DAY LINE: DATA VISUALIZATION AND ANALYSIS ON DAILY ACTIVITIES

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SIGNATURE PAGE

PROJECT: DAY LINE: DATA VISUALIZATION AND ANALYSIS ON DAILY ACTIVITIES

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ABSTRACT

This study developed a full stack productivity application, called Day Line using the MERN stack (Mongo, Express, React, Node.js). The application provides users with data visualization for all their daily activities and does statistical analysis to show users how many hours they spend on activities in a day, week, month, and year. The goal of the application is to help users improve their time management by showing users how much time they spend on all the activities they do in their daily life. Users can input the activities they want to track in a day then through data visualization they can see their days simplified into a digestible format and view a side by side comparison about all the hours spent on each activity. Thus, with data visualization and statistics, users can make the changes they want to see with their time. It was found that this application helped users with visualizing their time, reflecting on their day, and improved time management for some users.
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CHAPTER 1: INTRODUCTION

People often have trouble managing time, so there is an evolving need for productivity applications to help people stay on track and manage their time better. People usually use calendars and productivity applications to help manage their time. There are currently several useful productivity tools that involve tracking time such as Forest [1]: an application that helps people stay focused on the task at hand by setting a timer associated with the task and not being allowed to access your phone while the timer is running, Daylio [2]: an application that tracks daily activities, mood, and give statistics on mood. Trello [3]: an application that tracks tasks with to do, in progress and completed. However, there still does not exist an application for tracking users activities every day and the time spent on each activity.

To solve this problem, the creation of a web application for tracking all the activities done each day is carried out from front-end to back-end. From my research, there currently does not exist an application web or mobile that follows this design pattern and method of organization for displaying ones day to day activities. This web application will help users understand better where their time is going, and how much of their total time they are spending on each activity.

The system comprises of a cloud-based database service to manage user data. The components for the user interface are created with the use of open-source libraries. It is deployed as a SaaS in a cloud environment. As a result, a time management application will be deployed as a cloud-based web service. Since the system is deployed in the cloud environment as a SaaS, any user will be able to register an account and use the
application. From this, users will be able to better manage and visualize their time as well as understand how they are spending their time on particular activities each week.
CHAPTER 2: MOTIVATION

There are many productivity applications, but they still lack time tracking for all activities, data visualization to simplify a high amount of user data and obtaining useful information about all the activities and time invested. With consistent tracking of time spent on activities, users would be able to have a more realistic idea of how much on average they actually spend on any activity. It is often difficult to remember what meals were eaten in a previous day much less where every hour is spent and on which activities.

There have been applications and devices that track time automatically if the application is being run [4], but more often than not a user must be running the application on a device for it to be tracking, so it is not possible to track activities done outside of the device. In addition, information gathered is usually not shared with users in a meaningful way, but more for researchers to further their studies. There are other types of time trackers, but they are also geared towards specific activities. Also, if a user is tracking every activity in a day, the application is not made for that type of support, so it becomes overcrowded with data that cannot be easily deciphered.

Even if users want to track all their activities in a day, there isn’t an application that supports this type of tracking in a meaningful way, and it often leads to an overload of information that is difficult to manage for the user. As a result, there’s not much motivation for a user to try to track the majority of activities or time spent on certain activities. This makes it difficult for a user to get a solid perception of where their time is spent and where it can be reallocated to make meaningful changes in their life. These problems can be addressed with an application that encourages users to track all activities.
easily and format that information in an easily understandable manner. In this study, an application will be made to address these issues with the use of data visualization techniques and good usability, so users can easily understand their data, and be encouraged to log all activities they do in a day.
3.1 Ensuring Usability

Users will stop using an application because of poor usability and design [5] for a variety of reasons such as poor navigation, design, slow loading, confusing layout, or a lack of understanding of a website in general. These can all cause a user to stop using an application or leave a website. As a result, it is important to design with the user in mind, and ensure that users can easily understand each page they’re presented with.

3.2 Little Support for Tracking all Time Spent on Every Activity

Generally, time management and productivity applications do not encourage adding every activity that a user does. For example, a scheduler or calendar supports only adding specific activities such as appointments, meetings or specific tasks that require special reminders. If a user were to add all activities in a day it would only serve to add confusion and clutter. These applications also do not offer any analysis on the data input, they are simply for reminders. Other applications that do support tracking also tend to be only for specific activities such as sleep trackers do inform on sleep quality or daily mood trackers. Although these applications are good at what they do, they are more specialized and not made for tracking every activity in the day.

3.3 Lack of Data Visualization for User Data

Although most applications do offer tracking for activities, there is often not an easy way to visualize all the data input or tracked for the user. The ones that do have visualizations are more often than not for specific activities. For example, Daylio [2] shows data visualization for moods and average mood rating on a daily, weekly, and
yearly basis. They also have statistics for activities, but there is no time association with
time spent on any activity. The application is mainly helpful to see what activities a user
regularly participates in. Other applications that do track time, are still time specific to
when the application is running or only for specific activities, so any data visualization
will only be for a fixed set of activities. On the other hand, Calendars and scheduler
applications such as Google Calendar [6] do not offer any user statistics or insight for the
user about their appointments. Although some applications do offer helpful user insight,
it is not enough to get a consistent overall idea of where a user spends their time, and
ways to change and improve how a user spends their time on a day to day basis. Due to
this, most applications are good for reminders or tracking in the moment, but they are not
good for helping a user learn and reflect upon what they do, and work towards making
changes with their time management.
CHAPTER 4: SOLUTIONS

In order to address the challenges mentioned previously, this study has developed a full stack web application called Day Line shown in Figure 1. This application allows users to track all daily activities in a user-friendly manner with insightful statistics.

![Day Line user homepage](image)

*Figure 1. Day Line user homepage*

4.1 Design with Users in Mind

To create good usability and design with users in mind, it is important for users to easily navigate the site and understand the purpose of the site. First, understanding the user workflow shown in Figure 2 was done to understand the essential features.

![Day Line user workflow](image)

*Figure 2. Day Line user workflow*
To address users understanding the purpose of the website, an about page was included that could easily be navigated to. The wireframe was done with Figma [7] as shown in Figure 3. A navigation bar was added on every page for easy access to any additional pages. The number of navigable pages was also limited to prevent confusion for the user.

Figure 3. Wireframe design made with Figma
The color palette and font capitalization were also changed after initial design due to negative responses from user testing. For the colors, users complained of difficult understanding the colors and preferred a lighter background. Due to this, a new palette shown in Figure 4 was created, and users responded positively to the color change.

![Figure 4. Final color palette](image)

### 4.2 Track All the Time Spent for Every Activity

As discussed in the previous section, most applications do not encourage tracking for all activities in a day. A scheduler was added from a library called React Scheduler from DevExtreme Reactive [8] to encourage users to track all activities in a day as well as easily manage the activities they would add. The scheduler is a component that will show users scheduled data and allows for users to manage it. It supports a view switcher that allows for day and week view, a date navigator, time-scale, and a scheduler tooltip to show more details about a particular appointment shown in Figure 5. Users can also add a title to the appointment, repeat the appointment for multiple days, and add any notes. A tag component was also added to the appointment form so users can mark each appointment with an activity show in Figure 6. It was also important to figure out which activities users would want to track daily, and to provide that option for them. As a result, 10 activities out of 15 were chosen to represent the majority of daily tasks for any user. The activities chosen were chores, errands, entertainment, exercise, meal, other, school, sleep, social, and work. The scheduler also supports easy time and date adjustments with dragging and dropping interactions. Dragging the appointment down or up will lengthen
or shorten the time respectively, and dropping can move the appointment to any date or time slot on the scheduler. With DevExtreme scheduler, Day Line is able to provide an interface that is easy to understand for user and offers all the features needed to add and track any activity easily.

![Image of DevExtreme Reactive Scheduler](image1.png)

*Figure 5. DevExtreme Reactive Scheduler for users to track activities*

![Image of Form for Adding Appointments](image2.png)

*Figure 6. Form for users to add appointments to the scheduler*
4.3 Data Visualization for User Data with Bar Charts

Day Line tried to solve the lack of data visualization for user data with bar chart representations. The components used for this feature were React Timeseries Chart library [9] and DevExtreme Reactive React Chart library [10]. The library used from the React Timeseries Chart is an experimental EventChart [11] shown in Figure 7. Its main purpose was to simplify a user’s day down into simple colors that indicate the activity associated with that time frame. This way a user can easily see where the majority of their time is spent, or if their time is distributed among many different activities.

![Figure 7. Charts that show a user’s day on 24 hour scales, color indicate activity associated](image)

The DevExtreme Reactive React Chart [10] is used for depicting user statistics to show how many hours are spent on each activity. The user can pick which day they want to see, and if they want to see it for the day, week, month, or year. Then the bar chart will change accordingly to represent the requested data. The statistics are calculated by iterating through all the user activities and totaling up all the hours spent per activity for the day, week, month, and year.
Figure 8. User stats with hours as the y-axis, and activity as the x-axis
CHAPTER 5: DEVELOPMENT TECHNIQUES

Day Line was developed as a web service application, so that it can be separated to client side and server side. For the front-end, Day Line uses HTML, CSS, and Material UI library [13] for the application styling. JavaScript, React framework library [12], and axios library [14] are used to connect the front-end to back-end. The libraries DevExtreme Reactive Scheduler [8] and Charts library [10] as well as React Timeseries Chart library [11] are used as part of the front-end components. For the back-end Node.js [15] is for the JavaScript run time environment, Express [16] is used for the back-end application framework, MongoDB [17] for the database, and Mongoose [18] for object data modeling. A diagram of the architecture is shown in Figure 9.

![Figure 9. Day Line Architecture](image)

5.1 User Authentication

The user authentication was designed with Passport.js [19], an authentication library for Node.js [15], was used to keep sessions logged so that users could stay logged
in. Strategies are first created to support authentication using email and password as well as hashing the password with bcryptjs [20]. Once this is done passport serializes and deserializes the user through Express. First, deserialize user will check to see if the user is saved in the database, then serialize user will assign the user id and the whole user object to the passport session with Express.

5.2 MongoDB Database Structure

MongoDB [17] was used as the database to store all user data. Mongoose [18] schema was used to model the user data and appointment data. User models contain the user email of type String, password of type String, and appointments which was an array of appointment schemas shown in Figure 10. The appointment schema shown in Figure 11, contains the id of the appointment, title, start date, end date, location, all day for tracking if a task spans the entire day, notes for anything additional, rRule for repeating appointments on select dates, exDate for excluded dates, color for the activity type, and tag for the activity name.

```javascript
const userSchema = new Schema({
    username: { type: String, unique: true, required: true },
    password: { type: String, unique: false, required: true },
    appointments: [Appointment],
});

const appointmentSchema = new Schema({
    id: { type: Number },
    title: { type: String },
    startDate: { type: Date },
    endDate: { type: Date },
    location: { type: String },
    allDay: { type: Boolean },
    notes: { type: String },
    rRule: { type: String },
    exDate: { type: String },
    color: { type: String },
    tag: { type: String },
});
```

*Figure 10. User Schema*

*Figure 11. Appointment Schema*
5.3 Create My React App

The benefits of using create my react app is that it setups up the toolchain and provides some tools making development and deployment easier. It uses babel to translate modern JavaScript into browser-compatible JavaScript and webpack to bundle and minify assets for deployment.

5.4 Appointment Helper Component

The appointment helper component is involved in fetching the data from the backend and then processing the data to be used by the other components. The helper component also contains all the mappings from tags to colors and the reverse mapping. The fetchaData function will send a get request to the /user/add-day/ back-end to retrieve all the appointments. Axios [14] is utilized to make a get request to the backend in order to retrieve appointment data for a specific user. The payload is then converted into an array of objects that the frontend is prepared to handle. Events with repeating rules are set aside in an array to be processed further. Then all the events are sorted by start time. The group events function is responsible for taking all the appointments and based on its start date and time it will group them into a nested dictionary. The nested dictionary shown in Figure 12. Aggregate hours will take the input from groupEvents and sum up the totalHours for each set of dictionaries in order to compute the totalHours for each respective level.
The user statistics component from the DevExtreme Reactive Charts library [10] uses the Appointer Helper component to retrieve the appropriate objects to display. In addition, the statistics are calculated by day, week, month, and year. The user timeline component utilizes React Timeseries Chart library [11] to create the timeline for each day tracked by a user. The timeline component uses the Appointer Helper component to retrieve the appropriate objects to display.

5.5 Scheduler and Timeline Component

The scheduler component as mentioned earlier, was from the DevExtreme Reactive Scheduler library [8]. To get the components to work with the database, axios [14] was utilized to make post requests to the back-end for appointment information. A tags section was also added to the user input form when adding to the scheduler, shown in Figure 6. Every instance of the user interacting with the scheduler is synced to the MongoDB database by making a post request to the backend with the array of appointments as the payload. The backend receives the payload and coverts the object to an array of Mongoose Appointment documents and then saves it.
5.6 Deploy to Heroku

The application was deployed to Heroku [21], so that users could test and use the application for a 1-week deployment study. The Heroku deployment process was simplified because of ‘create react app’ initial setup. Heroku runs the production step in the package configuration which automatically compiles the front-end to be served. The front-end and back-end live together on the same server. On the first website access the back-end serves the compiled front-end. Heroku also automatically supplies SSL certificates to give the website its secure connection. Heroku is also responsible for creating a DNS target to reroute the www.day-line.com domain to. Heroku is also connected to the Github repository so when changes are committed the application is automatically redeployed.
CHAPTER 6: EVALUATION

The study was evaluated by 10 participants who used the Day Line application with a 1-week deployment study, then participants took 2 questionnaires based on their experience. One survey was the system usability scale [22] and the other was a mixed questionnaire with some Likert questions, multiple choice, and free response. Both were given to participants through Google Forms.

6.1 System Usability Scale (SUS)

First, the System Usability Scale (SUS) created by John Brooke in 1986 was used to classify the ease of use for the application. Participants were asked to score 10 questions on a Likert scale from 1 to 5; 1 being strongly disagree to 5 being strongly agree. The questions and scale are shown in Table 1.

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think that I would like to use this application frequently.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found the application unnecessarily complex.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I thought the application was easy to use.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I think that I would need the support of a technical person to be able to use this application.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I found the various functions in this application were well integrated.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I thought there was too much inconsistency in this application.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
I would imagine that most people would learn to use this application very quickly.

I found the application very cumbersome to use.

I felt very confident using the application.

I needed to learn a lot of things before I could get going with this system.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>95</td>
</tr>
<tr>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>85</td>
</tr>
<tr>
<td>4</td>
<td>90</td>
</tr>
<tr>
<td>5</td>
<td>92.5</td>
</tr>
<tr>
<td>6</td>
<td>97.5</td>
</tr>
<tr>
<td>7</td>
<td>82.5</td>
</tr>
<tr>
<td>8</td>
<td>67.5</td>
</tr>
<tr>
<td>9</td>
<td>87.5</td>
</tr>
<tr>
<td>10</td>
<td>95</td>
</tr>
</tbody>
</table>

Mean: 84.75
Median: 88.75

After participants finished taking the SUS questionnaire, their scores were calculated using the SUS scoring. For odd numbered questions, 1 is subtracted from the user given score. For even numbered questions, 5 is subtracted from the user given score. Then the new values are taken and summed together for the total user score. This is then multiplied by 2.5 to have a score out of 100. Based on research, a score of 68 is average and anything above is above average while anything below is below average, and a score above 80.3 is the point where users are more likely to recommend the product to a friend [22]. It was found that the mean score for the application was 84.75 shown in Table 2. This means users that perceived good usability from interacting with the application since
the score was above 68, and since it was also above 80.3 users would be more likely to recommend the application. However, the question that brought the majority of the scores down was the first question “I think that I would like to use this application frequently.” On average, users answered with a 3 or less, meaning it was unlikely for them to use this application regularly.

6.2 Day Line Questionnaire

Next, participants were given a questionnaire with a mix of Likert scale questions, multiple choice and free response shown in Table 3. These questions aimed to see if the application helped users with their time management and visualization of their time. It was intended to see what may have been lacking from the application that would help increase usability and satisfaction.

Table 3. Day Line Questionnaire

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly Disagree</th>
<th></th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>This web application improves my time management.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>This web application helps me reflect on my day.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>The data visualization helps me visualize my time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I would use this web application to prioritize my activities.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>This web application assists in visualizing my day.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>This web application makes me anxious about time.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I regularly use time management tools.</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>On average how many activities did you track?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>□ 1-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ 3-4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ 5-6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ 7+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are there any tags you wish were included that were not?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If those tags were included, would you have tracked more activities?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>□ Yes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The results for participant’s responses to the Day Line questionnaire are shown in Table 4. First, it was found that participants were not normally users of time management tools with an average response score of 2.2, which means the majority either disagreed or strongly disagreed with this statement. Also, the application was not good for improving time management, when users were asked to agree or disagree with this statement, the average response was 3.3. This means the majority of participants neither agreed nor disagreed that the application helped improve their time management. However, with regards to the statements that the application helps users reflect on their day and that the data visualization helped users manage their time. The scores came out to 4.5 and 4.4 respectively, meaning the majority of users strongly agreed with these two statements. From this, it can be inferred that Day Line was helpful in giving users a space to reflect on the activities they did each day, and that the data visualizations helped users better visualize their time. In addition, users also had an average response score of 4.4 when agreeing to the statement that the web application assists them in visualizing their day. This means that it helped users both visualize time and their day as a whole.

For the amount of activities that users tracked, 50% of participants tracked around 3-4 activities. 40% tracked 5-6 activities, and 10% tracked 7 or more. From this it can be inferred that the amount of activities and tags provided to user was enough to support their daily activities. However, it was found that there were a few tags that participants wish had been included that were not. This included commute, spiritual, and rest/mindfulness. Participants also indicated that if these activities had been included,
they would have tracked more activities. Lastly, for suggestions on improving their experience, some users suggested a mobile friendly version would help especially with having notifications or daily reminders to log their activities. Others wanted a way to prioritize activities that they track often. There was also a suggestion to see not only day and week on the scheduler but also a month view.

Table 4. Day Line Questionnaire Participant Responses

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>This web application improves my time management</td>
<td>3.3</td>
</tr>
<tr>
<td>This web application helps me reflect on my day.</td>
<td>4.5</td>
</tr>
<tr>
<td>The data visualization helps me visualize my time.</td>
<td>4.4</td>
</tr>
<tr>
<td>I would use this web application to prioritize my activities.</td>
<td>2.9</td>
</tr>
<tr>
<td>This web application assists in visualizing my day.</td>
<td>4.4</td>
</tr>
<tr>
<td>This web application makes me anxious about time.</td>
<td>3.3</td>
</tr>
<tr>
<td>I regularly use time management tools.</td>
<td>2.2</td>
</tr>
</tbody>
</table>

On average how many activities did you track?

- 1 - 2
- 3 - 4
- 5 - 6
- 7 +

Are there any tags you wish were included that were not?
- Commute (3)
- Spiritual (1)
- Rest/Mindfulness (1)

If those tags were included, would you have tracked more activities?

- Yes
- No
CHAPTER 7: RELATED WORK

There have been some studies to create different tracking systems to help improve time management for users. The most similar example is Kim Y. et al. [23], they created a flexible self-tracking productivity tool for users involving semi-automated tracking called OmniTrack, a mobile productivity application. The application allows users to customize the application to make their own trackers and change tracking items to meet their needs. The application still takes into account manual tracking and automatic tracking. Manual tracking is when a user needs to input the data. Automatic tracking is when a task tracked without any need for user input. For example, using a mobile phone can be captured automatically, but can be more difficult for a user to remember and input manually. The majority of the application is focused on semi-automated tracking takes into account user input as well as trying to automate certain aspects, so that users can fix anything that was wrongly tracked, but also do not need to leverage as much work.

The study describes that OmniTrack was first evaluated through a usability study to improve the interface based on user responses. Then a 3-week deployment study was conducted to see if OmniTrack’s customizable design would meet the user needs for tracking. They found that users used OmniTrack to change the tracker in several different ways to fit their needs such as for sleep tracking and daily tracking. They found that the mobile application did support participants tracking practices over time, but there were many bugs and unexpected uses from users that lead to errors in their application.
A web application called Day Line was designed on Figma and developed using the MERN stack (MongoDB, Express, React, Node.js). There was a 1-week deployment study done with 10 participants. Afterwards two questionnaires were given to participants, and based on the results, Day Line has good usability and users had no difficulties navigating the site. The web application is also helpful for users who want to reflect on their day, visualize their time or visualize the activities they do in a day. It was found; however, that the application was not helpful for most participants with time management.

For future work, adding a feature for users to set goals and see their progress towards that goal would be helpful to many users. Each time an activity is added towards a goal users could see the progress quickly, and this would encourage users to track their activities and time spent regularly as well as keep up with an activity they want to improve on. Also, porting the web application to mobile format for users to easily track activities wherever they are would likely also help with usability since some participants had to drop out due to unreliable internet, or not having a computer easily at their disposal. Also, if the application was ported to mobile the tracker could also include a mechanism to automatically track time the user spends on their phone and add those as activities to the scheduler. This way the user would not need to as many activities each day to the scheduler.
REFERENCES


