DEVELOPMENT OF ANDROID SMARTPHONE APPLICATION TO HELP IMPROVE SLEEP QUALITY BY USING SMARTPHONE SENSOR AND VALUE OF WEARABLE SAMSUNG GEAR FIT2

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ABSTRACK

Sleep is an important activity that needed for health of human body. But, based on 63 partisipant of adults who have answered the questionnaire, there are 93% of them do not know information to improve sleep quality, so 77% of them several times (about once a week) have problems or sleep disorders. Therefore, built applications that can be used to help improve sleep quality by utilizing the smartphone sensor and the value of wearable Samsung Gear Fit2. Applications utilize the smartphone's light sensor to detect light intensity and smartphone microphone to detect noise levels that may affect to sleep quality. The app also utilize the value of sleep data and footsteps from wearable Samsung Gear Fit2 through the S Health application which can be accessed by using Samsung Digital Health SDK to be processed by application into insert in sleep quality calculation process by PSQI method.

Based on *usability testing* to Android app, the average success rate of the testers completing task in the application is 85% and the difficulty level of completing the work calculated using the Likert Scale is in easy category. Overall of usability testing, can be concluded that the application has been able to help adults know the efforts to improve the quality of sleep and make it easier to know the quality of sleep.

Keyword : sleep quality, android application, smartphone sensor, wearable, samsung gear fit2

1. INTRODUCTION

Sleep is one of the important body needs because it has many benefits for the health of the body [1]. However, based on 63 adult respondents who have filled out questionnaires, 93% of them do not know the information to improve the quality of sleep. It can cause many consequences, such as creating unhealthy sleep patterns and allowing bad habits that can cause sleep disturbance.

In addition, do not know how the quality of sleep can be a cause of ignorance of adults against sleep, so do not make efforts to improve the quality of sleep. This will result in frequent sleep disturbances and cause unhealthy sleep patterns. Sleep problems should be addressed immediately, otherwise lack of quality sleep in the short term may affect judgment, mood, ability to learn and store information, and may increase the risk of serious injury and injury [2].

The number of innovations and services on the smartphone managed to pamper its users, do not be surprised if the smartphone is always taken to anywhere even when going to sleep though. Likewise on wearable devices that can track every user activity, such as the Samsung Gear Fit2 that can track footsteps, sleep, heartbeat and many more [3]. Therefore, it needs an easily accessible media by utilizing smartphone technology and wearable value, so that society especially adult age group can more quickly understand about healthy sleep, as well as to inform the efforts that can be done to improve the sleep quality of the user.

Based on background of the problems that have been described, the purpose of this research is to build applications that can be utilized to help improve the quality of sleep with the following objectives:

1. Helping the adult age group to know the efforts that can be done in order to get quality sleep.
2. Facilitate the adult age group to find out how good sleep.

2. VALUE OF RESEARCH

Stages of research to build this application include, idea validation, design with Google Design Sprint, system development with SCRUM methodology and testing with usability testing.

2.1 Idea Validation

Idea Validation is done to determine the suitability of the issues raised by an idea with the actual situation. The idea validation process is done by utilizing the Javelin Board tool. The steps in validating ideas with the Javelin Board include determining user segmentation, key issues, riestkiest assumption, performing tests or validation, and the

final step concluding the results of the validation of ideas [4].

Method that used in idea validation is with interview to group of adults between 18 – 59 years old. The result of validating this idea is a validated main functional solution as follows:

1. Information of sleep
2. Tips to improve sleep quality
3. Information of environment state that affect to sleep quality
4. Music Relaxation, and
5. Calculation of sleep quality

2.2 Google Design Sprint Designing

Doing a quick design of the interface ideas and conducted a vote on the idea of the resulting interface. After that a prototype is made and validated. So the result of designing Google Design Sprint is a prototype interface that has been validated [5]. Here are some prototype results from Google Design Sprint:

1. Prototype interface tips can be seen on Figure 1.



Figure 1. Prototype Tips

2. Prototype interfaces see the state of the environment can be seen on Figure 2.

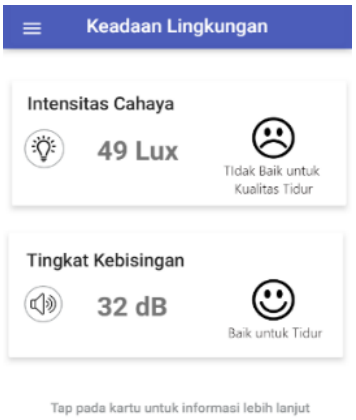


Figure 2. Prototype See the State of Environment

3. Prototype interface calculate sleep quality can seen on Figure 3.

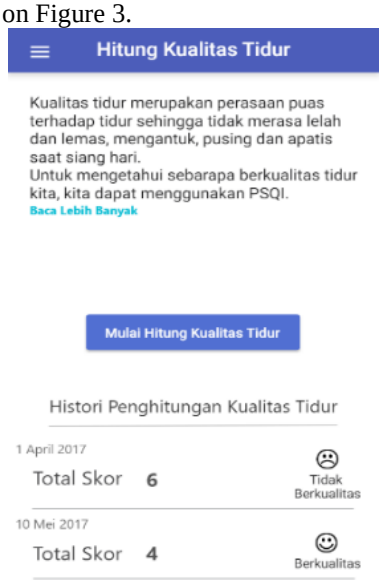


Figure 3. Prototype Calculate Sleep Quality

4. Prototype interface music relaxation can seen on Figure 4.

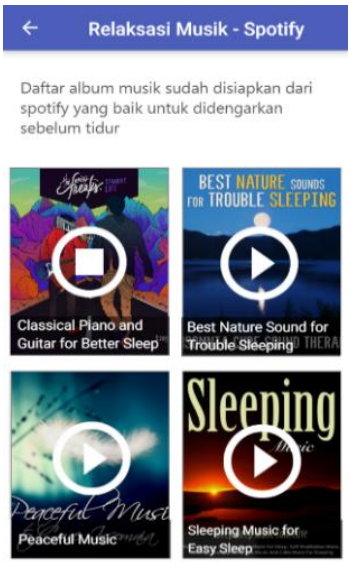


Figure 4. Prototype Music Relaxation

2.3 System Architecture Analysis

The architecture of the built system is divided into 2 sub-systems as can be seen on Figure 5.

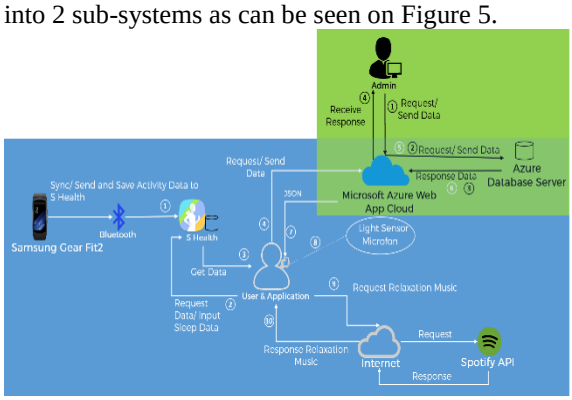


Figure 5. Arsitektur Sistem

2.4 Database Analisis

Database analysis isu sing Entity Relationship Diagram to show how the relation of entities. Entity Relationship Diagram that has been analized can seen on Figure 6.

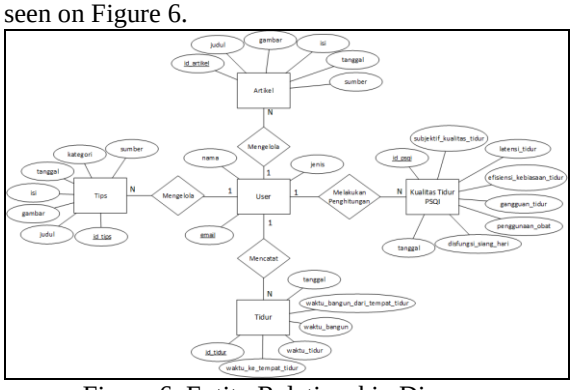


Figure 6. Entity Relationship Diagram

From Entity Relationship Diagram can be know data dictionary as can seen below.

a. User: {email, nama, jenis}
b. Artikel: {id_artikel, judul, gambar, isi, tanggal, sumber}
c. Tips: {id_tips, judul, gambar, isis, tanggal, kategori, sumber}
d. Tidur: {id_tidur, waktu_ke_tempat_tidur, waktu_tidur, waktu_bangun, waktu_bangun_dari_tempat_tidur, tanggal}
e. Kualitas Tidur PSQI: {id_psqi, subjectif_kualitas_tidur, latensi_tidur, efisiensi_kebiasaan_tidur, gangguan_tidur, penggunaan_obat, disfungsi_siang_hari}

2.5 Non Functional Requirement Analysis

Non-functional requirements of the system is a system requirement of things that are in the system environment, but it is not required by the functional found in the system. Non-functional system requirements consist of system user requirements, hardware requirements and system software as well as non-functional system software requirements specification.

1. User Needs Analysis

In addition to users of applications as for users who manage system content is Admin. The admin of the application is responsible for managing the article data and tips that he posts. The characteristics of each system user can be seen on **Error! Reference source not found.**.

Table 1 User Needs Analysis

Type of User	Criteria or User Ability	
Administrator	School	SMA/K or equal
	Age	20 – 35 years old
	Ability to Use Computer	Understand how to operate computer with good and correctly
	Experience using Application	Understand how to use Content Management System (CMS) based on Website
	Ability Level to Read	Able to read at medium speed or faster
	Typing Skills	Able to type at 40 words per minute
	Language Skills	Understand Indonesian language
	Level of Understanding About Sleep	Simply understand information about healthy sleep, at least knowing which information is wrong and correct
User of Application	Age Group	Adults or 18 – 59 years old
	Profession atau job	Collage Student/ Workers/ Employees/ Professional/

Type of User	Criteria or User Ability	
		Housewife
	Smartphone Used	Android

2. Hardware Needed

Hardware that need by each user is show below:

a. Hardware for User of Application

User of application smartphone, need an hardware smartphone Android with spesification as follows:

- Processor : Intel Atom® Processor Z2520 1.2 GHz, or higher
- RAM : 1.5 GB, 2 GB recommended
- Recommended available light sensor, and microfon

b. Hardware for Administrator

User of website or Administrator need hardware an computer unit or laptop with spesification as follows:

- Processor *Pentium* 4 1.5 GHz or higher
- RAM 500 MB
- *Harddisk* 10 GB
- VGA 32 bit 32 MB

3. Software Needed

Software that needed by each user application as follows:

a. Software that needed by User of Smartphone Application is as follows:

- Sistem operasi Android versi 4.4 (Kitkat atau API level 19) atau lebih tinggi
- Aplikasi Gear Manager yang dilengkapi dengan Gear Fit2 Plugin dan Samsung Accessory Service
- Aplikasi S Health versi 4.0 atau lebih tinggi dari Samsung, Inc.
- Koneksi *bluetooth* (dibutuhkan untuk mendapatkan data dari *wearable* Samsung Gear Fit2 ke aplikasi S Health)
- Koneksi internet (dibutuhkan untuk melihat informasi dan *tips* mengenai tidur)

b. Software that needed for Administrator is as follows:

- Sistem operasi Windows XP atau lebih tinggi
- Web browser Mozilla Firefox atau Google Chrome atau Microsoft Edge
- Koneksi Internet

2.6 Functional Requirement Analysis

The main functional of the application based on the validation of the idea is 5 functional, but to support the main functionality there are other supporting functions and involve actors outside the system. The functionalities of the system as a whole are analyzed and modeled using use case diagrams, use case scenarios, activity diagrams, class diagrams, and sequence diagrams [12].

2.7 Database Design

Database used is MySQL database with relation scheme and table structure in the database as follows.

1. Relation Scheme

Schema relation table in the system database can be seen on Figure 7.

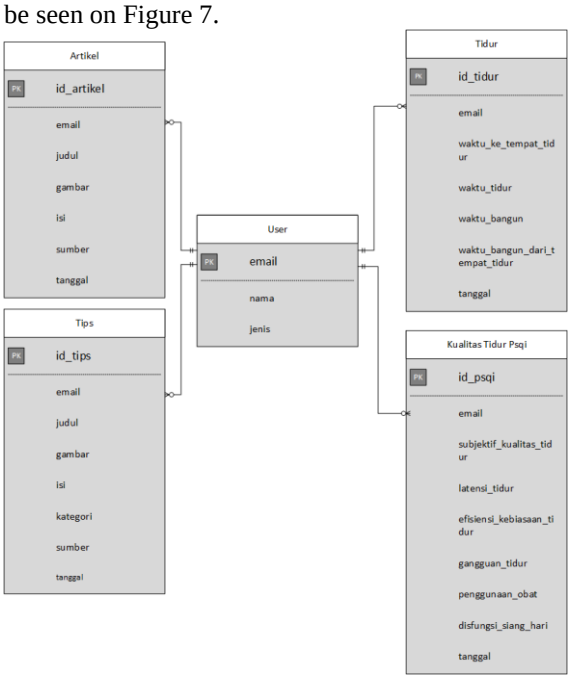


Figure 7. Relation Scheme

2. Table Structure

The structure of the database table using MySQL include the following.

a. Table structur of user can seen on Table 2.

Table 2 User Needs Analysis

Nama Kolom	Tipe Data	Size	Ket
email	varchar	125	Primary key
nama	varchar	225	
jenis	Enum('Admin','Pengguna Aplikasi')		

b. Table structur of sleep can seen on Table 3.

Table 3 User Needs Analysis

Nama Kolom	Tipe Data	Size	Ket
id_tidur	int	11	Primary key
email	varchar	125	Foreign key references User(email)
waktu_ke_	long		Not null

Nama Kolom	Tipe Data	Size	Ket
tempat_tidur			
waktu_tidur	long		Not null
waktu_bangun	long		Not null
waktu_bangun_ dari_tempat_tidur	long		Not null
tanggal	Date		Not null

c. Table structur of sleep quality can seen on Table 4.

Table 4 User Needs Analysis

Nama Kolom	Tipe Data	Size	Ket
id_psqi	int	11	Primary key
email	varchar	125	Foreign key references User(email)
subjektif_kualitas_ tidur	int	225	Not null
latensi_tidur	int	1	Not null
efisiensi_ kebiasaan_tidur	int	1	Not null
gangguan_tidur	int	1	Not null
penggunaan_obat	int	1	Not null
disfungsi_siang_ hari	int	1	Not null
tanggal	Date		Not null

d. Table structur of tips can seen on Table 5.

Table 5 User Needs Analysis

Nama Kolom	Tipe Data	Size	Ket
id_tips	int	11	Primary key
email	varchar	125	Foreign key references User(email)
judul	varchar	225	Not null
gambar	varchar	225	Not null
isi	text		Not null
kategori	enum(‘Latensi Tidur’, ‘Durasi Tidur’, ’Efisiensi Kebiasaan Tidur’, ’Gangguan Tidur’, ’Obat Tidur’, ’Disfungsi Siang Hari’)		Not null
sumber	varchar	255	Not null
tanggal	date		Not null

e. Table structur of article can seen on Table 6.

Table 6 User Needs Analysis

Nama Kolom	Tipe Data	Size	Ket
id_artikel	int	11	Primary key
email	varchar	125	Foreign key references User(email)
judul	varchar	225	Not null
gambar	varchar	225	Not null
isi	text		Not null
sumber	varchar	255	Not null, Default ‘-’
tanggal	date		Not null

2.8 Result of Implementation and System Testing

The result of system implementation by implementing database, API, interface, and functional.

1. Implementation of database

The database is implemented using MySQL as SQL language database processing software (Structure Query Language) and stored in the Azure SQL database.

2. Implementation of API

API as an intermediary exchange of data from application to database is implemented by building RESTful API with JSON format. Base URL from API that has been implemented is http://diamondsleep.azurewebsites.net/api/v1/.

The process of testing the website sub-system is done by using equivalent partition black box method by adjusting the input to the output on a functional to make sure the functionality is in accordance with software requirement specification or not. Based on black box testing done on Sleepy website, it can be concluded that the Sleepy application website for Administrator is in accordance with the requirements of the system software requirements and can be used by the Administrator to manage articles and tips.

While testing on sub Android application system to ascertain whether the built application has been able to help the adult age group know the efforts that can be done to improve the quality and make it easy to know how the quality of sleep. Therefore, testing with usability testing method. Usability testing is a testing method to users who focus on the ability of the application to be easy to use and studied by the user so that the purpose of the application can be perceived by the user [10].

The job scenarios given to users (application testers) can be seen on Table 7.

Table 7 Job Scenarios of Usability Testing

No	Job Scenarios
1.	You will see detailed information tips to improve sleep quality with the category 'Sleep Duration' and the title 'Tips to Get a Good Sleep Time'
2.	You'll find out how good your sleep was last night by following the sleep quality calculation method in this App. Please use this app to calculate your sleep quality!
3.	You will see the state of the environment in the form of light intensity and noise levels that can affect the quality of sleep. Please contemplate this app to see the circumstances of the environment!
4.	You will go to bed and want to play relaxation music before going to bed. You will play a playlist named 'Peaceful Piano' and playback duration for '5 minutes'. Please do relaxation music playback with this app!

The list of questions asked during testers using the app can seen on Table 8.

Table 8 Question Interview Usability Testing

No	Question	Time
1.	Can you tell which tips to improve the quality of sleep and which Articles on sleep?	When testers are on the home page
2.	Do you know how good your sleep is?	When the examiner has completed the question in calculating the quality of sleep
3.	Do you know which components of the assessment category are influencing your sleep to be poor quality? Please specify!	When the testers has completed the question in calculating the quality of sleep
4.	Can you find out where your tips are most needed to improve the quality of sleep?	When the testers finish counting the quality of sleep and then see the tips (are on the tips list page)
5.	Are you able to know the state of the light intensity and the level of environmental noise that can affect the quality of sleep?	When testers are on page to see the state of the environment that affects the quality of sleep
6.	What are your impressions and messages after using this app?	When testers exit the app by issuing their Google account.

The results of this usability testing test consist of the result of the ability of the user to complete the job given by using the application, the result of the interview, and the questionnaire results the difficulty level of completing the work in the application. Here is the result of testing usability testing on the application:

1. Some results of tester ability to complete the task can be seen on Table 9.

Table 9 Result of User's Ability to Complete Task

Tasks	Tester					Quantity	Success Rate
	1	2	3	4	5		
1	1	1	1	1	1	5	100%
2	1	1	1	0	1	4	80%
3	1	1	1	1	1	5	100%
4	1	1	1	1	1	5	100%
5	1	0	0	1	1	3	60%
6	1	1	1	1	1	5	100%
7	1	1	1	1	1	5	100%
8	1	0	0	0	0	1	20%
9	1	1	1	1	1	5	100%
10	1	1	1	1	1	5	100%
11	1	1	1	1	1	5	100%

2. The result of interview with users can view on Table 10.

Table 10 The Result Of Interview

Pertanyaan	Jawaban
1	The five users say "Can be differentiated or separated by tab."
2	Four out of 5 users say "Quite understandable."
3	Four out of 5 users say "Can." But 2 of them say "Some components of the assessment have not understood what it means, such as sleep latency and daytime dysfunction."
4	Four out of 5 users say "Good, the app can be used to help improve the quality of sleep.", and 1 other user gives hope and inserts for more apps.

3. The result of difficulty level questionnaire can seen on Table 11.

Table 11 Result of Difficulty Level Questionnaire

	Rating Result	Sub Total	Total	Avg	Category
Task 1	Very Easy (1) = 4 people Easy (2) = 1 people	1 * 4 = **4** 2 * 1 = **2**	6	6/5 = 1,2 ≈ 1	Very Easy
Task 2	Very Easy (1) = 3 people Easy (2) = 1 people difficult (4) = 1 people	1 * 3 = **3** 2 * 1 = **2** 4 * 1 = **4**	9	9/5 = 1,8 ≈ 2	Easy
Task 3	Very Easy (1) = 3 people Easy (2) = 2 people	1 * 3 = **3** 2 * 2 = **4**	7	7/5 = 1,4 ≈ 1	Easy
Task 4	Very Easy (1) = 1 people Easy (2) = 3 people Ordinary (3) = 1 people	1 * 1 = **1** 2 * 3 = **6** 3 * 1 = **3**	10	10/5 = 2	Easy
Task 5	Very Easy (1) = 1 people Easy (2) = 2 people Ordinary (3) = 1 people difficult (4) = 1 people	1 * 1 = **1** 2 * 2 = **4** 3 * 1 = **3** 4 * 1 = **4**	12	12/5 = 2,4 ≈ 2	Easy

	Rating Result	Sub Total	Total	Avg	Category
Task 6	Very Easy (1) = 2 people Easy (2) = 2 people Ordinary (3) = 1 people	1 * 2 = **2** 2 * 2 = **4** 3 * 1 = **3**	9	9/5 = 1,8 ≈ 2	Easy
Task 7	Very Easy (1) = 2 people Easy (2) = 1 people Ordinary (3) = 1 people difficult (4) = 1 people	1 * 2 = **2** 2 * 1 = **2** 3 * 1 = **3** 4 * 1 = **4**	11	11/5 = 2,2 ≈ 2	Easy
Task 8	Very Easy (1) = 2 people Easy (2) = 1 people Ordinary (3) = 2 people	1 * 2 = **2** 2 * 1 = **2** 3 * 2 = **6**	10	10/5 = 2	Easy
Task 9	Very Easy (1) = 4 people Easy (2) = 1 people	1 * 4 = **4** 2 * 1 = **2**	6	6/5 = 1,2 ≈ 1	Very Easy
Task 10	Very Easy (1) = 4 people Easy (2) = 1 people	1 * 4 = **4** 2 * 1 = **2**	6	6/5 = 1,2 ≈ 1	Very Easy
Task 11	Very Easy (1) = 4 people Easy (2) = 1 people	1 * 1 = **4** 2 * 1 = **2**	6	6/5 = 1,2 ≈ 1	Very Easy
Total			**92**		

Average overall score is obtained with total total score / (number of tasks * number of likert scale) = 92 / (5 * 11) = 1.67 ≈ 2. So the result of questionnaire assessment Sleepy difficulty level to 5 testers are in category ' Easy'.

3. CLOSING

Described the conclusions derived from the results of the discussion that existed in the previous chapters as well as suggestions provided for research improvements or application systems built.

3.1 Conclusion

Based on the results of tests that have been done on Sleepy application, it can be obtained the following conclusion:

1. The built application has been able to help adults to know the efforts that can be done to improve the quality of sleep. The efforts that can be seen in the application are presented in the tips feature. The views on tips are sorted out by the most influential rating categories from the sleep quality calculations. This is done so that users can first see the tips needed. In addition, adults are also notified if there is detected light intensity or noise levels that can affect sleep quality when relaxation music before going to bed.
2. Sleepy apps can also make it easier for adults to find out how good sleep is. How much sleep quality can be known through the use of the sleep quality calculation feature with the PSQI calculation method.

So, based on the tests that have been done on Sleepy apps, the overall Sleepy app already can be used to help adults know the efforts that can be done to improve sleep quality and make it easier for adults to know how quality sleep.

3.2 Suggestion

Based on the research that has been done also, got suggestions in the development of this application in the future that is as follows:

1. Conducting research to know the experience of adult sleep patterns during the application, this will get an output of how influential the application built on sleep patterns of someone, as well as the recommendation of user experience in the application.
2. Integrated with IoT or smart home devices to further help users make efforts that can improve the quality of sleep, such as can control or turn off light sources such as lights through the application (light controller) and the reading of the room temperature that can affect the quality of sleep.

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