented new features like a list with all the entries grouped in daily blocks, where the user can edit or delete an entry, as well as the possibility to switch between German and English, choose different time frames in the chart (week view, month view, and year view) and an automatic evaluation of what activities help with gaining energy and which drain energy.

Later I created an information page so that people can see what the web app does before they have to register. Additionally, I created a few onboarding screens that allow the users to set their preferences (like the language and the theme). Those preferences can be changed on the settings page at any time. To help the user understand how the app works, a guided tour starts after signing up, that shows the user around the app. Finally, I designed app preview posts that I published on social media [6] and in fatigue forums [7] in hope that someone with fatigue would test my app. At a later point, I also registered my domain on google search.

3. Web App

I decided to do the project as a web application (or web app). A web app is available through a browser. However, unlike a website, it does not just provide information, but it allows the user to interact with it. In contrast to mobile applications, web apps have the advantage that they are accessible from any device and operating system. Since the most used devices will be mobile phones, I designed the web app “mobile first” which means that the design is optimized for mobile devices, but it also works on larger screens. Nevertheless, I wanted to provide the possibility to download the web app to the user’s device, therefore I turned it into a progressive web app (see Chapter 4.1).

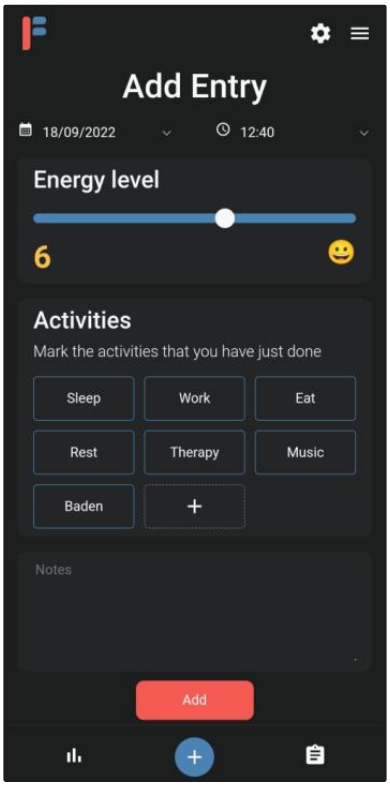

Figure 2: The screen to add new entries.

To help the users understand how the web app works, they are greeted with a few onboarding screens that help them set their preferences followed by a guided tour that shows them around the web app.

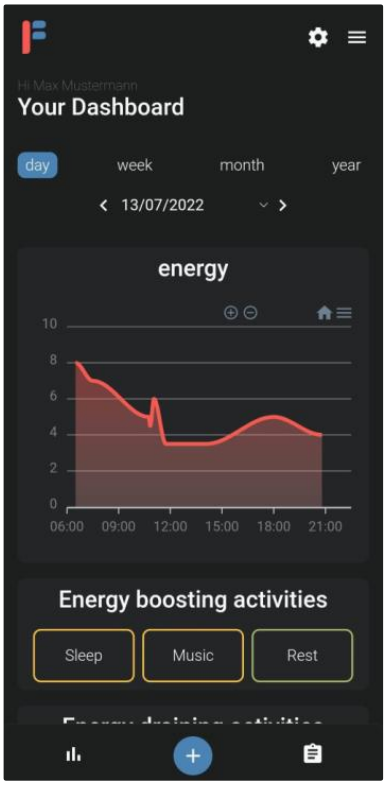

Figure 3: The dashboard with the chart of the energy level and the calculated activities.

The web app allows users to create entries as you can see in Figure 2. Just like in the chart by H. Lorenzen one entry should be created after every activity. These entries contain the current energy level, the activities one has just finished, as well as some optional notes and a date and time. To help the user decide on an energy level there is an emoji and a color that adjust, depending on what level is entered. Users can create their own activities.

Figure 3 shows the dashboard screen where charts based on the entered data are shown. For one the user can see their energy throughout the day. The date can be changed, and the user can also select another timeframe like a week, month, or year view. This allows the user to compare days or months with each other.

Below the chart, the activities are evaluated into two categories: energy-boosting and energy-draining activities.

The value for every activity is calculated using the data from the past 30 days. It has to be noted, that only the direct impact of the activity on the user's energy level is considered which means that late effects of PEM are ignored. Activities that on average have a positive influence are displayed in descending order. Every activity has one of three colors. The best activity always has a green color, whereas the one with the least positive impact is yellow. The other activities are colored with one of the three colors depending on their impact. The same follows for the energy-draining activities using red as the color for the activity with the worst impact.

Users can edit or delete their entries more conveniently than on paper. On the list view, one can see every entry from the past seven days grouped in daily blocks. Every day has an average, but the calculation is not as easy as the arithmetic mean. If it were just the arithmetic mean, time would not have an influence. However, as the following example shows, time is important in this calculation. As can be seen in Figure 4, the energy level starts at ten and ends at five in both charts, the difference is that the energy level in the chart on the left goes down to five earlier than in the one on the right.

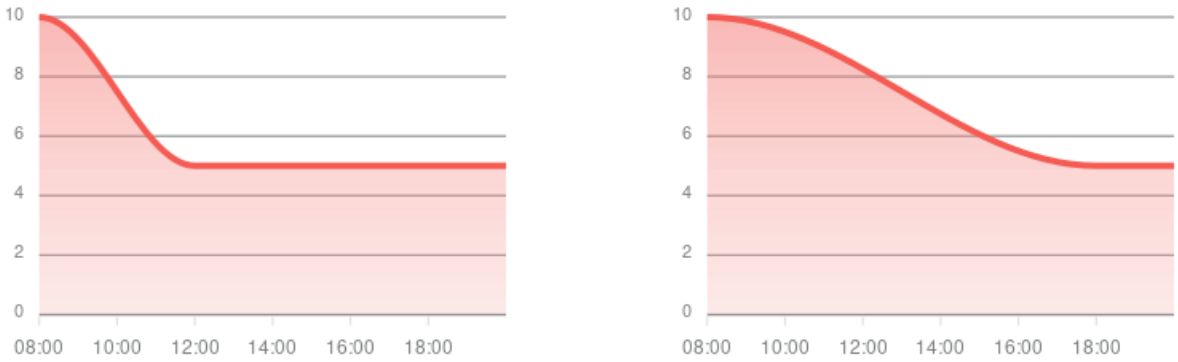

Figure 4: Two charts showing the energy level throughout a day with a drop from 10 to 5 at different times.

The arithmetic mean would be the same for both ($\overline{x} = \frac{10+5+5}{3} = 6.67$) but obviously the day on the right is significantly better than the one on the left. Therefore, time needs to be included. I decided to calculate the arithmetic mean $\overline{x}$ between two entries and then use the following formula, so that the average is weighted depending on the time Δt in minutes between those two entries and in relation to the time from the first to the last entry of the day t_{total}:

$$value = \frac{\overline{x} * \Delta t}{t_{total}}$$

Doing this for every two consecutive entries and adding up all values results in the average used for this project. Using this formula in the example above results in an average of 5.8 on the left chart compared to a 7.1 on the chart on the right which better reflects reality.

4. Programming

4.1 Website

The web app is created using HTML [8] for the structure of the website, CSS [9] for styling it, and JavaScript [10] for its interactivity. As a backend language, I used PHP [11] which generates the HTML pages on the server.

To allow the users to download the web app to their device I turned it into a progressive web application (PWA) [12]. PWAs can be installed on any device using a browser. Once installed the website opens in a standalone window instead of the browser window. This means that elements like the search bar of the browser are hidden, and the web app can take up as much space as possible. In addition, it gives the user the feeling of using a native app.

4.2 Structure

My code is structured into several folders as displayed in Figure 5. The *app* folder contains everything from the backend while the *views* folder contains mostly the frontend for pages including the dashboard and the onboarding screens. In the *assets* folder, I put for example the CSS and JavaScript code, images, and language files. A few files are located in the root directory. That includes the index file, the manifest (used to provide the PWA with information), the service worker (also used for the PWA), and the sitemap for google search. They all have to be put into the root directory for the web app to function properly.

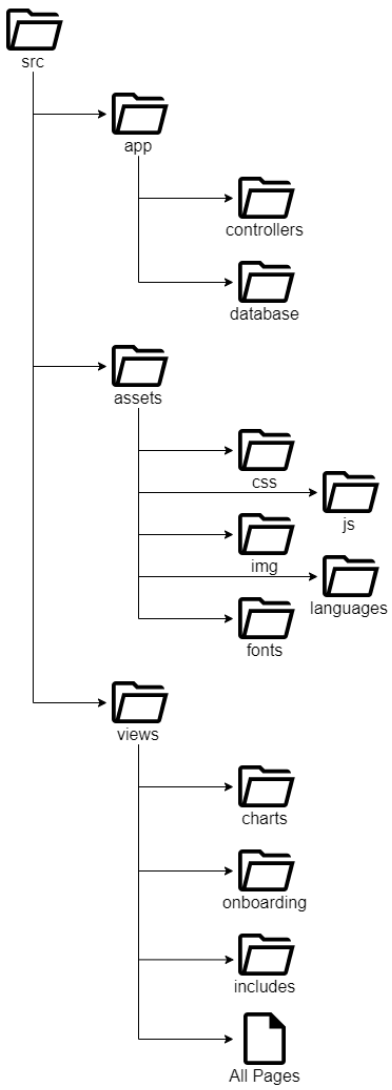

Figure 5: Folder structure of the code in my project.

4.3 Database

I used a MySQL [13] database to store the user's data. Figure 6 illustrates the database structures and the connection between its tables.

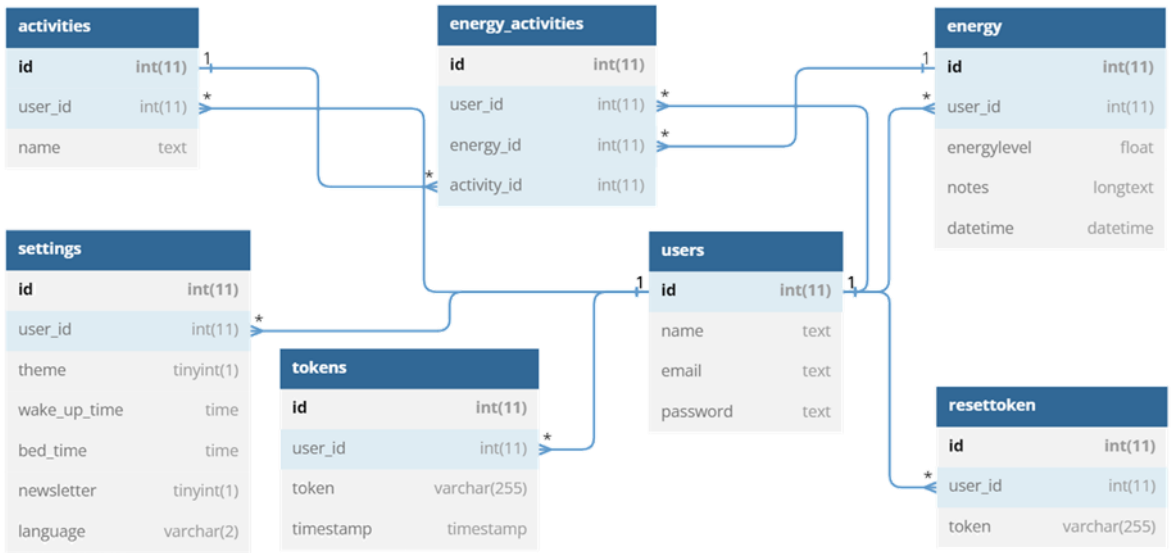

Figure 6: Structure describing my database setup. Graphic created with dbdiagram.io [23].

One of the tables is the *users* table, where the username, email address, and encrypted password are stored. Every user has a unique user ID. This ID is used to link rows from other tables to a user. The *energy* table contains the energy level, notes, and the date of every entry that is created. Users' activities are stored in the *activities* table. The *energy_activity* table is a connector between the *energy* and the *activity* table. It contains the ID of the entry and the ID of the activity. For every activity that a user attaches to an entry a new row in *energy_activity* is created. The *resettoken* table is used to create tokens (a long string of random characters that is difficult to guess) for resetting the password securely. The same applies to the *tokens* table with the difference that those tokens are used to keep the user logged in so that one does not have to log in whenever reopening the web app. *Settings* is a table used to store the preferences the user decides to set.

4.4 Libraries

After using chart.js [14] in the beta version of my web app I decided to switch to Apexcharts [15]. Mostly because I preferred the style of Apexcharts and the tooltip in Apexcharts is more user-friendly. A tooltip is a box that appears when the user clicks on the chart. It displays more information about the point on the graph that the user clicked on. With chart.js the user had to press exactly on the point, whereas with Apexcharts the user can just click anywhere on the chart, and it opens the tooltip for the closest point.

To improve the user experience, I used Toastify [16] which displays success or error messages. For example, when logging in as shown in Figure 7, but also when creating a new entry or changing the settings.

To help the user understand how the web app works and how to use it, I created a guided tour. After trying several tools, I decided to use Shepherd [17]. It displays popup messages that point to one element on the screen as seen in Figure 8. Those popups contain hints on how to use the app. Sadly, it did not work as I hoped it would since Shepherd has a problem with handling input fields. The error was already stated as an issue on their GitHub page [18], however, no one has found a solution yet. Therefore, I had to use a less optimal method. After saving a static version of my web app I disabled all the input fields and added the tutorial. Since it is static now, I had to create two versions, one in English and one in German.

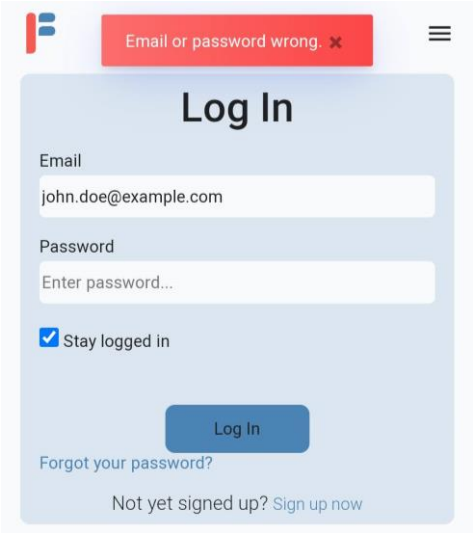

Figure 7: Screenshot of my web app showing an error message from the Toastify library.

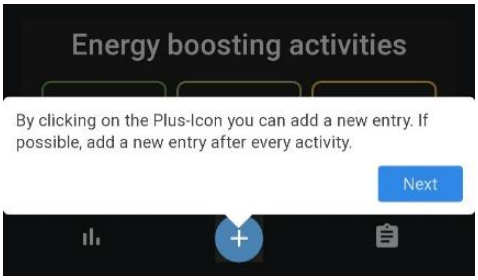

Figure 8: Screenshot of my web app showing the tutorial created with Shepherd.

4.5 Version Control

For this project, I learned about the version control system Git [19]. Git is the standard tool for version control and collaborative work used by a lot of small teams as well as big companies. It also serves in a way as a backup since one can go back to any desired version at any time. Additionally, it can be used to compare the current code with the one from a previous version. This helps to resolve errors that did not appear in a previous version.

As shown in Figure 9 I used several feature branches which I tested on my laptop using XAMPP [20] as a server environment. After testing a certain feature, I merged the corresponding feature branch into the development branch.

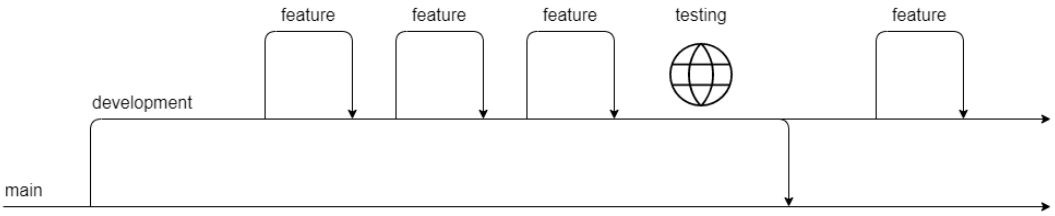

Figure 9: Structure of my workflow using several branches in Git.

The web server was linked to my GitHub repository [21] and set up with automatic deployment. This means that as soon as I pushed the development branch to GitHub, the testing website (https://dev.fatiguediary.ch/) was automatically updated to that version. If everything worked on the test site, I merged the development branch into the main branch which automatically updates the web app if there is a new commit pushed.

5. Conclusion

After using the web app daily for several months, I think that it is indeed more practical and faster to keep track of the energy levels than with the paper version. Additionally, the web app proved the findings we discovered in therapy (like for example what activities are draining a lot of my energy and what times of the day are usually better) but also provided more analysis.

I had about 15 therapists who voluntarily decided to test the web app. To collect their ideas and opinions I created a feedback form (see Appendix 8.4) and included the link on the website. At first, I received a lot of feedback about what additional features would be helpful. I tried to integrate those new features and fix the reported bugs. However, some of these features just didn't fit into the schedule of a matura project (like a symptom tacker or a way to enter the sleep quality). Towards the end of the project, I created a second feedback form to evaluate my work and sent it directly to all the initially interested therapists. Sadly, I haven't received any feedback about the current features and whether they are helpful in therapy. Understandably, it was difficult for therapists to find fatigue patients in such a short time who would be able and willing to try an app to see if it is helpful in therapy. Therefore, almost all patients who tested my app came from social media where I posted information about my web app.

Yet, the few comments I received were positive. One patient wrote in an email to me: *"found your app today, loving it so far! just what i need to keep track of my fatigue caused by my ms."*. A therapist stated in the feedback: *"The app can certainly not be useful for all patients, but still appeal to some and I think the idea is great! Thank you [translated from German by Jon Jampen]"*. I of course knew from the beginning that not everyone would be comfortable using an app, for instance, elderly people who do not use their mobile phones that much.

In my opinion, I completed my goal to create a web app that makes it easier to track one's energy by creating a simplified way to learn to pace while also providing more analysis for the patients. There are still a lot of features that would be useful (like a symptom tracker and a way to enter the sleep quality) and maybe I will implement those features at a later point.

By completing this project, I have learned a lot as it was the first time, I have worked on such a big programming project. It was also the first time that I have not just started with coding but taken time to plan and create designs beforehand. I really enjoyed working on this project since it connected one of my hobbies with school. During this difficult time while

suffering from Long COVID I have used up all my energy with school-related work and have not been able to pursue my hobbies. This project helped me to stay motivated and to continue working, nevertheless.

6. Figures

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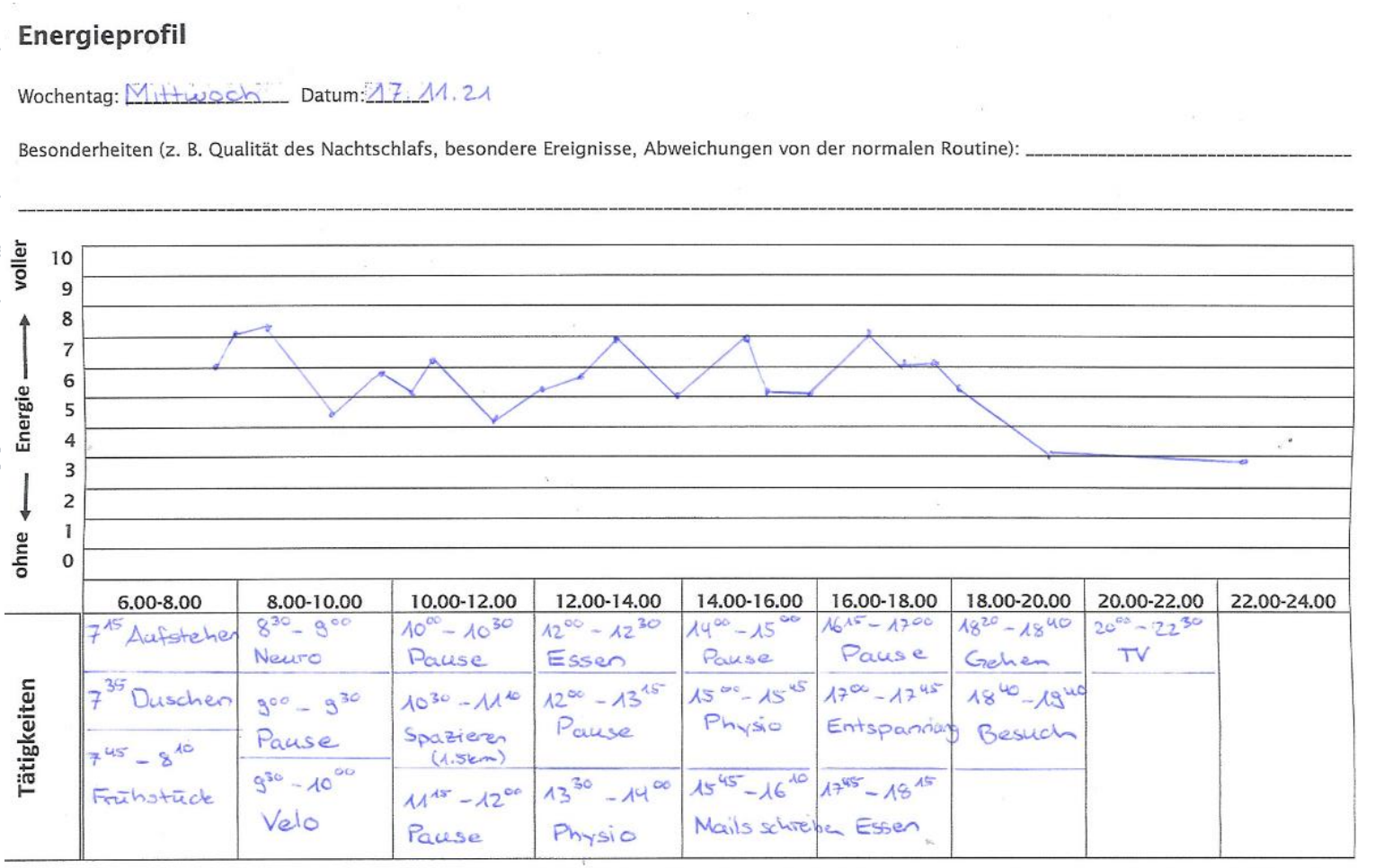

Energieprofil

Wochentag: Mittwoch Datum: 17.11.21

Besonderheiten (z. B. Qualität des Nachtschlafs, besondere Ereignisse, Abweichungen von der normalen Routine): _____

ohne ← Energie → voller

	6.00-8.00	8.00-10.00	10.00-12.00	12.00-14.00	14.00-16.00	16.00-18.00	18.00-20.00	20.00-22.00	22.00-24.00
Tätigkeiten	7^{15} Aufstehen 7^{35} Duschen 7^{45} – 8^{10} Frühstück	8^{30} – 9^{00} Neuro 9^{00} – 9^{30} Pause 9^{30} – 10^{00} Velo	10^{00} – 10^{30} Pause 10^{30} – 11^{10} Spazieren (1.5km) 11^{15} – 12^{00} Pause	12^{00} – 12^{30} Essen 12^{00} – 13^{15} Pause 13^{30} – 14^{00} Physio	14^{00} – 15^{00} Pause 15^{00} – 15^{45} Physio 15^{45} – 16^{10} Mails schreiben	16^{15} – 17^{00} Pause 17^{00} – 17^{45} Entspannung 17^{45} – 18^{15} Essen	18^{20} – 18^{40} Gehen 18^{40} – 19^{40} Besuch	20^{00} – 22^{30} TV	

nach H. Lorenzen (2010)

Andrea Weise & Ruth Hersche 2021

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Figure 10: Energieprofil nach H. Lorenzen. [3]

8.2 Mockups Version 1

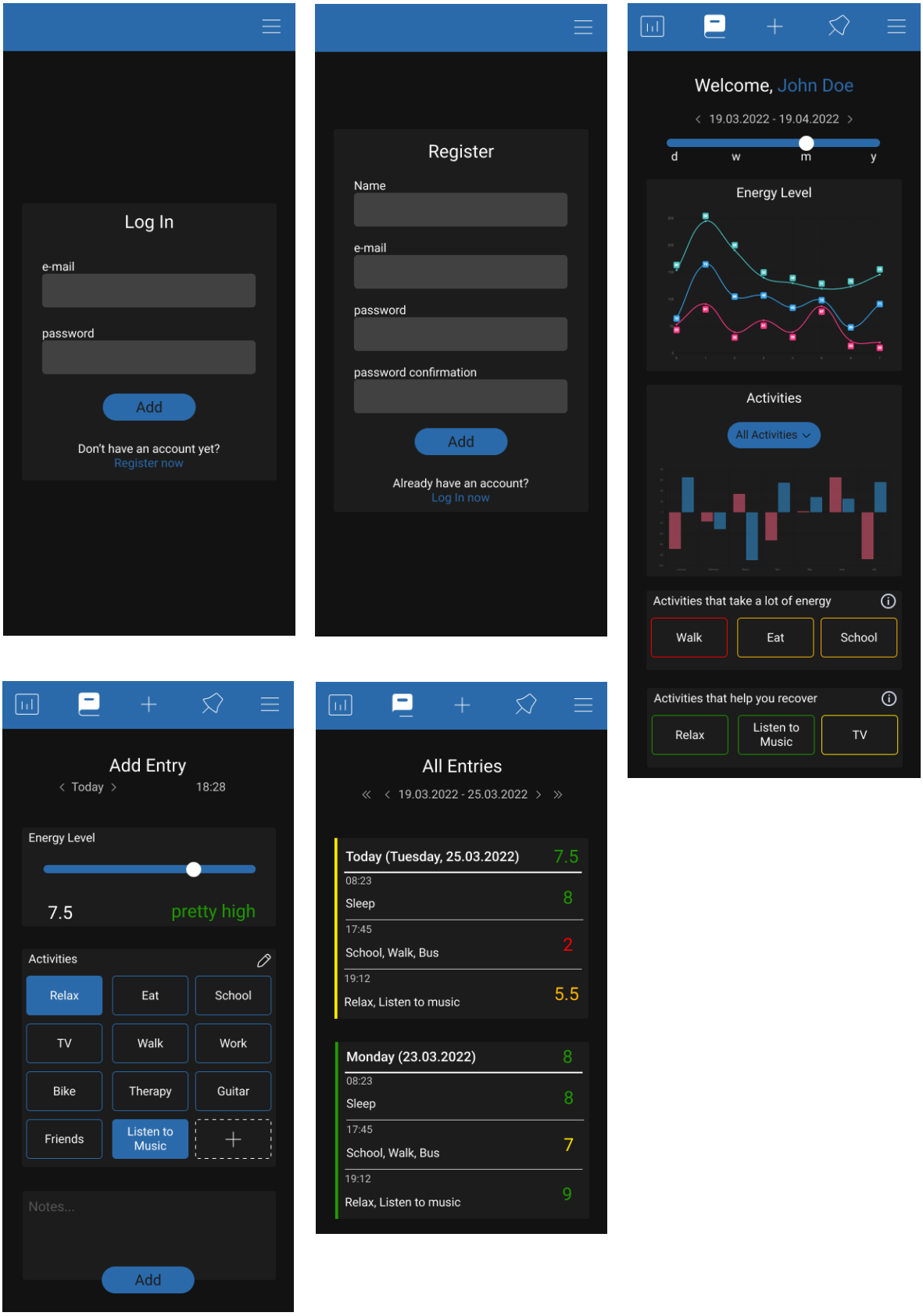

Figure 11: Version 1 of my mockups designed in Figma.

8.3 Mockups Version 2

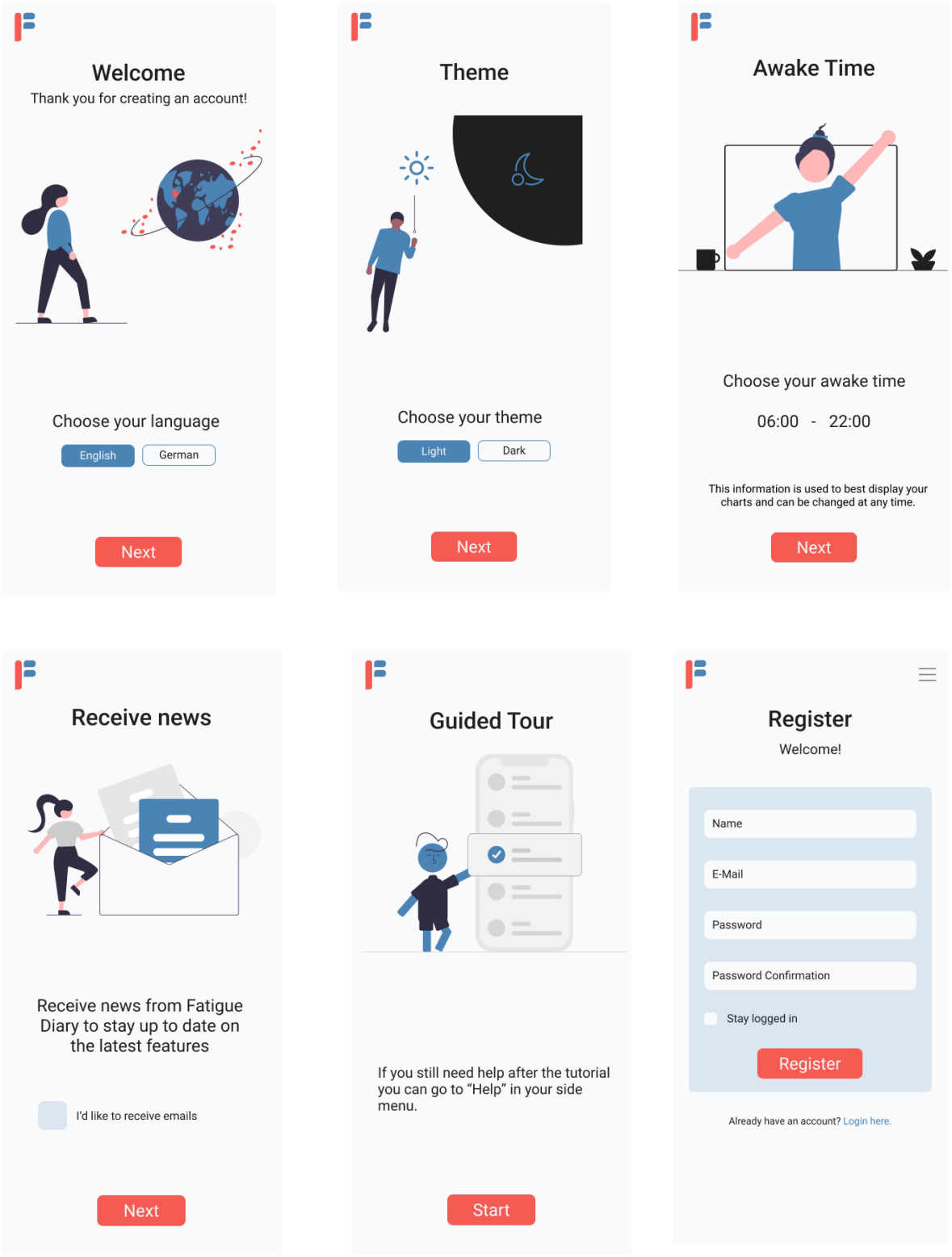

Figure 12: Version 2 in light theme of my mockups designed in Figma.

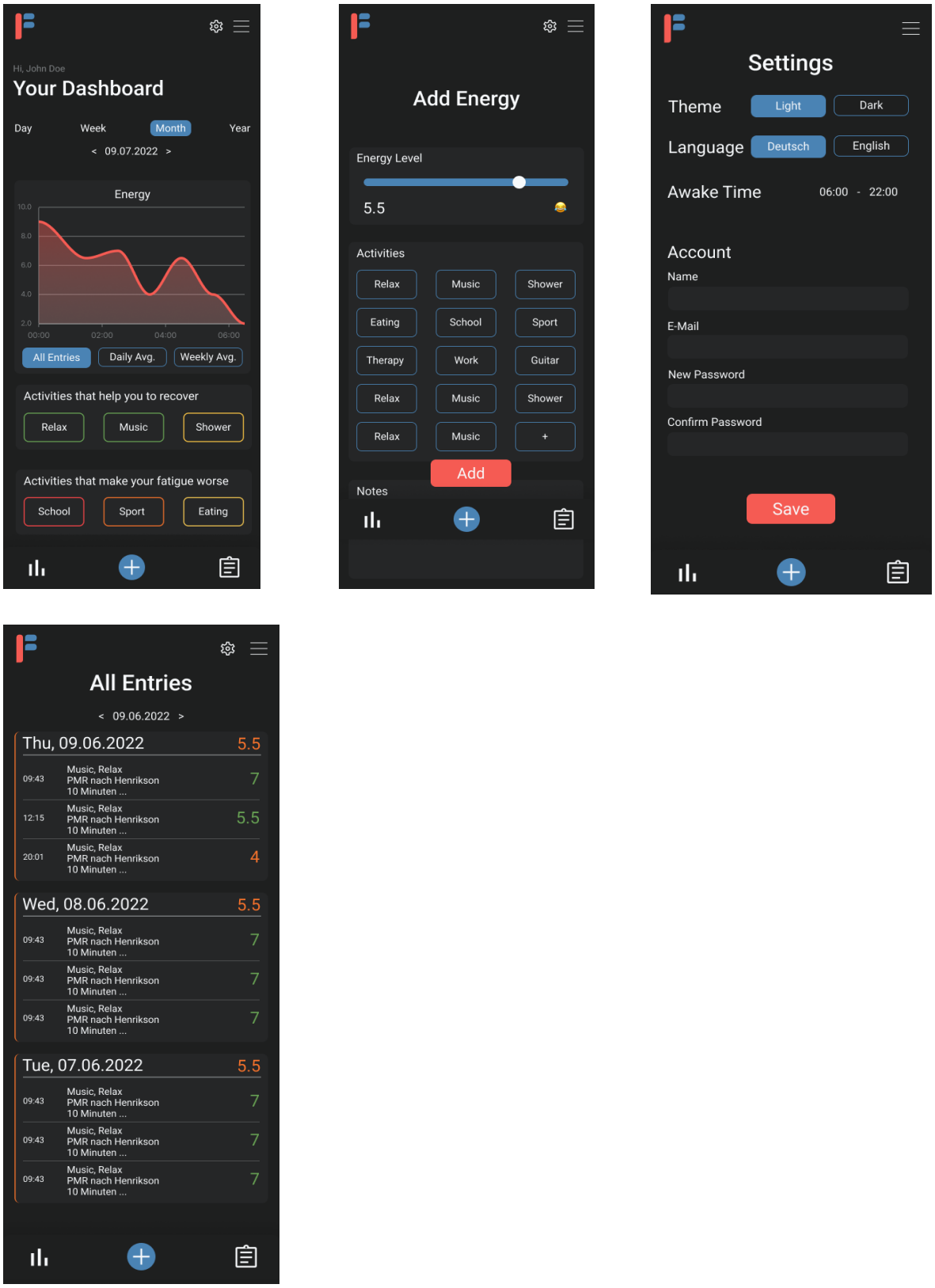

Figure 13: Version 2 in dark theme of my mockups designed in Figma.

8.4 Feedback Forms

1. I am a *

- ◯ Therapist
- ◯ Fatigue patient
- ◯ Other

2. email address (optional)

Enter your answer

3. Where did you have problems? What didn't work as expected? What should be improved?

Enter your answer

4. What features do you wish to see in the future?

Enter your answer

5. Is the web-app in your opinion helpful?

☆ ☆ ☆ ☆ ☆

6. Can the Web-App replace the paper version of the "energy profile"? (Only answer if you know the "energy profile by H. Lorenzen")

☆ ☆ ☆ ☆ ☆

7. Other remarks:

Enter your answer

Submit

1. E-Mail-Adresse (freiwillig)

Enter your answer

2. Treffen die folgenden Aussagen aus Ihrer Sicht zu? *

	ja	eher ja	eher nein	nein	weiss nicht
Die App kann die Papierform des Energieprofils nach H. Lorenzen ersetzen.	◯	◯	◯	◯	◯
Die App bietet für die Therapie einen Mehrwert gegenüber der Papierform.	◯	◯	◯	◯	◯
Die App ist für die PatientInnen praktischer zu benutzen als die Papierform.	◯	◯	◯	◯	◯
Ich kann mir vorstellen, die App mit PatientInnen einzusetzen.	◯	◯	◯	◯	◯
Die App sollte auch nach Abschluss der Maturaarbeit weiter betrieben werden.	◯	◯	◯	◯	◯

3. Was hält Sie allenfalls davon ab, die App in der Therapie einzusetzen?

Enter your answer

4. Sonstige Anmerkungen

Enter your answer

Submit