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# Platform for monitoring and treat depression

José Pedro Ornelas  
Dissertação de Mestrado apresentada à  
Faculdade de Ciências da Universidade do Porto em  
Ciência de Computadores  
2016

MSc

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CICLO

FCUP  
2016



Platform for monitoring and treat depression

José Pedro Ornelas



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**INESCTEC**  
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ASSOCIATE LABORATORY  
PORTUGAL

# Platform for monitoring and treat depression

José Pedro Alves de Ornelas

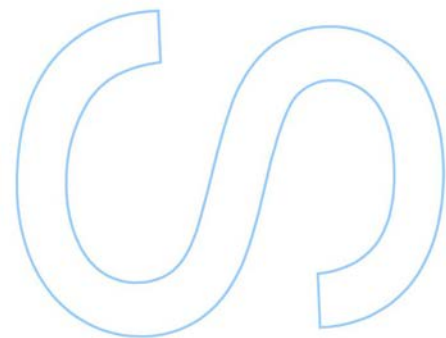
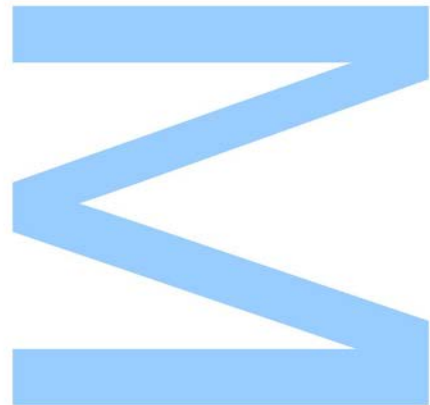
Mestrado Integrado em Engenharia de Redes e Sistemas Informáticos  
Departamento de Ciência de Computadores  
2016

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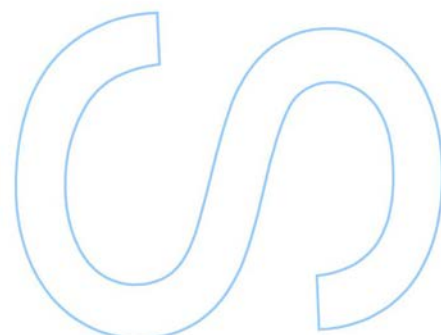
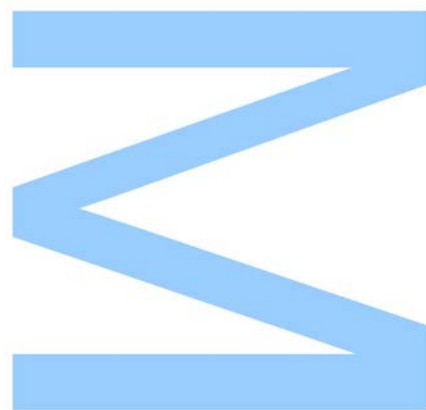




Todas as correções determinadas pelo júri, e só essas, foram efetuadas.

O Presidente do Júri,

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# Abstract

Depressive diseases have been spreading for the last few years. In primary care it is extremely difficult to deal with the high numbers of patients that fight this disease on a daily basis. It is extremely important to develop cheap and effective tools that allow to treat and follow these patients.

This master thesis aims to describe the work developed under the Stop Depression and the European Comparative Effectiveness Research on Internet-based Depression Treatment (**E-COMPARED**) projects. In these projects we gathered the requirements and created a new system that allows to create and deliver new treatments to treat depression. This system has in its core a new portal, called Intervention Builder (**iBuilder**), that is responsible to provide the necessary tools for creating the new treatments.

Creating this system involved reimplementing the current system, Moodbuster. Moodbuster is composed by two other portals: the Therapist portal that is used by the psychologists to monitor their patients at a distance and the Patient portal that is used by the patients in order for them to work on their treatments. Both these portals were reimplemented and although they do not offer all the functionalities from the current system they work with treatments created on the **iBuilder** portal. The developed portals only provide access to the treatments over the internet, although we implemented a web services' layer that in the future can be used to create these portals for other platforms.

Although this system is still under development we asked some expert psychologists to test it. Although they considered it is too early to evaluate the system at this point, they both acknowledged that this work has a lot of potential.



# Resumo

As doenças depressivas têm vindo a espalhar-se ao longo dos últimos anos. Os cuidados de saúde primários não conseguem lidar com o vasto número de doentes que lidam diariamente com esta doença. Torna-se fulcral desenvolver ferramentas baratas e eficazes que permitam tratar e acompanhar estes doentes.

A presente dissertação tem como objetivo descrever o trabalho desenvolvido no âmbito dos projetos Stop Depression and European Comparative Effectiveness Research on Internet-based Depression Treatment (**E-COMPARED**). No âmbito destes projetos foi feito um levantamento de requisitos que levou à criação de um novo sistema que permite criar e disponibilizar novos tratamentos para tratar a depressão. O sistema tem como componente principal um novo portal a que chamamos Intervention Builder (**iBuilder**) e que é responsável por fornecer as ferramentas necessárias à criação dos novos tratamentos.

A criação deste sistema envolveu uma reimplementação do sistema atual, o Moodbuster. Este sistema é composto por dois portais: o portal do Terapeuta que é direcionado aos psicólogos e que permite monitorizar à distância os pacientes e o portal do Paciente que é utilizado pelos pacientes de forma a que possam seguir as suas terapias. Estes dois portais foram reimplementados e embora ainda não ofereçam todas as funcionalidades do sistema atual, funcionam com os tratamentos gerados pelo portal **iBuilder**. Os portais desenvolvidos apenas suportam o tratamento através da internet, contudo tomamos as providências necessárias, através da implementação de uma camada de serviços, para que no futuro estes portais possam estar acessíveis através de outras plataformas.

Embora o sistema desenvolvido ainda esteja numa fase de desenvolvimento, passou por uma fase de testes feitos junto de dois psicólogos reconhecidos globalmente. Embora estes tenham reconhecido que é precoce avaliar o sistema nesta fase, ambos reconheceram que este trabalho tem valor e potencial.



# Agradecimentos

A escrita de uma secção de agradecimentos torna-se uma tarefa um pouco ingrata pois não será possível enumerar todos aqueles que me motivaram para o desenvolvimento e conclusão desta dissertação. Mas a todos eles deixo o meu sincero obrigado.

Contudo, não poderia deixar de agradecer primeiramente ao Professor Pedro Brandão por ter aceite orientar e participar neste desafio.

Ao Eng.º Artur Rocha, por me ter dado a possibilidade de participar num projeto tão ambicioso e que no futuro terá concerteza um impacto direto e importante na vida de milhares de pessoas.

Ao Professor João Correia Lopes que aceitou coorientar esta dissertação e que se demonstrou sempre disponível no debate de ideias e na procura de soluções.

E por fim à minha família que sempre me apoiou, sustentou e incentivou, em especial à Mariana pela paciência e motivação.

Obrigado!





# Contents

<b>Abstract</b>	<b>1</b>
<b>Resumo</b>	<b>3</b>
<b>Agradecimentos</b>	<b>5</b>
<b>Contents</b>	<b>9</b>
<b>List of Figures</b>	<b>13</b>
<b>Listings</b>	<b>15</b>
<b>Acronyms</b>	<b>17</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Objectives . . . . .	2
1.2 Document structure . . . . .	3
<b>2 State of the art</b>	<b>5</b>
2.1 Cognitive Behavioural Therapy (CBT) . . . . .	5
2.2 E-Mental Health (eMH) . . . . .	7
2.3 Tools for depression treatment . . . . .	8
2.3.1 Moodkit . . . . .	8
2.3.2 iFightDepression . . . . .	9
2.3.3 Cognitive Diary CBT Self-Help . . . . .	10

2.3.4	Moodtools . . . . .	10
2.3.5	Minddistrict . . . . .	11
2.3.6	Mood Watch . . . . .	12
2.3.7	MoodHacker . . . . .	13
2.3.8	ICT4Depression Moodbuster . . . . .	13
2.4	Conclusion . . . . .	14
<b>3</b>	<b>Background</b>	<b>17</b>
3.1	Components . . . . .	17
3.1.1	Mobile phone application . . . . .	18
3.1.2	Wearable biomedical devices . . . . .	18
3.1.3	Reasoning system . . . . .	18
3.2	System architecture . . . . .	19
3.3	Web client applications . . . . .	20
3.3.1	Patient Portal . . . . .	20
3.3.2	Therapist Portal . . . . .	26
3.4	Database . . . . .	28
3.5	Conclusion . . . . .	30
<b>4</b>	<b>Design</b>	<b>33</b>
4.1	Use cases . . . . .	33
4.1.1	Actors . . . . .	34
4.1.2	System use case diagrams . . . . .	34
4.2	Conceptual domain model . . . . .	36
4.3	Activity diagrams . . . . .	38
4.4	Interface . . . . .	39
4.5	Conclusion . . . . .	41
<b>5</b>	<b>Development</b>	<b>49</b>

<i>CONTENTS</i>	9
5.1 Architecture . . . . .	49
5.2 Technology . . . . .	50
5.2.1 Database . . . . .	51
5.2.2 Front-end . . . . .	52
5.2.3 Back-end . . . . .	52
5.3 Implementation . . . . .	54
5.3.1 Database . . . . .	54
5.3.2 Back-end . . . . .	58
5.3.3 Front-end . . . . .	60
5.4 Evaluation . . . . .	61
5.5 Conclusion . . . . .	64
<b>6 Conclusion</b>	<b>69</b>
6.1 Future work . . . . .	70
<b>A Use cases</b>	<b>71</b>
<b>B Detailed design process</b>	<b>77</b>
<b>C Front-end portals</b>	<b>83</b>
C.1 Intervention Builder (iBuilder) . . . . .	83
C.2 Patient portal . . . . .	83
C.3 Therapist portal . . . . .	83
<b>D Evaluation responses</b>	<b>89</b>
<b>Bibliography</b>	<b>95</b>



# List of Figures

- 2.1 Cognitive Behavioural Therapy (CBT) cycle . . . . . 6
  
- 3.1 Moodbuster system overview . . . . . 19
- 3.2 Moodbuster homepage . . . . . 21
- 3.3 Moodbuster therapy . . . . . 21
- 3.4 Moodbuster exercises . . . . . 21
- 3.5 Psychoeducation module video. . . . . 22
- 3.6 Psychoeducation module - My rewards . . . . . 22
- 3.7 Behavioural Activation module - pleasant activities . . . . . 23
- 3.8 Behavioural Activation module - monitoring . . . . . 23
- 3.9 Behavioural Activation module - balancing activities . . . . . 23
- 3.10 Behavioural Activation module - evaluate . . . . . 23
- 3.11 Cognitive restructuring module - automatic thoughts . . . . . 24
- 3.12 Cognitive restructuring module - automatic thoughts credibility . . . . . 24
- 3.13 Cognitive restructuring module - thinking errors . . . . . 25
- 3.14 Cognitive restructuring module - challenging . . . . . 25
- 3.15 Cognitive restructuring module - evaluation . . . . . 26
- 3.16 Patient Health Questionnaire (PHQ) . . . . . 27
- 3.17 Therapist portal - ratings page . . . . . 28
- 3.18 Therapist portal - therapy page . . . . . 28
- 3.19 Therapist portal - exercises page . . . . . 29

3.20	Moodbuster database - users . . . . .	30
3.21	Moodbuster database - patient . . . . .	30
3.22	Moodbuster database - psychoeducation and physical therapy . . . . .	31
3.23	Moodbuster database - cognitive restructuring . . . . .	32
4.1	Use case - actors . . . . .	34
4.2	Usage scenario - system overview . . . . .	35
4.3	System use case diagram - Intervention Builder (iBuilder) overview . . . . .	36
4.4	System use case diagram - modules . . . . .	37
4.5	System use case diagram - treatments . . . . .	42
4.6	System use case diagram - translations . . . . .	43
4.7	Conceptual domain model diagram . . . . .	44
4.8	Activity diagram - create module . . . . .	45
4.9	Activity diagram - create treatment . . . . .	45
4.10	Activity diagram - access module . . . . .	46
4.11	Activity diagram - manage patient . . . . .	47
4.12	User-Interface (UI) HyperText Markup Language (HTML) prototype. . . . .	47
4.13	UI final sketches. . . . .	48
5.1	System architecture diagram . . . . .	51
5.2	User's data model . . . . .	58
5.3	System's API . . . . .	59
5.4	Front-end - elements . . . . .	61
5.5	Edit modals . . . . .	62
5.6	Page modes. . . . .	63
A.1	Patient portal use cases overview. . . . .	72
A.2	Patient portal modules use cases overview. . . . .	73
A.3	Therapist portal use cases overview. . . . .	74

*LIST OF FIGURES* 13

A.4 Therapist portal patients use cases. . . . . 75

A.5 Therapist portal edit patients use cases. . . . . 76

B.1 Old UI sketches. . . . . 78

B.2 Old UI sketches. . . . . 79

B.3 Old UI sketches. . . . . 80

B.4 New UI sketches. . . . . 81

B.5 Therapist portal treatment page. . . . . 82

C.1 iBuilder pages part 1. . . . . 84

C.2 iBuilder pages part 2. . . . . 85

C.3 Patient portal pages. . . . . 86

C.4 Therapist portal pages. . . . . 87

D.1 Questionnaire answers and responses. . . . . 90

D.2 Questionnaire answers and responses part 2. . . . . 91

D.3 Questionnaire answers and responses part 3. . . . . 92

D.4 Questionnaire answers and responses part 4. . . . . 93





# Listings

- 5.1 Mongoose input schema . . . . . 55
- 5.2 Mongoose list schema . . . . . 56
- 5.3 Mongoose textarea schema . . . . . 57
- 5.4 Mongoose page schema . . . . . 57
- 5.5 Mongoose module schema . . . . . 65
- 5.6 Mongoose treatment schema . . . . . 66
- 5.7 Mongoose translation schema . . . . . 67
- 5.8 Postgres treatmentState attribute . . . . . 68



# Acronyms

<b>API</b>	Application Programming Interface	<b>INESCTEC</b>	Institute for Systems and Computer Engineering - Technology and Science
<b>BVP</b>	Blood Volume Pulse	<b>JSON</b>	Javascript Object Notation
<b>CBT</b>	Cognitive Behavioural Therapy	<b>JWT</b>	JSON Web Token
<b>CMS</b>	Content Management System	<b>MVC</b>	Model View Controller
<b>CSS</b>	Cascade Style Sheets	<b>MVVM</b>	Model View ViewModel
<b>EAAD</b>	European Alliance Against Depression	<b>NoSQL</b>	Non SQL
<b>ECG</b>	Electrocardiography	<b>ODM</b>	Object Document Mapping
<b>E-COMPARED</b>	European Comparative Effectiveness Research on Internet-based Depression Treatment	<b>ORM</b>	Object Relational Mapping
<b>EDA</b>	Electrodermal Activity	<b>PHQ</b>	Patient Health Questionnaire
<b>EMA</b>	Ecological Momentary Assessment	<b>PHQ-9</b>	Patient Health Questionnaire version 9
<b>eMH</b>	E-Mental Health	<b>PTSD</b>	Post Traumatic Stress Disorder
<b>GUI</b>	Graphical User Interface	<b>REST</b>	Representational State Transfer
<b>HTML</b>	HyperText Markup Language	<b>RDBMS</b>	Relational Database Management System
<b>HTTP</b>	HyperText Transfer Protocol	<b>SOA</b>	Service Oriented Architecture
<b>iBuilder</b>	Intervention Builder	<b>SQL</b>	Structured Query Language

<b>TAM2</b>	Technology Acceptance Model 2	<b>WYSIWYG</b>	What You See Is What You Get
<b>UI</b>	User-Interface	<b>WWW</b>	World Wide Web
<b>UML</b>	Unified Modeling Language	<b>YAML</b>	Yet Another Markup Language

# Chapter 1

## Introduction

Depression is a common mental disorder that affects about 350 million people around the world. [31] This disease is characterized by mood changes and it is expressed essentially by feelings of unhappiness, sadness and frustration. In severe cases it may even lead to suicide. These features make it a serious illness that affects not only the individual but also those around him. Usually the symptoms include, among others, thoughts of suicide, acts of self-harm, reduction of self-esteem and self-confidence, reduction of concentration and attention, and sleep disturbance. [21]

The World Health Organization predicts that in 2020, mental health disorders will be the second leading cause of disease. [30] However there are effective methods to prevent and treat this disease and they can reduce the disease burden in about one third. [25] The treatment of this disease is usually made face-to-face, what makes it very expensive and time consuming. One of the most important methods to reduce the depressive disorders is psychotherapy, however this method does not reach all patients. It is estimated that less than half of the patients that suffer from mental illness receives treatment, and this number is much lower in teenagers, older people, people with lower socio-economic status and people from ethnic minorities. [11]

Most of the patients with depression are treated in primary care where medical resources are limited and involve high costs for the patient and for the society. In most cases, patients are treated with pharmacotherapy although they prefer psychotherapy. [11] Given the limited time that doctors have for each patient, the disease growth and high costs required for the treatment urges the necessity to find different methods of treatment that can reach more patients at lower costs.

Over the past few years E-Mental Health (eMH) field is increasing its notoriety. This field aims to use technology and digital devices to provide tools capable of delivering screening, health promotion, prevention, early intervention, treatment or relapse prevention as well as improve health care delivery, professional education and online research in the mental health field. [34] The progress made in this area allows the treatment of depressive disorders to spread to a higher number of patients.

The treatment most frequently applied consists in Cognitive Behavioural Therapy (CBT) that has been adapted to the Internet and mobile devices. It divides essentially in two formats: self-help and blended. The first one, has been used in books, articles and audio records over many years, and aims that for the patient to follow a therapy guide by himself. The second is the blended model, also called guided self-help, and combines the self-help and face-to-face therapy. The patient follows the therapy modules under guidance of his doctor that guides him through face-to-face appointments or through feedback messages sent by telephone or email. Both formats have proven effectiveness in a large number of trials [22] and studies, however the first one has higher rates of drop-outs. [11] These tools have been tested, improved and are part of different studies that analyse the rates of success and drop-outs. Some of these can reach a higher number of patients, such as Moodbuster [35, 40] which is present in 7 different European countries. The future presents more prosperous alternatives to fight the depression disease, these tools can scale and reach a large number of patients, reduce the treatment cost as well as the waiting lists, they let the patient take the treatment at his own pace and allow to reduce the disease stigma.

## 1.1 Objectives

This work was developed at Institute for Systems and Computer Engineering - Technology and Science (INESCTEC) under the project Stop Depression [9] and the project European Comparative Effectiveness Research on Internet-based Depression Treatment (E-COMPARED) [12], and all the acquired knowledge has been obtained from its development. The Stop Depression [9] project is a pilot study funded by the EEA Grants that aims to answer the needs of the Portugal Mental Health Program through the improvement of the access to the mental health services. The E-COMPARED project aims to provide mental healthcare stakeholders with evidence-based information and recommendations about the clinical and cost-effectiveness of blended depression treatment. Both projects include, among other tools, a web application based in Moodbuster that implements CBT.

Through the technological evolution of this application, medical specialists associated with both projects started creating new requirements. Currently, the process to create a therapy module goes through some stages. First the module is typified by these specialists, then it moves to the software developers that integrate it in the application and finally the module is translated. This process takes some time especially because of the software development part. Therefore, the main objective of this work is to develop a platform which allows the psychologists to create the therapy modules without the intervention of software developers. The overall objectives of this work are the following:

- Comparison of existing tools implementing CBT;
- System architecture design that ensures support of multiple devices;

- Data model design that ensures flexibility, reliability, security and data integrity, involving re-design of the current data model;
- Implementation, test and documentation of the treatment creation tool.

## 1.2 Document structure

In addition to this chapter this thesis includes other 5 chapters:

- **Chapter 2:** in the State of the Art chapter we will analyse how depression is being treated from the theoretical perspective and the technological perspective;
- **Chapter 3:** in the Background chapter we will analyse how the Moodbuster system has evolved to its current version;
- **Chapter 4:** in the Design chapter we will specify all the requirements needed for the proof of concept prototype that we will develop;
- **Chapter 5:** in the Development chapter we will analyse the technologies used, some of the implementation aspects and the results of the system evaluation;
- **Chapter 6:** in the Conclusion chapter we will analyse all the findings and future work.





## Chapter 2

# State of the art

Depressive disorders constitute a big challenge for the next decades. [11] There are several effective treatments for depressive disorders like Interpersonal Therapy, Cognitive Behavioural Therapy (CBT), Short-term Psychodynamic Therapy and Problem Solving Therapy. [24]

In this chapter we will approach the use of CBT and E-Mental Health (eMH), which are becoming important tools on fighting the mental disorders' burden. CBT has strong empirical base for depression with hundreds of controlled trials. [24, 28] eMH makes use of the latest technology and applies it to increase the treatment effects on mental diseases.

Everyday new methods and tools appear to fight the depression burden. Some of them are structured and supported by scientific methods and others are unstructured, usually created by the necessity of its users. In this chapter we will cover some of the most recent tools used to treat and prevent depression.

### 2.1 CBT

A depressed patient it is generally "trapped" in a vicious cycle (figure 2.1) of thoughts, behaviours and feelings. For every situation these three elements are linked and influence each other. For example, if a patient is feeling sad, it will start having sad thoughts and it will likely act in a way that will reinforce these feelings and thoughts.

CBT is a form of psychotherapy that as evolved from several approaches of dealing with mental disorders. It targets to break the figure 2.1 cycle, by helping the patient develop a set of skills that will teach him to think and act differently. Learning this will help him to control is feelings and actually feel better.

We can see CBT more like a generalization for a set of very similar therapies. [18] This set of therapies started to appear in the late 60s and have been influenced by the work of Albert Ellis (Rational Emotive Behaviour Therapy) and Aaron Beck (Cognitive Therapy). [18]

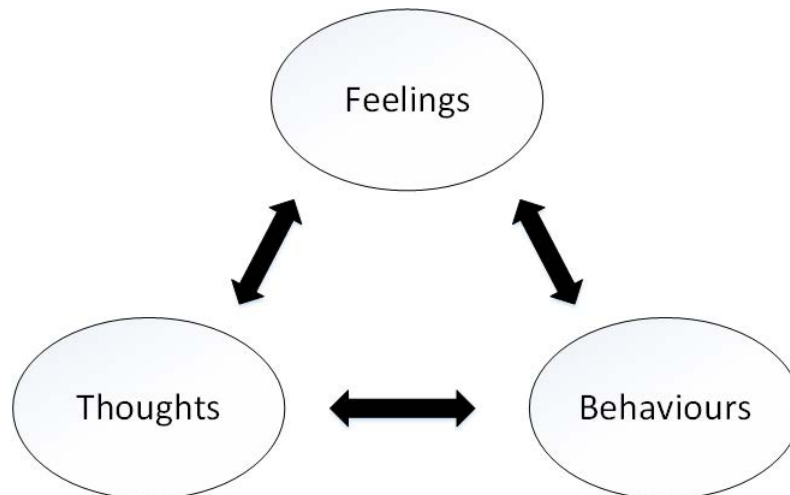


Figure 2.1: Thoughts, behaviours and feelings cycle

There are multiple variants of the CBT treatment but they all share a set of characteristics. [18] The treatment consists in time-limited interventions that can be applied to individuals or groups. These start with a psychoeducation component where patients learn how to notice their own thoughts, feelings and behaviours and are provided with treatment strategies to handle them. The patients usually receive some self-help exercises that allow them to practice and enhance the strategies learnt outside of the therapy room. These treatments require a high level of therapist activity. The therapist must assess the psychiatric state of the patient and develop the necessary therapeutic strategies for each case. These therapies have been built with empirical evidence that supports and guides the therapist while choosing the right techniques to apply.

The therapy can be adapted to each patient according to his problem nature or severity. Depending on the mental disorder and the patient, it can be applied as face-to-face therapy, self-help (based in books, audio or a computerised system like a computer or a smart-phone), individual or group sessions. Also, depending on the severity of the problem it can require a shorter or longer period of time to treat the patient.

The human being usually just reacts to thoughts and feelings instead of reading or questioning about them. Emotions and feelings are difficult to change, for this reason, CBT teaches how to examine thoughts and behaviours. Usually, it focus on dealing on present and recent events but some variants also search for past events that could trigger the patient current state. The therapy is very goal oriented and involves a collaborative effort between the therapist and the patient. Additionally, it implicates a practical cognitive and behavioural reconstruction, which results from the practice of the strategies developed in the therapy room. The patient must reach the point where he can do it on his own, he feels well and he is prepared to tackle his problems.

CBT has proven to be an effective treatment for adults, older adults, teenagers and children, by various studies. [22] This therapy has proven to be effective and one of the fastest methods for treating a wide range of mental diseases like depression, obsessive compulsive disorder, anxiety disorders, Post Traumatic Stress Disorder (PTSD), bipolar disorder, and many others.

## 2.2 eMH

Technology is more and more present in our lives, we are using it everywhere everyday. In healthcare we are using it to control, detect, prevent or treat almost every type of diseases. The concept of using telecommunications and information technologies in health care is frequently called as eHealth. As to mental illnesses, technology started to be used in the late 90s [11] to provide mental health services through the use of eMH. [34]

The main objective of eMH is to empower patients and providers with more efficient and sophisticated tools. These tools must ultimately impact in the quality of the service provided to the patient. This may be seen in four primary forms: [28]

- better access;
- evidence-based treatments by preference;
- empowerment, in the form of choice, access, and incentive to participate;
- ability to engage providers, clinics and systems more directly.

The use of eMH has several advantages the first being cheaper than the traditional face-to-face therapy. Also, it makes possible to assist people from rural areas, to facilitate traditional and new treatments, to provide tools that allow the patient to self-manage his condition, to spread health promotion, to reduce stigma, to improve early detection and continuous prevention. [10] Furthermore, it helps improving therapists' skills through online classes or formal training at distance. This results in several improvements for the patient, ultimately a faster and better diagnosis.

The traditional method of treatment, also known as face-to-face therapy, has been evolving to self-help therapy and to the blended model that combines the previous two, supported by information technologies. The ratio of patients for each mental health professional does not allow the traditional method to scale to a point where it is possible to fight the mental disorders efficiently. Therefore, this evolution of the traditional method allows the treatment to reach higher numbers of patients and to improve screening, treatment and relapse prevention effectiveness.

Regarding depression, the treatment options usually focus on internet or mobile mood diaries implemented with self-help or blended CBT. Over the last years, several controlled trials focused on providing and studying these new ways of treatment. Most of these trials implemented internet treatment solutions and the most recent ones are also implementing mobile applications. The results of these trials allow to make direct comparisons between these new types of treatment and the traditional face-to-face therapy. They have been proving that there are no big differences between their effectiveness. [4, 11, 28] The effectiveness is higher in those that implement a blended model although those that use unguided self-help also present significant numbers in the reduction of the depressive disorders but with higher drop-out rates. [11]

The online treatments usually work better [4] if a proper diagnosis is made before the treatment starts. Usually this is made via self-reports with clinical semi-structured interviews by telephone or in person. [5] Both the patient and the therapist must be provided with access to secure systems that allow them to communicate. The treatment materials provided to the patient must be evidence-based, easy to read and navigate, and not technically advanced. [4] These materials must be also accessible by the therapist and usually include text, streamed videos, illustrations and audio files. [5] Each patient can require different treatments specifications therefore it must be possible to apply a personalized treatment although in typical cases a general treatment is applied. The patient must be followed by an identified therapist that provides him with support and advice on the treatment progression. [5] This guidance is usually done in face-to-face sessions, via video chat or telephone. The treatment duration depends on the treatment type, for example when CBT is applied the duration varies between 8 and 15 weeks. [5]

## 2.3 Tools for depression treatment

### 2.3.1 Moodkit

Moodkit [38] is a paid application for iOS devices made available by Thriveport. It was designed to help the user apply effective psychology strategies throughout the day. This application aims for the user to explore mood-enhancing activities, identify and change unhealthy thoughts, rate his mood and create a journal that has been designed to promote his well-being.

The application was developed by two clinical psychologists and applies the CBT techniques. Moodkit was designed to be used as a self-help application but it can be used as part of a professional treatment. It is structured in four core tools:

- **Activities:** displays a wide variety of specific suggestions for the user improve his mood. These activities are provided with examples and tips and aim to implement psychological principles and techniques that are known to reduce the negative thoughts and to enhance the user well-being. This mood improvements are categorized in 5 different types: productivity, social, enjoyment, physical and healthy habits.
- **Thought checker:** helps the user to manage negative feelings that are connected to specific situations. Its objective is that user identifies and changes the thoughts that increase and contribute to these feelings. The user must change the way he thinks by learning through repetition how to control and change these feelings.
- **Mood tracker:** allow the user to rate his mood on a daily basis. The information provided can be consulted in a chart that displays the mood ratings of the last 7 or 30 days.
- **Journal:** provides user with a space to create, save and export notes about the mood-related activities. This tool presents pre-formatted templates to help the user create his

journal in ways known to help improve his state. These notes can also be integrated with the previous tool, this way the user can write notes explaining his mood.

This application presents the user with a very simple and clean interface. Its strengths reside in the Mood tracker and the Journal that integrate with each other. The negative side is that every time we start the application it goes to the main menu instead of letting the user resume from where he left.

### 2.3.2 iFightDepression

iFightDepression [1, 6] is an Internet-based guided self-management tool that targets individuals with minor, mild or moderate depression. This tool includes two versions, one for adults older than 25 and other for young people aged between 15 and 24. It is currently available in 8 languages: English, German, Spanish, Catalan, Hungarian, Estonian, Bulgarian and Dutch.

It follows the CBT principles and it is composed by a set of modules that users can follow at their own pace. After each module the user can practice the skills learnt through a set of exercises that teach him how to self-manage his depressive symptoms. The set of modules available focus on resolving specific problems, such as:

- Manage thoughts, actions and feelings;
- Handle sleep problems;
- Planning and doing enjoyable things;
- Identify and change negative thoughts;
- Improvement of lifestyle;
- Dealing with social anxiety.

iFightDepression is a cost-free tool included in a program developed by the European Alliance Against Depression (EAAD). It passed through a study that included approximately 200 patients and 160 healthcare professionals. This study has demonstrated some interesting results about the capabilities of this tool, which proved to be:

- A complementary resource to complement the existing treatment options, because it can be offered to practice the skills learnt in face-to-face psychotherapy.
- An encouragement to patients seek professional help and an important tool for patients who can not afford treatment expenses.
- A helpful tool for patients in waiting lists and patients who do not require long-term therapy.

- A useful tool for relapse prevention and for patients with limited mobility or with hearing impairments.

### 2.3.3 Cognitive Diary CBT Self-Help

Cognitive Diary CBT Self-Help [17] is a mobile application available for Android devices. It aims to identify and change irrational beliefs that lead to many life problems like depression, stress or anxiety. This self-help application uses CBT principles to challenge the irrational thinking and helps to train and to automate rational thoughts. It provides psychoeducation modules in order to make the user aware about mental health problems. The diary allows the user to describe all his daily events and to express the emotions, thoughts and irrational beliefs relative to an event. Furthermore, it presents the user with random motivational messages.

This free application mainly focus on providing information in order to educate its users. It presents the user with 'old fashioned' design making the reading and navigation difficult. Regarding the content, it could be more interactive and supported by psychology experts.

### 2.3.4 Moodtools

Moodtools [13] is a free mobile application, with optional paid premium features, available to Android and iOS devices. It aims to deliver comprehensive tools with smooth design and it was created to act as self-help tool as well as a supplement to treatment.

This student-developed application is based on CBT acceptance and commitment therapy principles. It helps the user to lift his mood from sadness, anxious or depressed feelings through the use of 6 modules:

- **Information:** presents psychoeducation info. This info is presented as detailed self-help guides and as links for online therapeutic resources.
- **Test:** presents the Patient Health Questionnaire version 9 (PHQ-9) [?] questionnaire to track the user symptoms' severity over time.
- **Videos:** suggests a selection of videos that can improve the user mood and behaviour. The video offer goes from guided meditations, motivational videos, enlightening TED talks<sup>1</sup> to soothing sounds.
- **Thought diary:** applies self-help CBT. The user can write about negative feelings and thereby identify/correct distorted thinking patterns.
- **Activities:** are based on Behavioural Activation Therapy. It motivates the user to list and track his activities. This way it is possible to identify which activities improve the mood the most.

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<sup>1</sup>Influential conference videos from experts of wide variety of areas. Available at: [www.ted.com](http://www.ted.com).

- **Safety plan:** allows user to create an emergency plan for a suicidal crisis. This plan must include some family, therapeutic and emergency contacts.

Although the application provides a clean and easy to use interface it presents heavy amounts of text and very few multimedia resources aside from the YouTube and Ted links. The navigation is easy to use and combines nicely with the multimedia features. The suicide safety plans are well made although they should provide immediate phone numbers to suicide safety hotlines. The symptom tracking could be better designed, it uses a PHQ-9 but presents the score in a not so careful way. Lastly, it could use some of the smart-phone features like alarm settings, notifications and other graphical features. Nevertheless, it is one of the cleanest and easy to use applications.

### 2.3.5 Minddistrict

Minddistrict [26] is a paid online therapy room that delivers guided self-help therapy. This product is directed to individual professional therapists and corporate medical centers. Regarding the therapy, the platform follows a simple process that starts with a face-to-face conversation with the client, followed by an online personalized planning with the therapist before the treatment starts. During the therapy, the progression made by the patient is analysed and the treatment is adjusted to his needs.

The online therapy room offers other innovative features to the patients such as:

- **Messaging:** therapist and patient can have contact by sending and receiving messages in a simple way. The message can include attachments and email notification is provided.
- **Patients progress:** the therapist can easily follow his patients and for each one he can check a detailed progress report.
- **Video calling:** the online therapy room includes video calling through a secure connection so the therapist can easily connect with his patients and other professional colleagues.
- **Module customization:** the platform offers a module catalogue for the therapist to choose from. Furthermore, the therapist can customize his own modules and add some questionnaires and triage to them. Each module can be personalized for each patient, also, they can be used with accompanied or unaccompanied support.
- **Diary:** is an essential instrument to the treatment. The therapist can prepare different types of diaries for the patient. These diaries can be filled out with the Minddistrict mobile app. All of the information provided can be consulted and monitored in the online therapy room.

Regarding the modules provided, all are evidence-based and created with collaboration of medical experts. Each of the module passes a 6-week development process where the experts and



Minddistrict editors go through several sessions to conceptualise, create, review and test it. All of this process uses the company guidelines that explain how to combine the various module elements such as text, images, exercises or audio. In the end, using this set of tools they can provide a easy to use and motivating module that can be translated to different languages. The modules that pass this process are available in the expert module store divided in different categories such as age and problems type. The therapists can choose from the provided modules or create new ones using the module development method that is provided by a Content Management System (CMS) and the company support. Then, the therapist can choose to share the created module with other health organizations through the platform. Each module can be adjusted to each individual patient. The therapist can choose the order of the sessions, as well as create or delete them in order to improve the effect of the module for each patient.

The depression module uses a CBT approach. It covers all the relevant passes of the therapy such as activation, structure, thought patterns and relapse prevention. This module provides the patient with information, exercises and examples from non-real patients so he can learn and practice skills that help him dealing with sad feelings and thoughts in a more effective way. As in previous tools, the module can be used as self-help or combined with face-to-face therapy.

Minddistrict is oriented to small and large organisations. Since this is a paid application it was not possible to test it.

### 2.3.6 Mood Watch

Moodwatch [23] is a paid mobile application available to Android and iOS devices. This application was created by Kimberly Knox who was diagnosed with bipolar disease. She started tracking her mood and medication in a paper along with some notes. In a few days she started realizing some patterns in her mood graph and with this information she started taking some actions that made her feel better. After sharing her findings with her doctors they came to the conclusion that her techniques should become a mobile application.

Nowadays Moodwatch provides much more than bipolar tracking, it's used in many other mood disorders such as anxiety, depression, borderline and PTSD. It focus on tracking five aspects of the user's well being. The tracking system records the anxiety, mood, calm, focus and energy in four fixed time intervals: Morning (8am), Lunch (noon), Dinner (6pm) and Night (10pm). Depending of the time of the day, each entry of the tracking system asks a set of questions to the user such as:

- "How are you feeling today?", where the user can categorize between some options like "Bad", "Good" or "Excellent".
- "How many hours of sleep last night?", where the user can provide the number of hours.
- "Quality of sleep?", where the user can categorize between some options like "Fair" or "Good".

- "Blood pressure before meditation", where the user can provide the values of the systolic, diastolic and pulse.

All the information provided can be complemented with relevant notes provided by the user. This information is then showed to the user in a graph format. The user can select one or more of the five aspects of the user's well being he wants to exhibit in the graph. Each aspect has a different color and the information is summarized by day.

Regarding the medication, it helps track the medication and supplements. The user can indicate the time of day to take his medication and set up a reminder alarm for it. This feature could be more complete, because the user is limited to the four alarm options provided, it would be better if the user could choose the time intervals. Also, despite the user's being able to take some notes about the dosage and frequency of the medication, it could be useful to track the changes and relate it with the changes in well-being.

All the information provided is summarized in weekly reports that could be shared with the user doctor. The report presents all the data provided during the week such as anxiety levels, vitals, medication and sleep. The first part of the report presents a graph that could be helpful to highlight patterns in the mood changes, the second part summarizes the medication, mood notes and sleep entries for each day in a barely worked table.

Although the graphs part is well designed the overall design could be better worked. Also, having psychologists in this application development team would certainly improve its features.

### 2.3.7 MoodHacker

Moodhacker [29] is a mobile application demo available for companies as an employee assistance program. It was designed to improve emotional well-being through self-management intervention based in CBT and Positive Psychology. It aims to help employed users to track, understand and improve their mood as well as reducing their depression symptoms.

The user is encouraged to improve his mood with a practical intervention approach, that goes from healthy habits like physical activity, sleep and nutrition to social support. It helps the user through personalized messages based in CBT, Positive Psychology and Theory.

Moodhacker effectiveness was validated scientifically in a randomized controlled trial that proved that the more the program was used the more the results improved. Nowadays, this paid mobile application is only available to companies or through some health plans. Although, it was not possible to test it, it was possible to see that it presents a nice and clean design.

### 2.3.8 ICT4Depression Moodbuster

ICT4Depression [40] is an European project that resulted in a platform called Moodbuster. It aims to improve the outcome of treatments for depression. The system delivers guided self-help

via internet and mobile phones and is used in primary care. The internet treatment is delivered by a set of modules:

- Psychoeducation: contains general information about the treatment of depression, exercises about goal setting and tries to help the patient to assess the severity of his problems.
- Behavioral activation: focuses on learning how to increase the pleasant activity level and how to balance the level of necessary activities.
- Problem solving therapy: teaches the patient how to get control over their problems.
- Cognitive restructuring: helps to detect and deal with negative thoughts.
- Exercise: this module provides general information about physical activity because it is proven that exercise improve depressive symptoms.
- Relapse prevention: the patient learns how to prepare a plan of action for future events which can trigger depressive symptoms.
- Medication adherence: this module aims to provide an adequate and personalized support for the management of patients' drug intakes.

The mobile phone can be used to follow shortened versions of the treatment modules available in the internet, but it is also used to monitor the patients' progress. It helps to measure the patient's mood, quality of sleep and distress. Through the day the patients receives a pop-up message to rate their mood in a scale of 1 to 10. The quality of sleep and the level of distress are assessed once a day. The information provided is also used to provide feedback to the patient about the evolution of his well-being status.

In addition to the mobile phone and the internet treatment this project also used a set of wearable biomedical sensor devices to capture the patient biosignals but limited research has been made to relate these signals with the mental health diseases.

The platform is supported by a reasoning system that provides automated feedback to the patient. The reasoning system provides feedback via mobile phone and the internet platform. It was developed to help the patient understand his progress in the therapy and to increase the therapy effect.

Both the internet platform and mobile application content is well worked which facilitates the reading and navigation. The overall design could be better worked. The major advantage is that all the content has a strong empirical base.

## 2.4 Conclusion

The psychological treatment is one of the most important treatments on fighting the depressive disorders burden. [11] CBT fits in this category and has it effectiveness proven by many controlled

trials. As we have seen eMH is expanding its support to corporate and individual projects that result in a complete set of tools that are now available to the patients.

In table 2.1 it is possible to see a comparison between these tools. Almost all of these tools make use of some form of CBT which not only spreads even more this effective treatment but also proves its versatility on adapting to new technologies. Some of these tools were tested in trial studies to prove their effectiveness. The tools used in a study are in general well documented which allow us to understand how they work. The others, some created by companies and other started by individual users, sometimes to fulfil their own necessities, only provide the information necessary for the final user to understand its characteristics and behaviour. Most of these tools provide a mobile application, but only three provide it in the form of a web application. Only Minddistrict and Moodbuster allow the patients to be monitored by their therapists.

Table 2.1: Comparison of tools for depression treatment

	<b>CBT</b>	<b>Study</b>	<b>Free</b>	<b>Mobile</b>	<b>Internet</b>	<b>Monitoring</b>
<b>Moodkit</b>	✓	×	×	✓	×	×
<b>iFightDepression</b>	✓	✓	✓	×	✓	◆
<b>Cognitive Diary CBT</b>	✓	×	✓	✓	×	×
<b>Moodtools</b>	✓	×	✓	✓	×	×
<b>Minddistrict</b>	✓	×	×	✓	✓	✓
<b>Mood Watch</b>	✓	×	×	✓	×	×
<b>MoodHacker</b>	✓	✓	×	✓	×	◆
<b>ICT4D Moodbuster</b>	✓	✓	✓	✓	✓	✓



## Chapter 3

# Background

As mentioned in chapter 1 this work is part of Stop Depression [9] and European Comparative Effectiveness Research on Internet-based Depression Treatment (**E-COMPARED**) [12] projects. Both projects share some of their objectives, being the most important, providing a system that includes a set of tools that allows to increase the access and effect of depression treatment.

These projects aim to study the feasibility and acceptance of the depression treatment. The Stop Depression project aims to do that in Portugal, while **E-COMPARED** covers United Kingdom, Poland, Spain, Germany, Switzerland, Sweden, France and Netherlands. To do this, both projects use the Moodbuster system.

In this chapter we will study how this system has evolved and how its main components work.

### 3.1 Components

As we have seen in chapter 2, the development of the Moodbuster system started in the ICT4Depression project. Between 2012 and 2013 the system was integrated in a trial in Netherlands and Sweden. At the time, the system aimed to provide some technological innovations that included: [40]

- flexible self-help treatment for depression;
- automatic assessment of the patient using mobile phone and web-based communication;
- wearable biomedical sensor devices for monitoring activities and electrophysiological indicators;
- computational methods for reasoning about the state of the patient and the risk of relapse (through a reasoning system);
- flexible system architecture for monitoring and supporting people using continuous observations and feedback via mobile phone and the web.

The system core was composed by six therapeutic modules: psychoeducation, behavioural activation, problem solving therapy, cognitive restructuring, exercise therapy and relapse prevention. These modules, described in subsection 2.3.8, were the base of self-help interventions and were accessible to the patients through a web client. [40] In addition to the self-help treatments for depression, the system was developed taking into account three other components: a mobile phone application, wearable biomedical devices and a reasoning system, that will be described in the next sub-sections.

### 3.1.1 Mobile phone application

The mobile phone application was used to provide a modified version of the treatment modules and to track the patient progress.

In order to provide adequate support each therapist must be aware of their patients progress. The mobile phone collects the patient progress information through Ecological Momentary Assessment (EMA). EMA is a validated method of collecting real-time data on context, behavioural and mood from natural environments through the use of a signalling device to minimize recall bias. [40] This method allows to track and measure patient's mood, quality of sleep and distress on a daily basis. Collecting this data allows the reasoning system, through the mobile application, to provide the patient with automatic generated feedback of his progress.

### 3.1.2 Wearable biomedical devices

The wearable biomedical devices are composed by a set of wireless miniaturized and non-intrusive wearable sensors that were created considering patients' comfort and usability. These sensors were integrated in a chest-strap and in a glove-like device, and allowed continuous and ecological monitoring. They also allowed to measure Electrodermal Activity (EDA), Blood Volume Pulse (BVP), respiration, Electrocardiography (ECG) and acceleration. [40]

### 3.1.3 Reasoning system

The reasoning system provides automatic feedback to both the patient and the therapist. Thus, patients can have a better perspective about their performance on the therapy. This reasoning system includes four main components: [40]

1. a component that is capable of reading the sensors data and estimate the patient performance and involvement in the therapy;
2. a component that derives how the patient current state is in line with his therapy;
3. a component that analyses if the patient, considering his current state, could benefit of another therapeutic module;

4. a component that provides both the therapist and patient with feedback based on the data collected by the sensors and data derived by 2 and 3.

## 3.2 System architecture

The system developed for the *ICT4Depression Moodbuster* was in the form of a Service Oriented Architecture (SOA)<sup>1</sup>, that relied on web services to communicate. As we can see in figure 3.1 it included different components, some of these were described in the previous section, that were developed by different partners. For the Stop Depression [9] and *E-COMPARED* [12] projects the development and implementation was similar. In this study we will focus on the system core, the therapeutic modules. These were developed at Institute for Systems and Computer Engineering - Technology and Science (*INESCTEC*), although *INESCTEC* was responsible for the development of other technological parts for each project.

The therapeutic modules created for the Stop Depression and *E-COMPARED* projects share the same basic structure used in the *ICT4Depression Moodbuster*. Nevertheless, the objective of each project differs which result in slightly different implementations. For example, comparing with the *ICT4Depression Moodbuster*, both Stop Depression and *E-COMPARED* does not include the medication therapy module, however, both have an introduction module that teaches the patient how to use the Moodbuster platform.

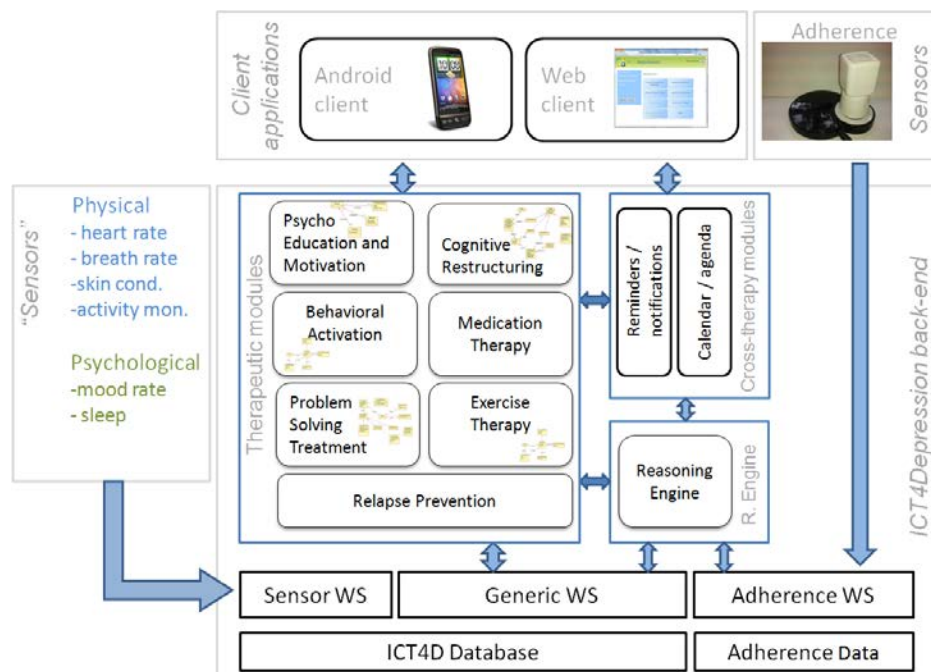


Figure 3.1: *ICT4Depression Moodbuster* system architecture, from *ICT4Depression* - service oriented architecture applied to the treatment of depression. [35]

<sup>1</sup>Software design pattern in which application components provide services to other components through a communication protocol.



As seen in figure 3.1 the entry point of the system are the client applications. In this analysis we will go through E-COMPARED [12] Moodbuster Web client, in order to get some insight on the platform. We will also analyse how the back-end database provides some of the information necessary for the therapeutic modules to work.

The therapeutic modules were made in collaboration with psychologists. These were developed considering the end user experience. The technological implementation was done by computer scientists. The collaboration between this two parties makes the development of modules to be slow.

### 3.3 Web client applications

The web client implemented for E-COMPARED [12] project used Symfony<sup>2</sup> [33]. This client is split in two different portals: Patient Portal and Therapist Portal. There are also two other tools. The first, allows to make the portal's translations, and the other one is used by the programmers to generate the translated PHP files. These tools will not be analysed. In the next sub-sections we will analyse both portals.

#### 3.3.1 Patient Portal

When a patient enters the Patient Portal is presented with the homepage we see in figure 3.2. There, he has access to his therapy, mood statistics and messages. This portal allows him to contact his therapist, work on or review his therapy, and manage his calendar. For the purpose of this study we will only focus on the therapy part.

After entering the therapy page it is possible to access, as figure 3.3 shows, the therapeutic modules. The patient can easily see his progress in each module and resume his current therapeutic module.

As the patient works through the therapy he can easily access his exercises through the exercises page seen in figure 3.4. This helps him to remember them and gives him direct access when he wants to practice.

Each therapeutic module is composed by different elements. Usually they begin with text elements that introduce the patient to the therapy theory. Multimedia elements like images and YouTube videos are also used. As we move along the therapy we start to find exercises that are composed by more complex elements.

The first time a patient uses the platform it is for working through the introduction module. This module presents only theoretic content, mostly text and multimedia. It presents the platform to the patient and explains him what he will encounter in each of the menus. After ending this

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<sup>2</sup>Symfony is a PHP full-stack framework that is used to create web applications. [33]

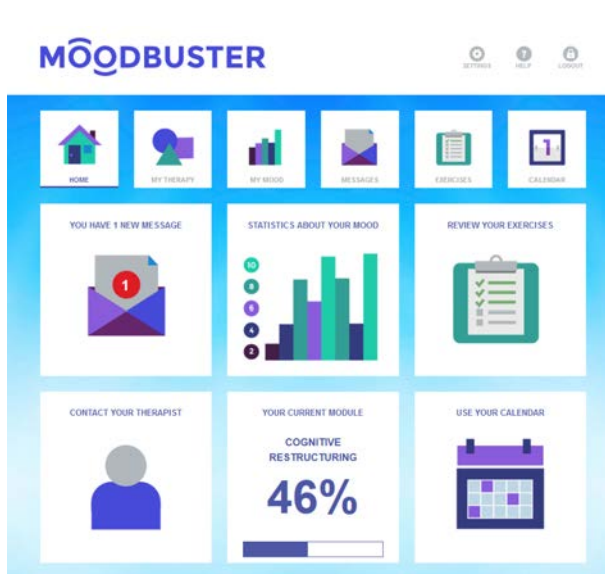


Figure 3.2: Moodbuster homepage.



Figure 3.3: Moodbuster therapeutic modules.



Figure 3.4: Moodbuster exercises page.

module the patient is redirected to the psychoeducation module.

### Psychoeducation

The psychoeducation module provides general information about depression, goal setting, daily registration of mood and feedback about the level of mood during the week. [35] This information is mostly presented as text and multimedia as we can see in figure 3.5.

The module also helps to assess how severe are the patient's problems. It uses a set of exercises in which the patient must write his life goals, treatment goals and rewards. This information is provided by the patient in the form of a list, see figure 3.6, and is used in the following modules.



Figure 3.5: Third page of Psychoeducation module presenting a YouTube video.



Figure 3.6: The patient must complete a reward list to complete the third exercise of Psychoeducation module.

### Behavioural activation

The behavioural activation module aims to treat depression through the reinforcement of pleasant and unpleasant activities. [35] The first exercise helps the patient to identify, through a list, these activities. Then the patient must analyse his recent past to classify how these activities make him feel and how often did he made them. As we can see in figure 3.7, this exercise uses other type of elements. The elements used on this page access the list of activities provided earlier by the patient and provide a way for him to classify them. Also, the information provided is displayed in a table that is easy to consult. The third exercise of this module, figure 3.8, makes use of the patient calendar. The patient mood will increase with the amount of activities he does, so in this exercise he can schedule his activities on his personal calendar to a day and time that fits him.

In the next exercises the patient his asked to list his necessary activities and overcoming barriers. It is important for the patient to be aware of the barriers that keep him away from carrying out his goals.

The sixth exercise, figure 3.9, helps the patient to set some goals. He is asked to balance his activities through the day. This is done through new elements that help to quantify the pleasant activities and necessary activities per day. In order for the patient to achieve is goals, he is asked to select one of the rewards he suggested on the psychoeducation module.

The next exercise helps the patient to schedule in the calendar both pleasant and necessary

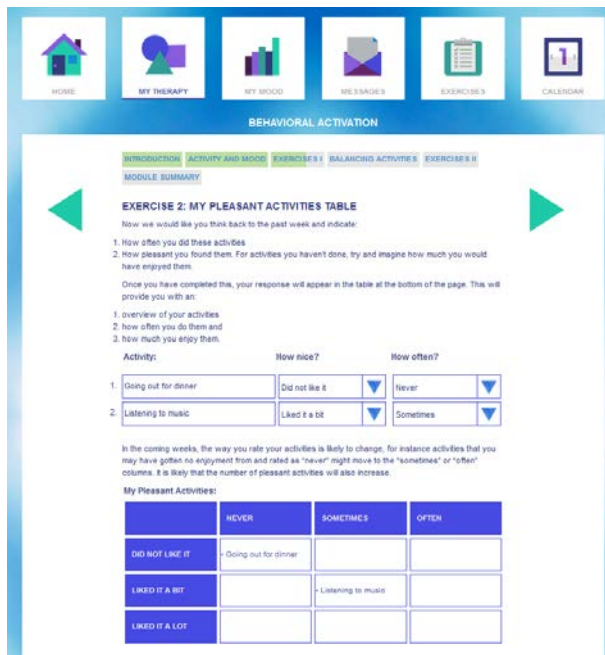


Figure 3.7: The patient must classify, for the past few weeks, how often and how it feel to make his pleasant activities.

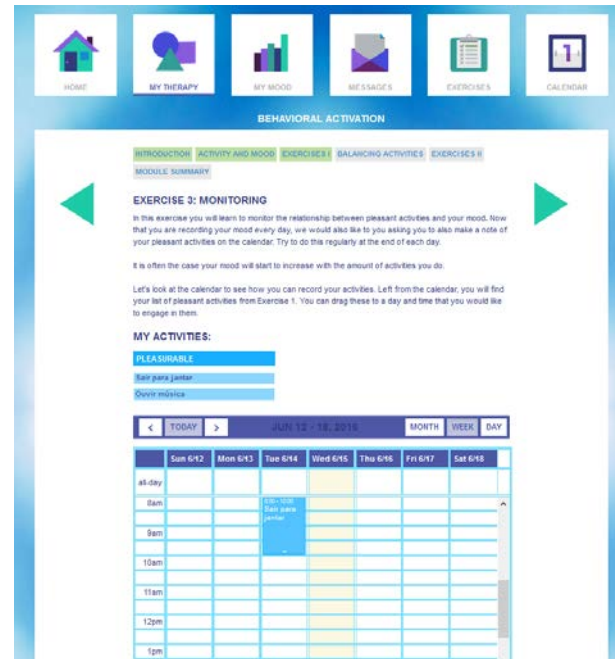


Figure 3.8: In order to increase his mood, the patient schedule his pleasant activities.

activities. To finish the module the patient must evaluate his progress. This page presents new elements, figure 3.10, that allow the patient to describe how the plans made in the previous exercises make him feel. At the end of this exercise the patient can select if one of his goals, defined in the psychoeducation module, has been accomplished.

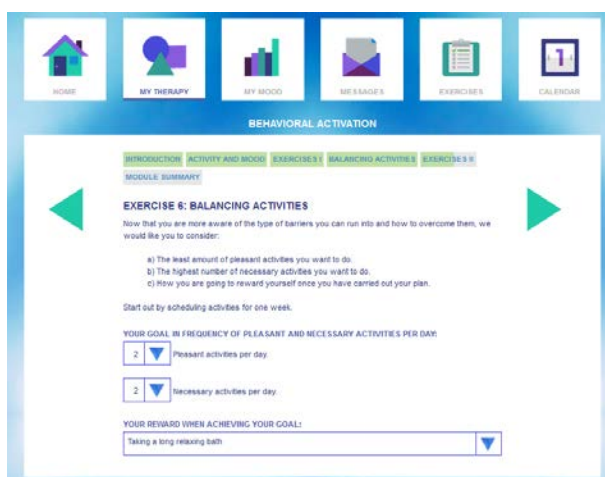


Figure 3.9: Setting frequency and reward of pleasant and necessary activities.

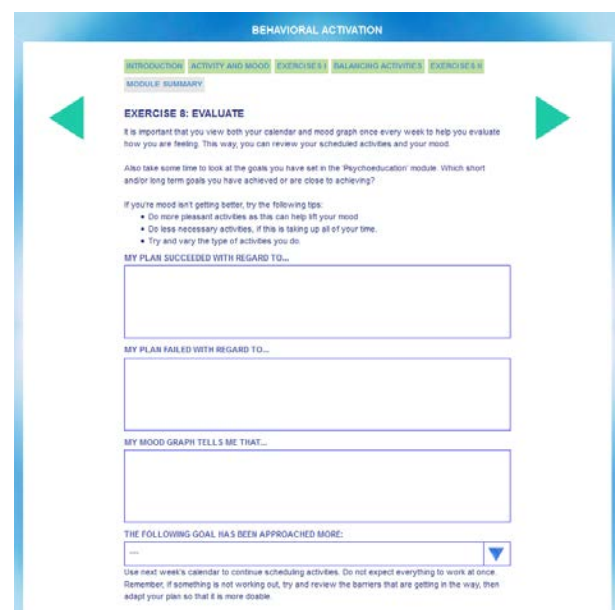


Figure 3.10: Evaluation of the plan made in the previous exercises.

## Cognitive restructuring

The cognitive restructuring module helps the patient to regain control of his negative automatic thoughts. [35] These feelings are frequently associated with depression. The first exercise, figure 3.11, helps the patient to analyse a recent situation that affected his mood. The elements used are already known from the previous modules, although this module uses a different procedure. In the previous modules, the exercises worked as a sequence of independent exercises, but in this module a new element is added. The exercises are grouped in steps and each step is sometimes connected to the previous ones. Such an approach allows the patient to, at each step, verify his answers in the previous steps, see figures 3.12, 3.13, 3.15.

The module challenges the patient to reason, through the analysis of automatic thoughts and identification of thinking errors. To do this new exercise elements were used. Figure 3.11 show us the second step that includes a list that allows the patient to classify the credibility for each of the inserted items. Regarding the thinking errors, in figure 3.13 we have represented another new element. This element is composed by two lists and allows the patient to identify his thinking errors.

Figure 3.11: Stepped exercise in which the patient is able to describe a situation through text area elements and to point the date of occurrence of the situation through the calendar element.

Figure 3.12: List element to describe automatic thoughts with classification about the credibility.

The final objective of this module is to make the patient to act more logically. In the fourth step, figure 3.14, it helps him consider all the evidence. To accomplish this, it uses another new element that allows him to identify evidences and counter evidences for each of the automatic

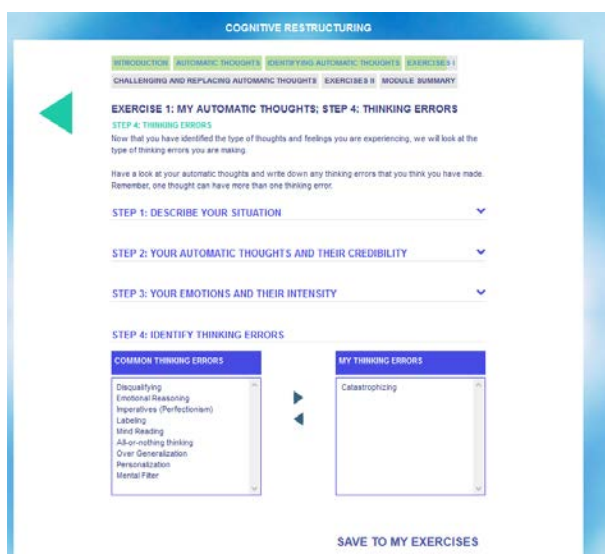


Figure 3.13: Two list element that allows the patient to move common errors to his list of thinking errors.

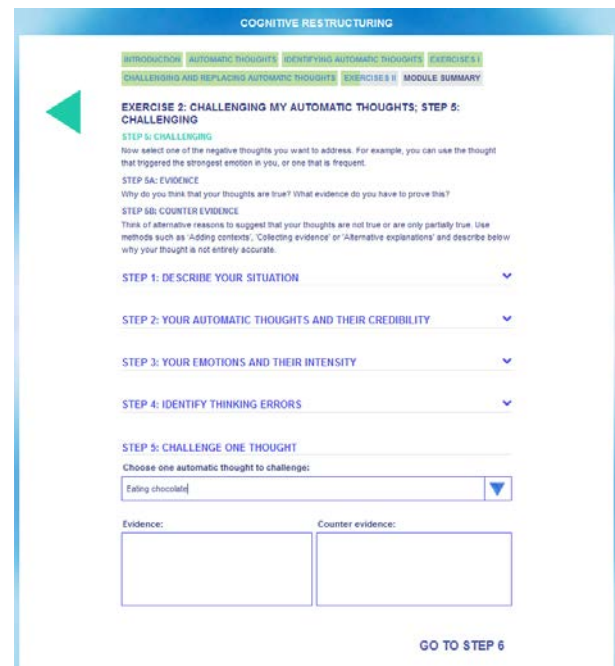


Figure 3.14: An element that allows the patient to comment the evidences and counter evidences of a previously inserted thought.

thoughts provided earlier.

At the end of this module, figure 3.15, is possible to analyse the patient achievements. Two new elements appear that help the patient identify which of his life goals and treatment goals had been achieved so far.

### Problem solving

The problem solving module aims to help the patients regain control of his life. To do this this module guides the patient in two different ways. First it helps the patient to identify what is important to him and then it teaches how to deal with things that he can not change. This module also offers a workflow that guides the patient on how to solve the problems that he thought were unsolvable. [35]

All the exercises elements used in this module were seen in the previous ones. The most used element is the list, but in this module is also possible to encounter elements that help on classification of the problems through text areas or select lists, and elements that interact with the calendar. One of the exercises also use steps which allows to, at each step, preview the previous.

### Physical exercise

The physical exercise module aims to increase the patient physical activity. This is not only a way of making the patient to get healthy, but is also a non-stigmatizing way of treating

**COGNITIVE RESTRUCTURING**

[INTRODUCTION](#) | [AUTOMATIC THOUGHTS](#) | [IDENTIFYING AUTOMATIC THOUGHTS](#) | [EXERCISES I](#)  
[CHALLENGING AND REPLACING AUTOMATIC THOUGHTS](#) | [EXERCISES II](#) | [MODULE SUMMARY](#)

**EXERCISE 3: EVALUATION**

Take another look at the goals you have set in the psychoeducation module.

Which treatment goals have you gotten closer to achieving or have you achieved?

Which long-term goals or life goals have you gotten nearer to achieving?

You will have to repeat this exercise on a regular basis to address other negative automatic thoughts. If you continue to practice, you can succeed in replacing your negative thoughts with ones that are more accurate. Also, remember doing this will not only help you change your distressing thoughts, but will help raise your mood.

None

**LIFE GOALS**

1. Be a more relaxed person

2. Go travel the world

**TREATMENT GOALS**

1. be more confident

2. not be afraid of people

**SAVE TO MY EXERCISES**

Figure 3.15: Two elements that allow the patient to mark as achieved the previously inserted life goals and treatment goals.

depression. [35] Regarding the exercises elements, this module also uses some of the ones we seen in the previous modules, mostly lists, selection of rewards and interactions with the calendar.

### Calendar and Patient Health Questionnaire (PHQ)

There are two important pieces that are present in almost all the modules: the calendar and the PHQ. The calendar is used as a backbone and connects several therapeutic modules. It allows the patient to schedule and plan his exercises.

The PHQ, figure 3.16, is questionnaire composed by multiple-choice questions and is used for screening and diagnose of depression. This questionnaire provides a score for each question that reflects the severity of the patient depression. It is used at the end of each module and allows the therapist to evaluate the evolution of his patients.

### 3.3.2 Therapist Portal

The therapist portal is the place where each therapist can follow their patients' evolution. In the homepage of the portal the therapist has access to a sortable table of his patients' information. The table summarizes, for each patient, the information about the start date on the therapy, the state (active or not), the last login, the next appointment, the last received message, the last completed module and the therapy progress. In this page it is also possible to create new patients.

After selecting a patient, the therapist can access even more detailed information. This

**COGNITIVE RESTRUCTURING**

[INTRODUCTION](#) | [AUTOMATIC THOUGHTS](#) | [IDENTIFYING AUTOMATIC THOUGHTS](#) | [EXERCISE 1](#)  
[CHALLENGING AND REPLACING AUTOMATIC THOUGHTS](#) | [EXERCISE 2](#) | [MODULE SUMMARY](#)

**QUESTIONNAIRE PHQ-8**

Well done! You have just finished the Cognitive Restructuring module. Before you continue, please fill out the questionnaire below.

	Not at all	Several days	More than half the days	Nearly every day
Little interest or pleasure in doing things.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feeling down, depressed, or hopeless.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trouble falling or staying asleep, or sleeping too much.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feeling tired or having little energy.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Poor appetite or overeating.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Feeling bad about yourself, or that you are a failure, or have let yourself or your family down.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trouble concentrating on things, such as reading the newspaper or watching television.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Moving or speaking so slowly that other people could have noticed. Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

1. HOW MUCH DID YOU LEARN FROM THIS MODULE?

Not very much				Very much
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2. IF YOU SUFFER FROM DEPRESSIVE SYMPTOMS, WOULD YOU USE THIS MODULE AGAIN IN THE FUTURE?

No  
 Probably  
 Yes

3. WOULD YOU RECOMMEND THIS MODULE TO OTHER PEOPLE WITH DEPRESSIVE SYMPTOMS?

No  
 Yes

4. DO YOU HAVE ANY SUGGESTION/REMARKS ABOUT THIS MODULE?

SUBMIT

Figure 3.16: PHQ and four other questions regarding the cognitive restructuring module.

information is accessible by six menus: profile, calendar, ratings, therapy, exercises and messages.

The profile page presents the patient username, language, register and start date, state and self-help mode (on/off). It is possible to edit some of the patient's information. When the patient completes his treatment, the therapist can change his state to 'archived' or move the patient to self-help therapy. Also, it is possible to create a new password to the patient or change his language. The page also presents a table with all the appointments with the selected patient.

In the calendar page it is possible to consult the patient activities. The activities are grouped in four types: pleasurable, necessary, physical and appointments. It is possible to select all the activities or just the ones that correspond to the current year, month, week or day.

The ratings page, figure 3.17, allows the therapist to assess the patient level of depression through the analysis of the PHQ ratings. The information is provided for each module in the form of a graph that presents the global score or in the form of a table that presents the detailed score for each question of the questionnaire.

At the therapy page, figure 3.18, it is possible to verify, in percentage, how much the patient completed in each module. Also, it is possible to consult when the patient completed a module and how much time passed since he accessed his portal. At the end of the page it is possible to consult all the automatic generated messages and reminders that Moodbuster sent to the patient.





Figure 3.17: Ratings page provides access to detailed PHQ scores and graph view.

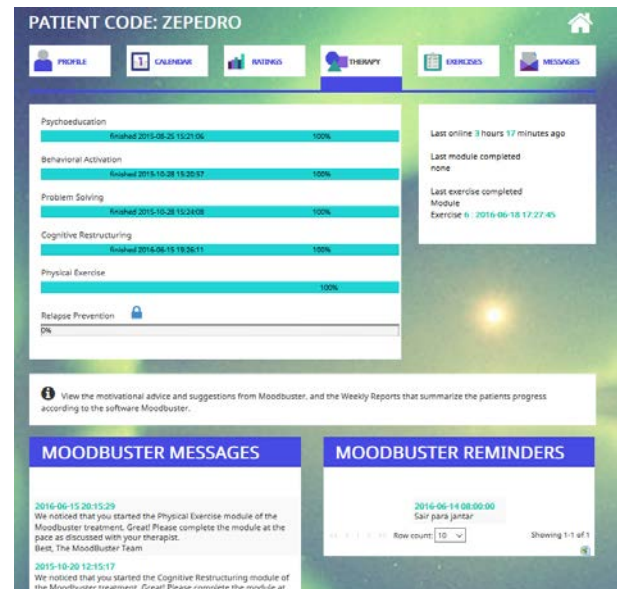


Figure 3.18: Therapy page allows to easily assess the patient evolution in each module. It also presents a log information and the automated messages that Moodbuster sends to the patient.

The exercises page, 3.19, presents all the exercises for each module. The page allows to see if the module has been completed. For each exercise it is possible to see the completed and last edit date. Clicking in a exercise takes the therapist to the exercise detail view where the therapist can consult the patient responses.

Finally, in the messages page it is possible to consult all the messages exchanged with the patient or create new ones.

### 3.4 Database

The Moodbuster system has a relational database, more specifically it uses the Microsoft SQL Server to store and retrieve the necessary data. The database presents a high level of complexity with numerous tables and complex connections. Similarly to the approach in the previous section, we will only study the database parts related with the users and with the therapeutic modules.

Starting by the users, figures 3.20 and 3.21, we have three different types: patient, therapist and supervisor. The first two we have seen in previous sections but the last one is new. The supervisor manages the therapists and can have the same view as a therapist over their patients. These three types extend the users table that have the basic information like the username and

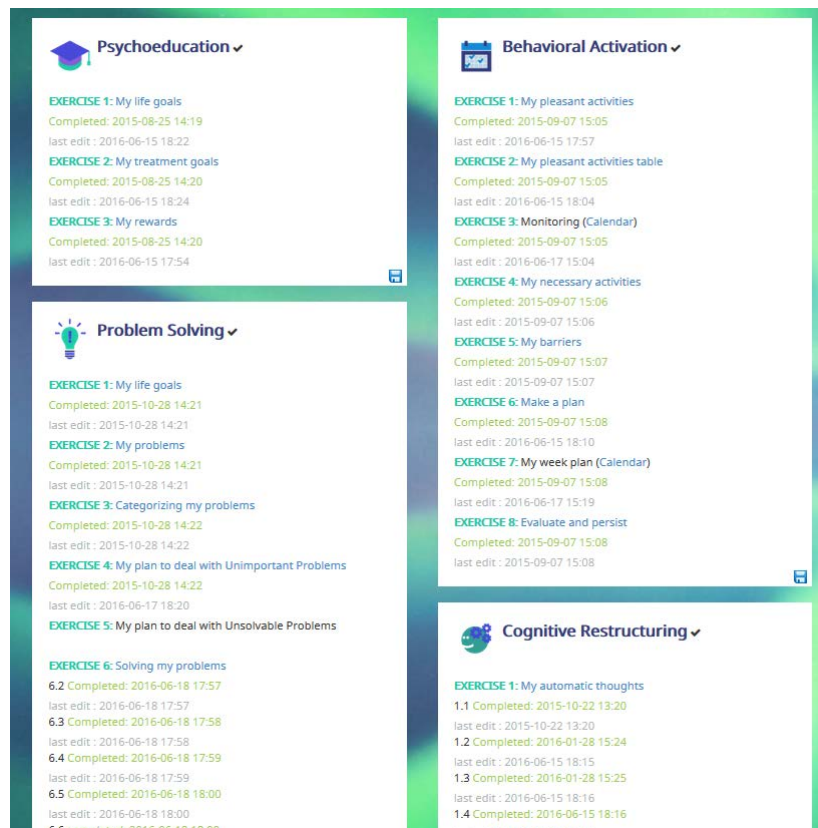


Figure 3.19: In the exercises page are listed all the completed exercises by the patient.

the password hash.

As we can see in figure 3.21, considering the number of connections to the patient's table is easy to notice that the database is patient-centered. Almost all the tables have a connection to the patient's table. The connections to this table include connections from the different types of users and from all the modules' tables. Also, in this database were some of the sensors tables that also connected to the patient's table. The patient's table stores all patients' information and its primary key is used in the exercises tables that store the patient's progress for each exercise.

Each module makes always use of more than one table. Actually the tables are created for almost each exercise element which increases the complexity of the database. The simplest examples are the psychoeducation and the physical exercise modules. In figure 3.22 it is possible to see part of their tables. For each list in each module at least one table is created. In figure 3.22 it is possible to identify a table for the patient rewards and exercises. Each of these tables is supported by one or more lookup tables. These tables allow the patient to select a reward or exercise that were previously inserted by the therapists' team. Nevertheless, the patient can create new rewards and exercises entries.

In figure 3.23 is possible to analyse the tables of a more complex module. The cognitive restructuring module presents the patient with stepped exercises and with more complex elements. The tables presented the figure 3.23 are only a part of the modules' tables. It is easy to identify

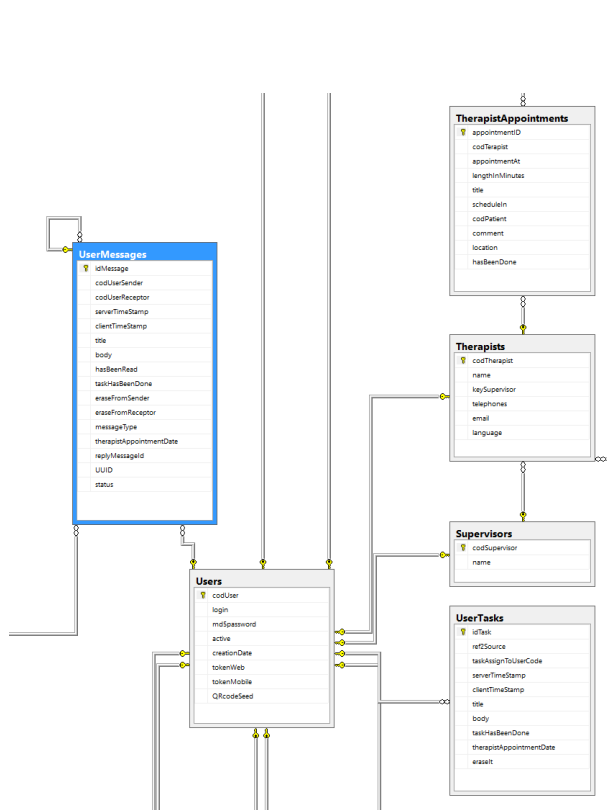


Figure 3.20: Users, supervisor and therapist database tables.

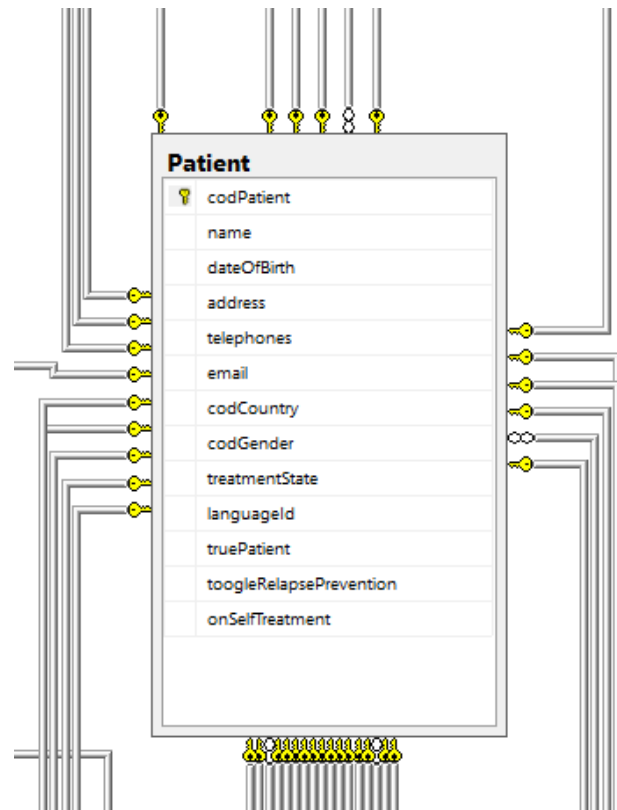


Figure 3.21: Patients database table.

the tables of some of the elements described earlier, like the table that contains the elements used to challenge the automatic thoughts with evidences and counter evidences, or the situation table that includes all the descriptions provided for every situation.

The more complex a module exercise and elements are the more complex the database becomes. It is important to highlight that these tables are almost all connected to the patient table. Also, for each exercise element that fetches values from a previous one, their tables are also connected.

### 3.5 Conclusion

The Moodbuster system has suffered several changes over the last years in order to support the projects in which it was used. It is important to refer that most of the technological implementation was made at the same time that the therapeutic modules were created. The development process, in collaboration with the psychologists, has resulted in a complete and efficient system.

Nevertheless, the system has its limitations. It is very difficult and expensive to scale the system to support new therapeutic modules, even if they use some of the implemented exercise

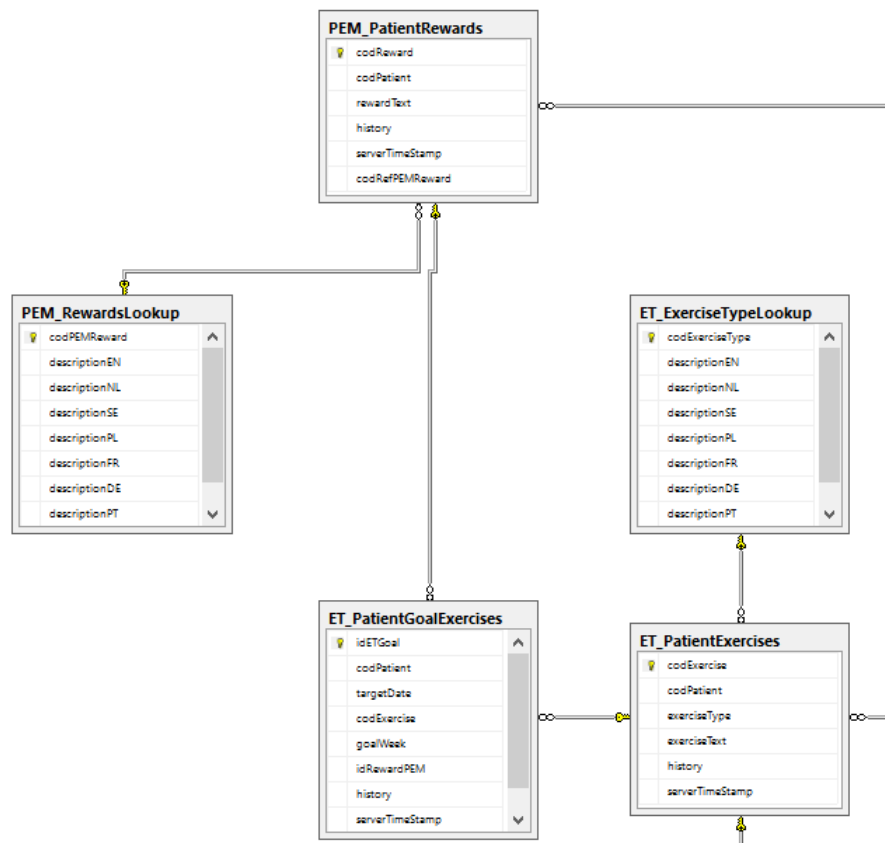


Figure 3.22: Partial representation of the psychoeducation and physical exercises modules.

elements. The problem resides mostly in the database that becomes almost unaffordable to the creation of new therapeutic modules. Creating and editing modules is currently only achievable by a programmer by changing or adding directly to the database.

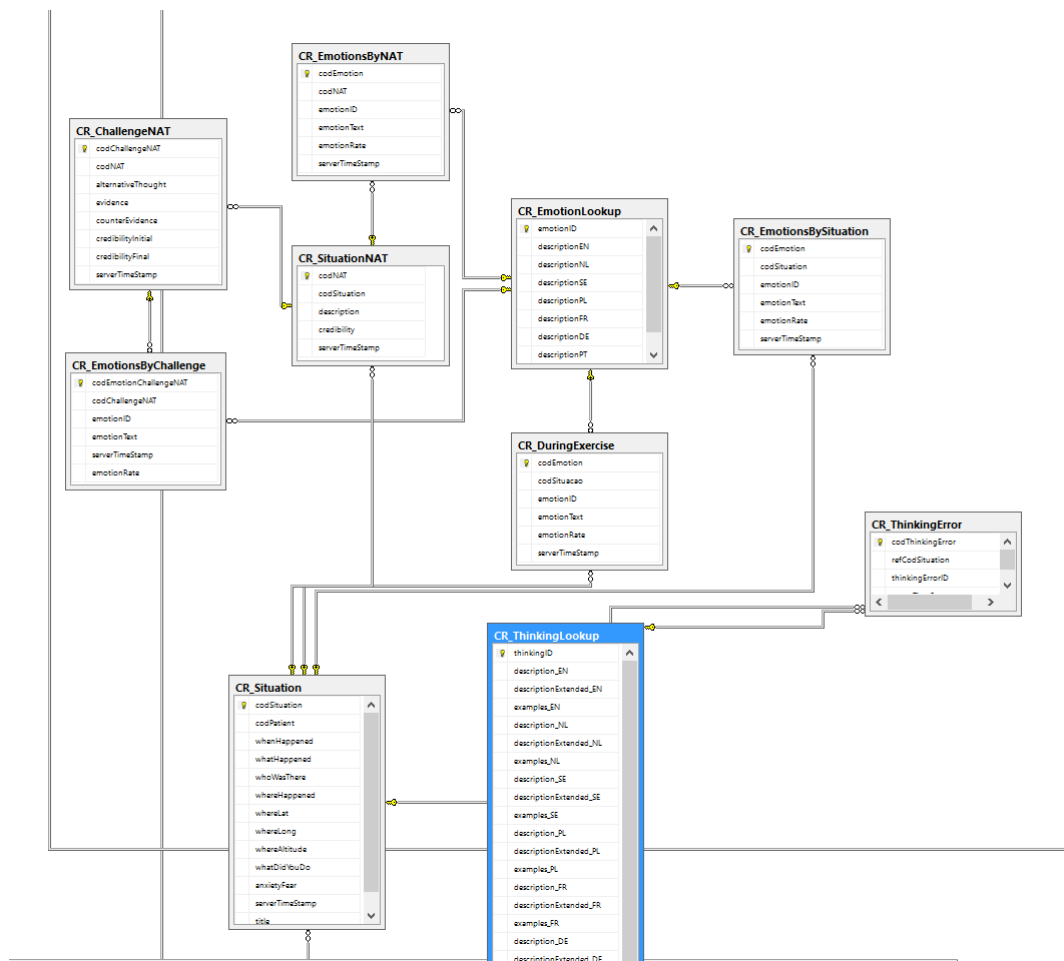


Figure 3.23: Partial representation of the cognitive restructuring database tables.

# Chapter 4

## Design

As we have seen in the previous chapter the current system makes the process of creating new therapies too slow and expensive. In this chapter we will focus on the design of a new Moodbuster portal that will focus on solving these problems. The portal will be called Intervention Builder (**iBuilder**) and, as referred in chapter 1, it will act as a tool that allows to create treatments that will interact with the therapist and patient portals. The whole system is composed by these three portals.

The main objective of this new system is to break the therapeutic development chain. We aim to prove that it is possible to create a tool that makes the psychologists almost independent in the process of creating therapeutic modules. To prove this concept we will try to build a system that needs little or none intervention from programmers.

In the design process we will use Unified Modeling Language (**UML**)<sup>1</sup> to specify the system. Its rich notation will be used to specify the requirements of the system that we will develop as proof of concept. This will not only work as a way of specifying the system but also as an easy way of documenting it.

### 4.1 Use cases

Dealing with new systems makes extremely important to understand the business problem that the system addresses. In order to do that, we will design the system use cases. This will allow us to show the relationship among the actors and the system. [2, 3] The goal is to capture the functional requirements for the system. In this section we will identify the actors and the usage scenarios through the use case diagrams.

In this section we will only describe the **iBuilder** use cases. The use cases for the other two portals will be presented in the appendix A.

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<sup>1</sup>**UML** is an object-oriented standard to model software systems.

### 4.1.1 Actors

An actor is the representation of anything or anyone that interacts with our system. [2] In figure 4.1 we have represented the system actors. The system actors are divided in the three portals. As in the Moodbuster system, we will have the patient that can only access the patient portal and the supervisor and the therapist that will have access to the therapist portal. Apart from these, we will create two more actors, the module manager and the translator, that will only have access to the *iBuilder*. Each of these actors has a specific role:

- **User:** authenticated user in the system;
- **Supervisor:** manages the therapists and has the same view over their patients;
- **Therapist:** manages and monitors a patient during his treatment;
- **Patient:** uses the treatments;
- **Module manager:** manages and creates treatments;
- **Translator:** translates treatments.

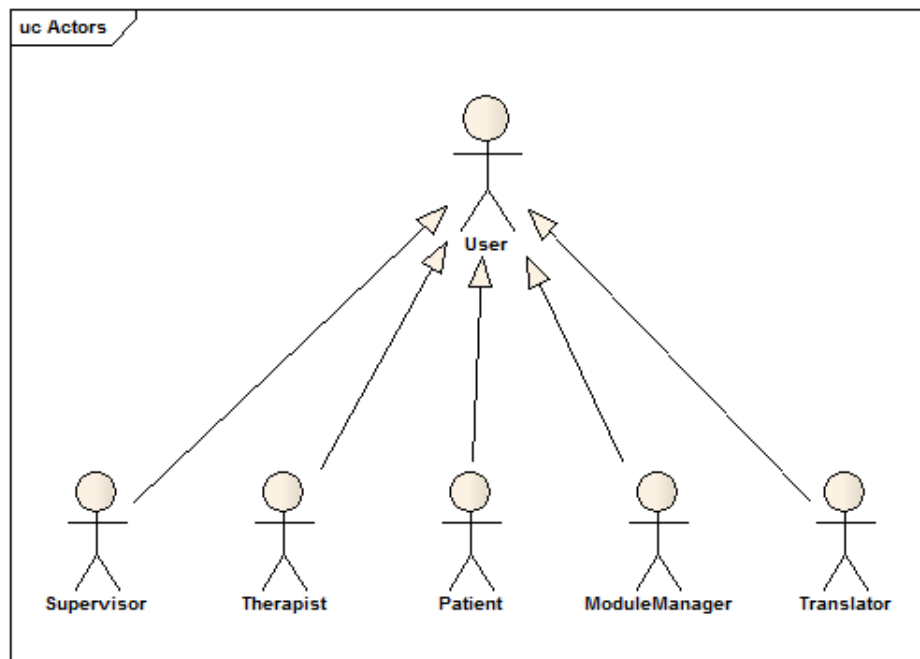


Figure 4.1: Actors.

### 4.1.2 System use case diagrams

A system use case describes how a real-world actor interacts with the system. It is used to capture the user intentions within a system. [2] The diagrams from figures 4.2, 4.3, 4.4, 4.5 and 4.6 contain the description of the way how the user will interact with the system.

In figure 4.2 we have an overview of the whole system which makes possible to see how each actor interacts with each portal. As stated above, the use case's diagrams cover all the portals, although in this section we will only analyse those related with **iBuilder**.

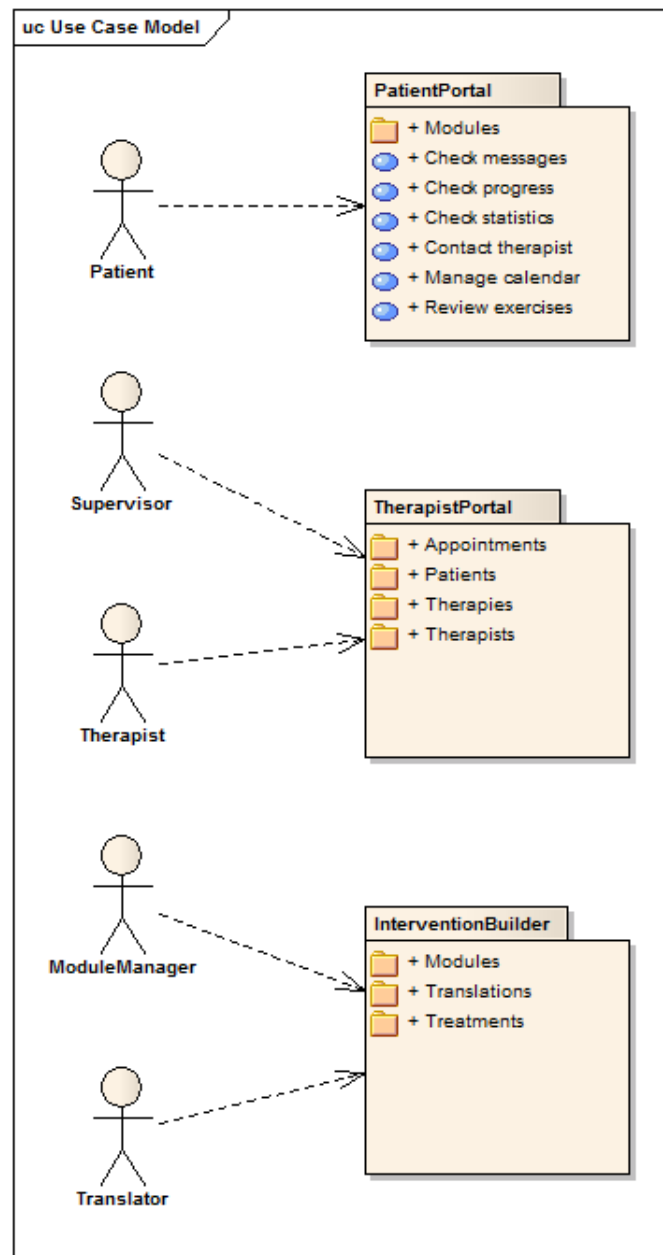


Figure 4.2: Overview of the system use case diagrams.

The interaction with the **iBuilder** portal, figure 4.3, is made through the module manager and translator actors. The diagram splits in three main areas where each actor as a different role. The first one is depicted by figure 4.4 and reflects the requirements about the therapeutic modules interactions. In figure 4.5 is depicted the treatments interactions. The last one, is depicted in figure 4.6, and on contrary to the previous ones it depicts interactions from the two actors and it is focused in the interactions related with the translation process.



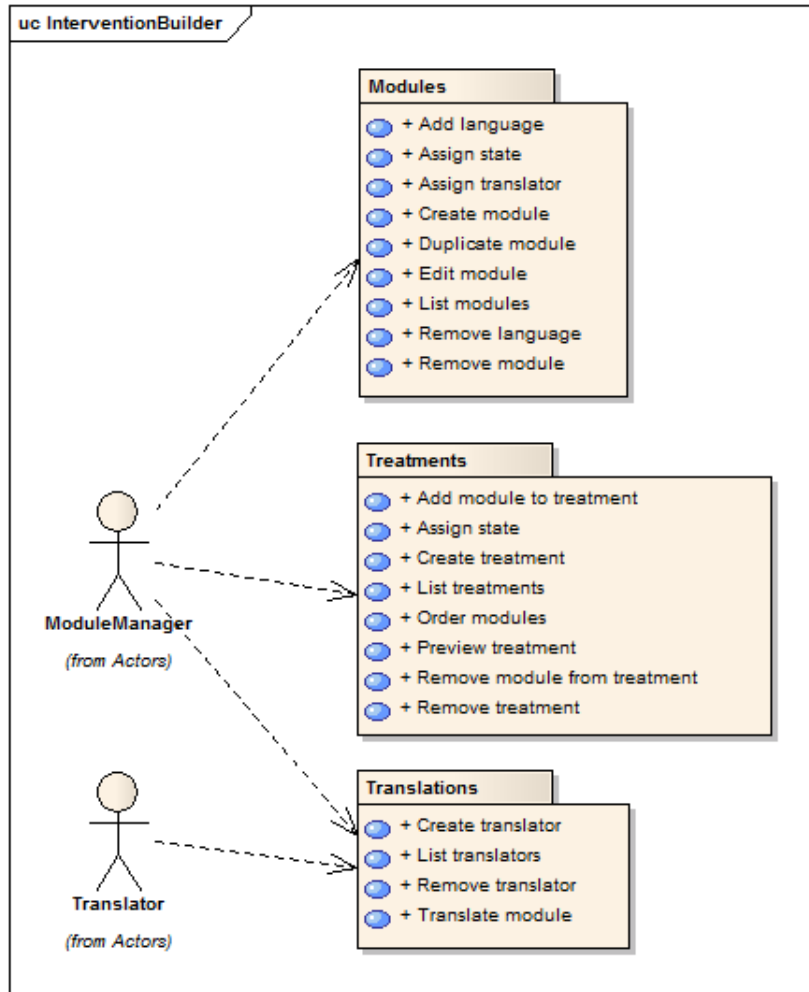


Figure 4.3: Overview of the iBuilder portal.

## 4.2 Conceptual domain model

The requirements presented earlier are important to understand what our users want us to build. However, it is also necessary to understand what we will build. To do this, we will use the conceptual domain model to represent the entities and relationships that are relevant to the system domain problem. [2]

Figure 4.7 depicts an UML class diagram representing the developed conceptual domain model. The domain entities are represented by classes that are connected by lines which, in turn, illustrate the relationships.

Comparing to the Moodbuster system it is noticeable some new classes, being the treatment entity one of them. Each treatment has associated one or more modules, being their order relevant. A treatment also has a state associated and must be used in at least one country.

The entity module is composed by the aggregation of the page entity and has associated two more other entities. The module is associated with a state and with one or more languages that

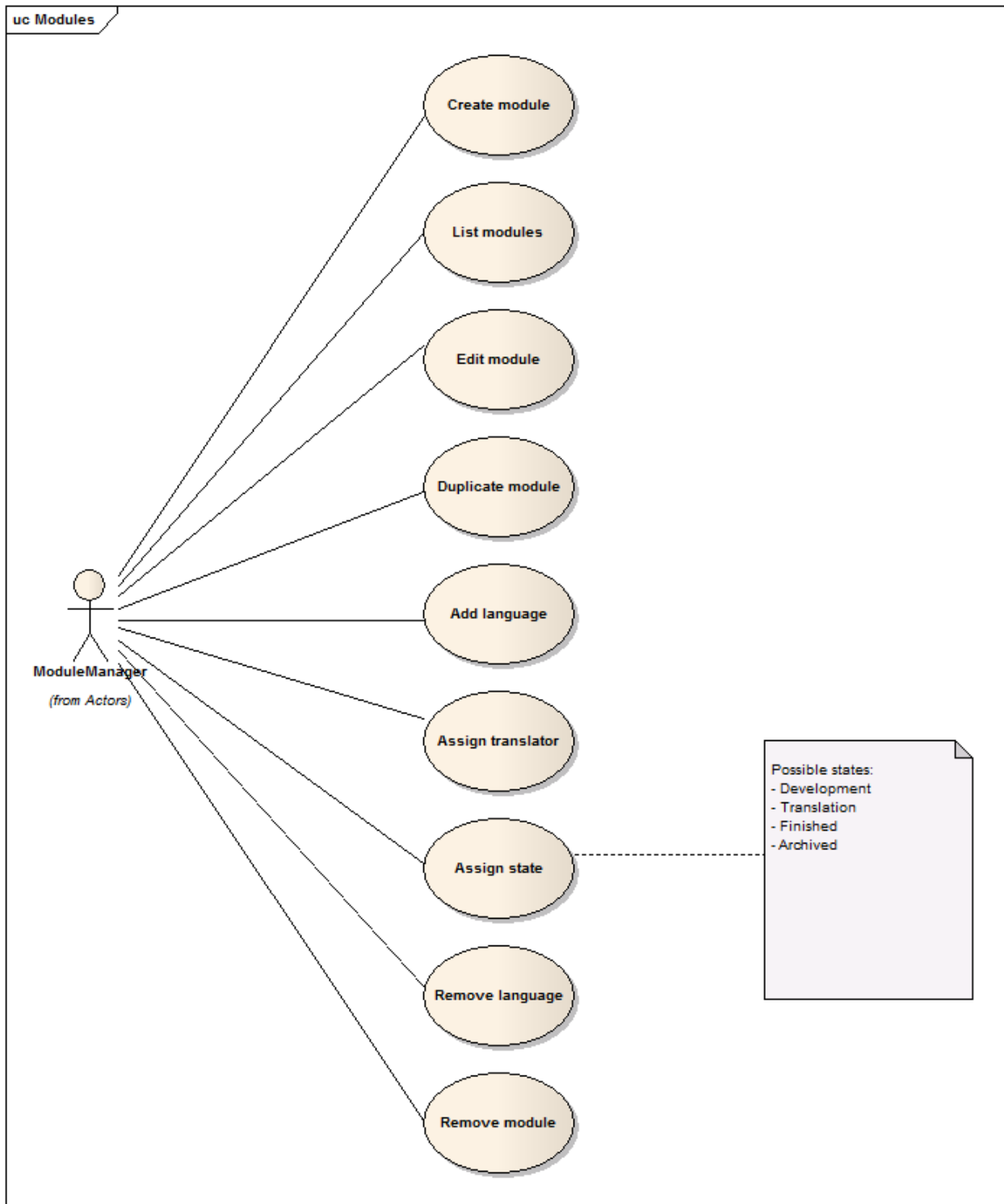


Figure 4.4: Modules diagram.

allow the translation operation.

The page entity is composed by an aggregation of elements that must have a type. The step entity inherits the pages properties and is used to compose the exercises. In order to cover some of the therapeutic instruments like the Patient Health Questionnaire (PHQ), an exercise may

have an instrument associated. Finally, a set of pages compose a group.

Regarding the system actors, all of them inherit from the user entity. The translator, as seen in the previous section, is only associated with the translation entity and the module manager manages the treatments. The supervisor, as stated earlier, is associated to therapists which are associated to their patients. A patient is also associated with the treatments and the modules. Also, each patient may be at a determined state.

As the diagram shows, each module will be a piece on the system. Adding the treatment level ensures the ability to create different therapies with different sets of modules. By doing this we became able to apply different and adjusted treatments to each patient which could improve the effectiveness of the therapy.

This approach also helps us to deconstruct the process of creating therapies. We aim that programmers only have to intervene in the construction of the elements that compose a page. This way it becomes possible for the therapists to construct the treatments on their own.

### 4.3 Activity diagrams

In order to better explore the logic of some of the system complex operations we used **UML** activity diagrams. These diagrams always have a starting a point (black circle) and an ending point (filled bordered circle). Some of the activity flow may occur in parallel. This situation is depicted in figure 4.8 by the two parallel bars. The first bar is called a fork and the last bar is called a join. [2, 3]

We will use these diagrams to model the logic of some of the processes described by the use-cases. Figure 4.8 depicts the activity of creating a module. The starting point divides in parallel actions that involve selecting one or more languages and pages, and to add the title to the module. After this, the module can be send to translation in order to reach its ending point.

The construction of a module is necessary for the creation of a treatment, depicted in figure 4.9. In addition to the selection of one or more modules, it is also necessary to add a title to the treatment. After publishing the treatment the ending point is reached.

A treatment must be published in order to become available to the patients. A patient can access a module, as illustrated by figure 4.10. Accessing the module's pages allows a patient to go through the theoretical content and to solve the module exercises.

The process of managing a patient is done by either the therapist or its supervisor. This activity, depicted in figure 4.11, makes it possible to create and edit a patient. Through the analysis of the patient treatment progress and exercises' answers, it is possible to assess the patient progress. The combination of these four activities are essential to reach the system ultimate goal of treating the patients.

## 4.4 Interface

The process of developing the user interface is very important. No matter how good the system is our users must be comfortable using it. To do this we used essential User-Interface (UI), mostly created in paper but also supported by some HyperText Markup Language (HTML) prototypes. Both the patient and therapist portals are already designed. We will only have to provide a way for the therapist to apply a treatment to his patients. This feature was not designed in Moodbuster so we will have to find a way to integrate it with the whole system.

We will focus on the design of the module manager portion of the iBuilder. The interface was divided in four main parts:

- the homepage contains some instructions on how to use the portal;
- the treatment page allows to interact with the treatments;
- the module page allows to interact with the module, pages and elements;
- the user page allows to manage the users of the portal.

The process of UI design was made in paper and converted to a digital sketch. The interface design process will be explored in more detail in the appendix B. We started by designing an interface completely different from the other two existing portals. The goal was to disrupt with the other portals in order to be clear that we were in a different portal with different functionalities.

In order to test this approach we developed a simple HTML prototype, depicted in figure 4.12. Comparing to the other portals the design disrupts by being completely different. In figure 4.12a we can see the pages that compose a module are ordered as defined earlier. Ordering the pages must be accomplished with a drag-and-drop functionality that would be difficult to support in different browsers. The process of creation of a new page would pass by the interaction with a modal window <sup>2</sup>. To get deeper in the page we should edit its elements as illustrated in figure 4.12. In this page is possible to add different elements to a page in an What You See Is What You Get (WYSIWYG) way. Double clicking each element would open an area to edit each of the elements.

After some tests with the prototype we decided to redesign the interface. We realized that if we used some of the elements present in the other two portals we could improve the user interaction with the system. This change would also make easier to support all the interface functionalities in almost all the browsers.

We started by using some of the design included in the other two portals. This decision was highly driven by the need to visualize a module during its creation in the same as the final user,

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<sup>2</sup>Graphical element that pops-up from the main window.

the patient. So this would imply re-use some of the components present in the therapist and patient portals.

In order to disrupt the therapists that will use both the therapist portal and the iBuilder portal we opted to choose drastically different colors for each portal. In figure 4.13 are depicted the final sketches of iBuilder. Comparing with the prototype figures the changes are highly noticeable. The figure also includes some actions that are represented by numbered yellow dots. The overall structure is very similar with the Moodbuster portals. In the top corner left we have the Moodbuster image logo followed by three buttons. These buttons are used in the same way as in the Moodbuster portal so the actions 1-3, depicted in figure 4.13a, allow the user to access his settings and the help function modal windows, and to logout from the portal. The menu bar that helps to navigate in the different pages was also included.

The approach developed uses frequently modal windows to facilitate the creation and edition of the various components. For example, figures 4.13a, 4.13b and 4.13c include actions 4, 6, 10 and 12 that use modal windows. In these actions the modal window is used to create the modules and the pages respectively, and in actions 10 and 12, that represent the module and page titles respectively, they are used to edit a component.

To access the pages of a module we must click in the module row taking the action 5 from figure 4.13a. Accessing the page elements of a page works in the same way although action 7 from figure 4.13b must be taken.

Regarding the elements of a page, depicted in figure 4.13c, we have a very different way of interaction comparing with the first approach. Action 8 remains and allows to add elements to the page. In previous approach we were unable to see the module in the same way as the patient will see it. To solve this problem we changed the interface, therefore the final interface includes two modes, that can be accessed by using action 9, of interacting with the edition of a page. The preview mode displays the page exactly how the patient will see it, in edit mode each element is bordered with a small dashed line that helps to separate the elements. Also, in edit mode for each element is possible to see edit and remove buttons. Contrary to the previous approach that showed an in-line edit area, here we can edit each element through modal windows. One of the biggest changes is that in action 11 is possible to see all the page groups and the current page group. This is a useful change that was not present in the previous approach.

Finally, although it is not represented in figure 4.13, we removed the drag-and-drop reordering from all the pages that needed it. After some study we concluded that it would be difficult to support this feature in a wide variety of browsers. So we changed the reordering to two simple buttons: arrow up and arrow down, in order to allow reordering some of the components.

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## 4.5 Conclusion

The UML tools and techniques are very useful to define fast and clear approaches to specify all the system requirements. Most of the information provided and the techniques used in this chapter were improved through the several phases of the development. In this way it is possible to solve some conceptual errors that may lead to implementation errors.

Changing the process of creation of the modules may lead to different approaches on dealing with the information generated by the system. Although the patient entity remains the centre of the domain model, other entities like the treatment or the module will have a different weight on the system model.

The work presented in this chapter will be very important to support the development of the system, but is also a useful way of documenting the system that did not exist in the current one.

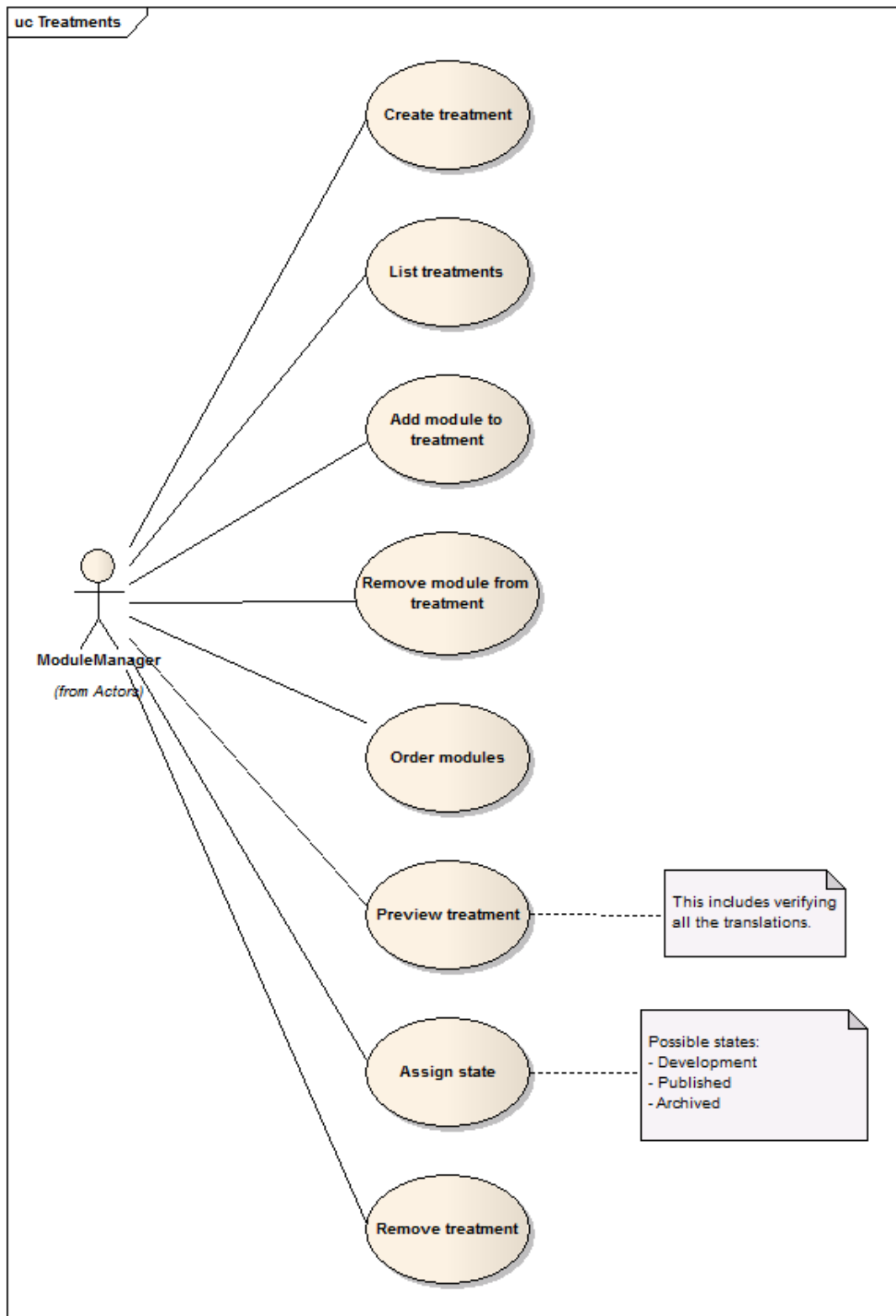


Figure 4.5: Treatments diagram.

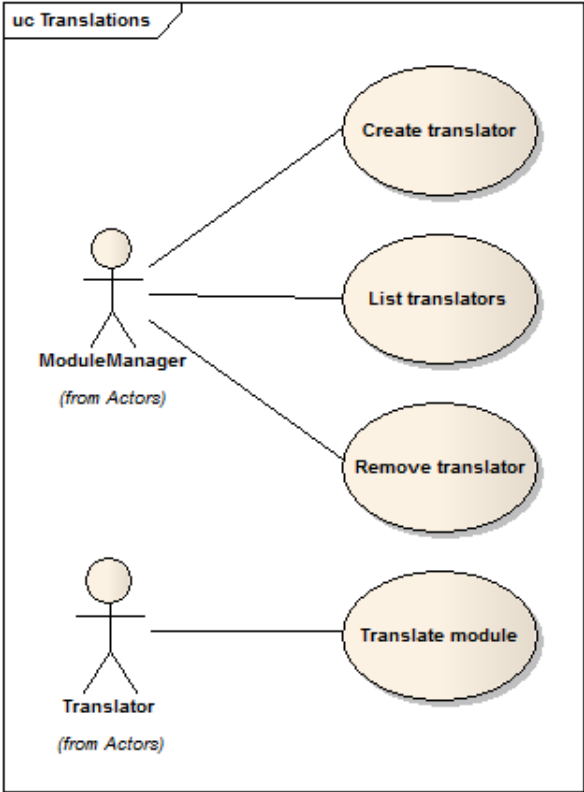


Figure 4.6: Translations diagram.



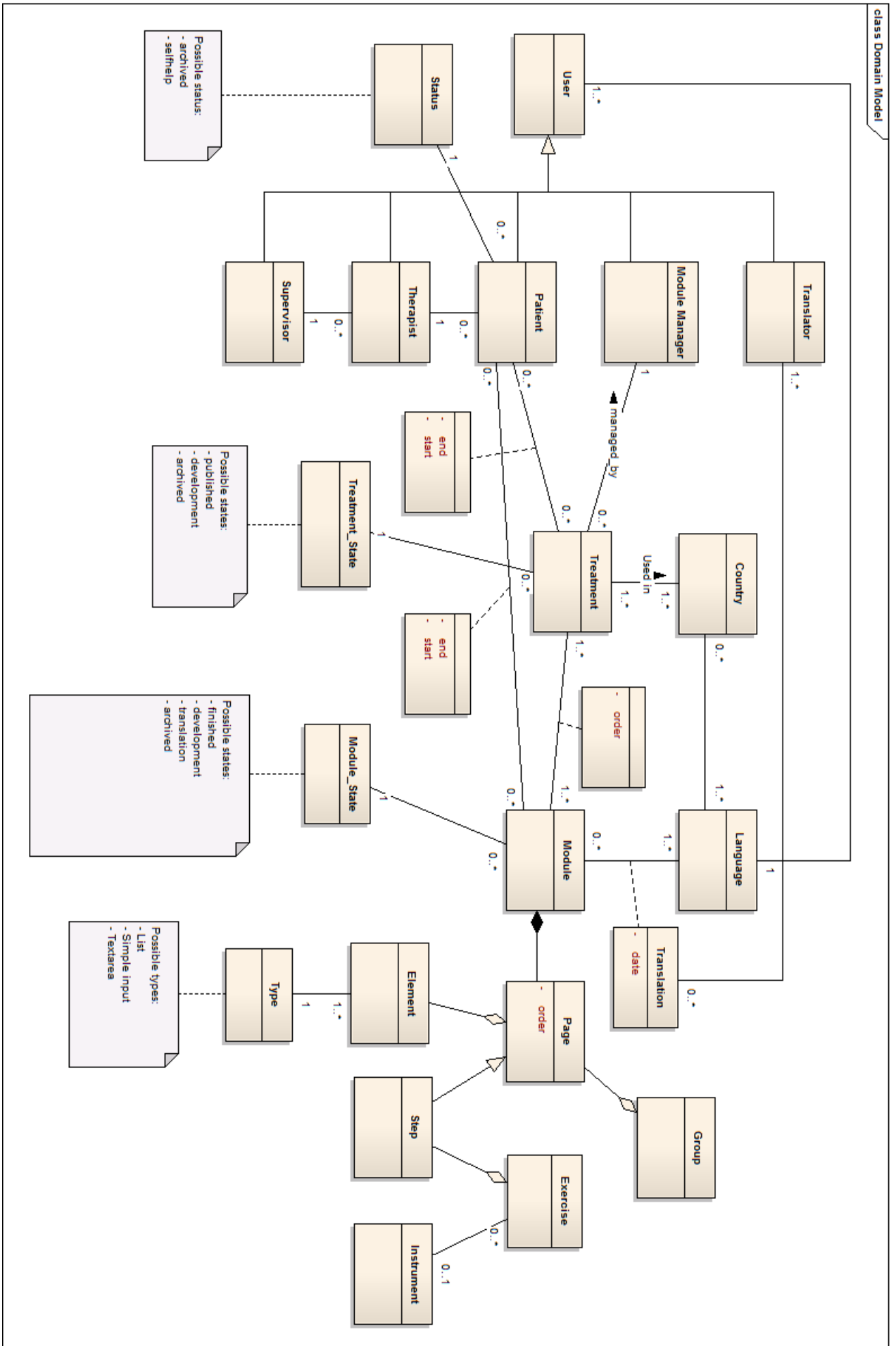


Figure 4.7: Conceptual domain model diagram.

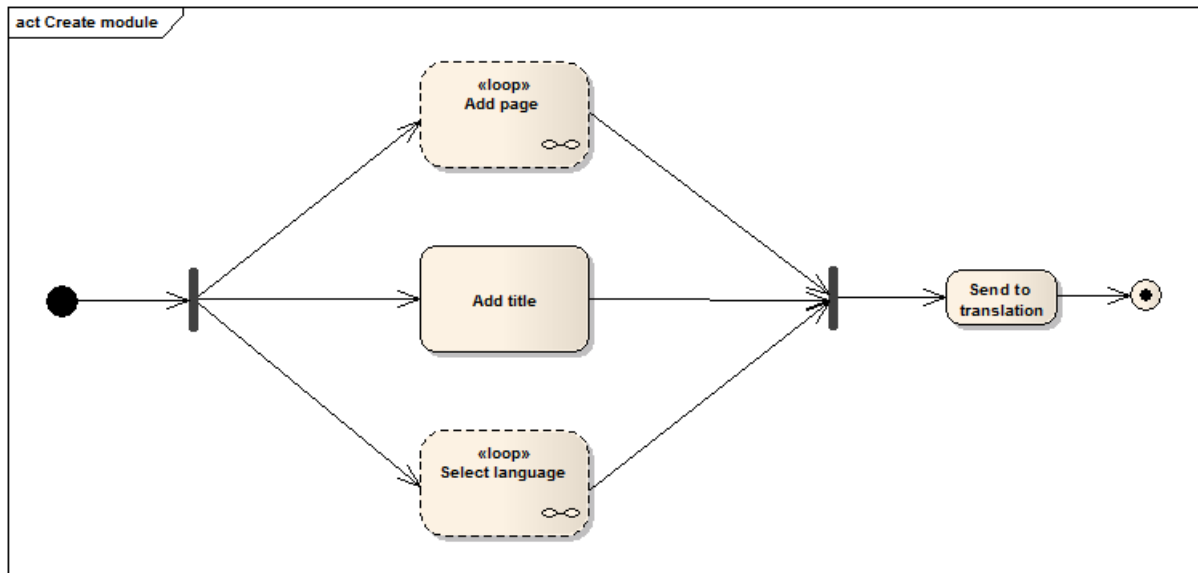


Figure 4.8: Create module activity.

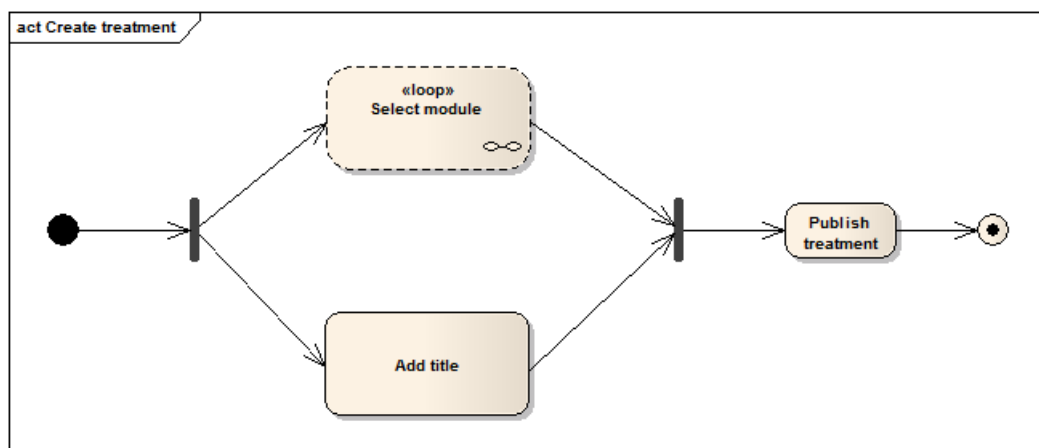


Figure 4.9: Create treatment activity.

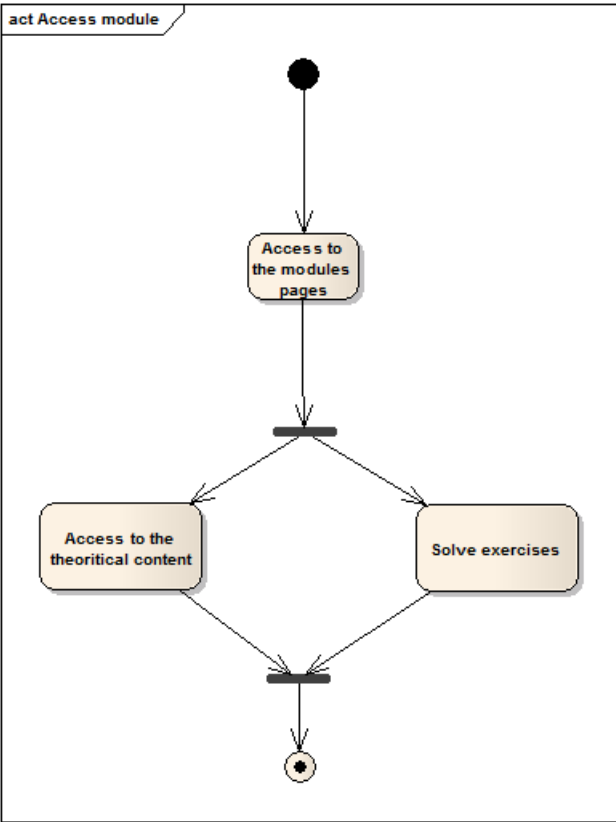
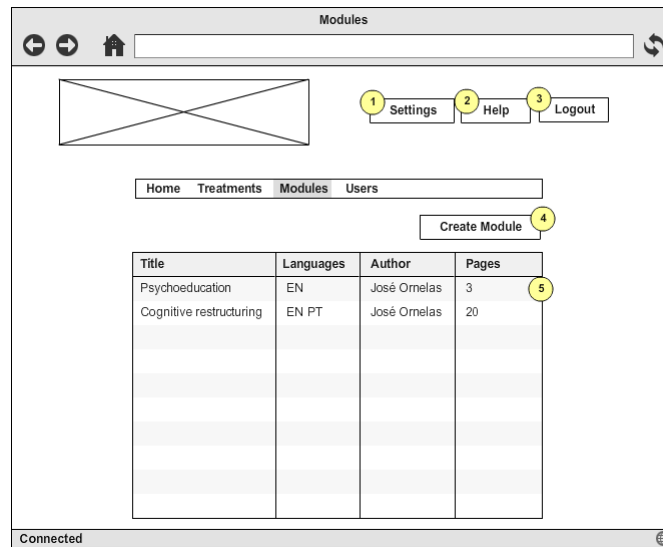
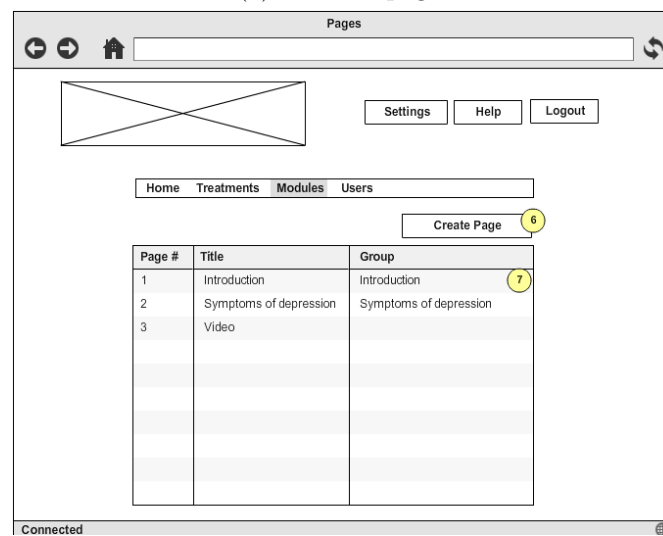


Figure 4.10: Access module activity.

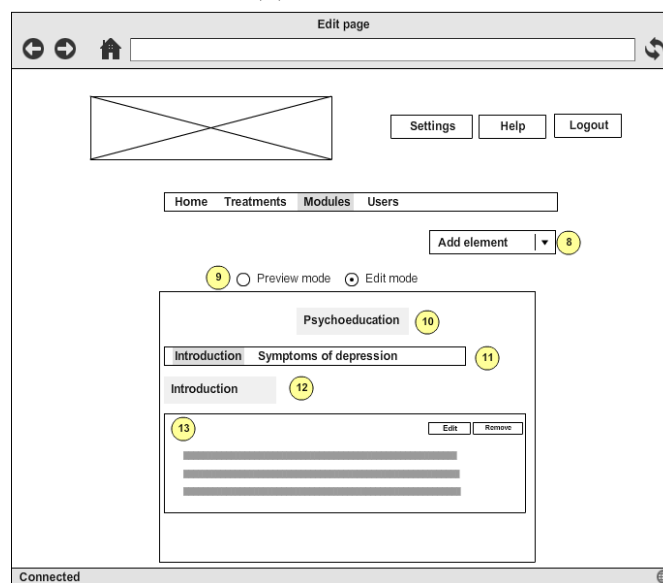




(a) Modules page.



(b) Pages page.



(c) Page edit page.

Figure 4.13: UI final sketches.

## Chapter 5

# Development

In this chapter we will analyse the main aspects of the development of the new system. The solution we implemented as proof of concept involves not only the Intervention Builder (**iBuilder**) but also the Patient and Therapist portals. In order for the whole system to work it was also necessary to reimplement some of the already existent back-end and front-end components.

Some of the system features like the calendar or the messaging component were not implemented. As a matter of fact for this proof of concept we aimed at obtaining a system that was at least able to generate a treatment with the introduction and psychoeducation modules of Moodbuster. Regarding the existent portals, we must at least be able to execute the activities depicted in figures 4.10 and 4.11. The front-end development involved implementing the web portals, in the back-end system we implemented all the services needed to support the web clients and future mobile portals. Regarding the database we approached it in a whole different way. We maintained some of the user's structure, but we changed the way of storing the treatment modules.

In short, the overall goal was to implement a server-side Application Programming Interface (**API**) that will serve the three client side portals. In the next sections we will explore the architecture design, the technology used, the implementation details and the tests made by the psychologists.

### 5.1 Architecture

Figure 5.1 depicts the system architecture. We implemented the commonly used three-layered architecture. The front-end layer, hosted in a Apache server, uses AngularJS to provide the Patient, Therapist and iBuilder portals. The second layer, runs on top of the Ubuntu operating system and represents the back-end. The system business logic runs on top of NodeJS and it is supported by the Swagger, Sequelize and Mongoose libraries. The third and last layer, also hosted on the Ubuntu operating system, represents the database. In order to persist all the

necessary data we will use the PostgreSQL<sup>1</sup> and MongoDB<sup>2</sup> databases. The communication between the layers uses Javascript Object Notation (**JSON**) for the data transfer. **JSON** is a key-value text format that has been gaining some weight in the last few years both in exchanging and storing data. It is easy to use, lightweight and language independent. We chose it because its lightweight works really well both on web clients and mobile devices, and Javascript supports it natively. [39]

Comparing with the current Moodbuster system that used Symfony as a full-stack framework, and in order to develop faster, we chose different micro-frameworks for each job. Although a full-stack framework would bring us other benefits we opted for micro-frameworks not only for making the development faster but also because they make it easy to develop new versions of each component. If in the near future we need to implement, for example, a new patient portal it will not interfere with the whole structure. The developed architecture allows us to integrate new functionalities in the near future like the mobile clients for each portal.

## 5.2 Technology

A part of the development of this system included reimplementing some of the existent features. The current system was not very well documented, thus integrating the **iBuilder** in it would be very expensive. Having this in mind, we opted to break up with some of the technologies used. The system we proposed to develop includes a vast set of components so we chose tools that allowed us to develop fast. It was also important to select tools with fast learning curves in order to facilitate an easy adaptation for future members of the development team.

In order to choose between the wide variety of technology choices we defined two main factors for selection:

- **Opensource** - it is important to select opensource technologies because using it may be a requirement in future projects where we will apply the system<sup>3</sup>;
- **Support** - it is important to select stable technologies that are preferably supported by a strong community.

Due to the high number of components to develop in a short period of time we chose Javascript as the main programming language for the whole system. Thus, and being this a language that we already know and have worked with, it was possible to gain some time that would have been used on learning a new programming language.

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<sup>1</sup><https://www.postgresql.org/>

<sup>2</sup><https://www.mongodb.com/>

<sup>3</sup>Some organizations require opensource implementations on their projects.

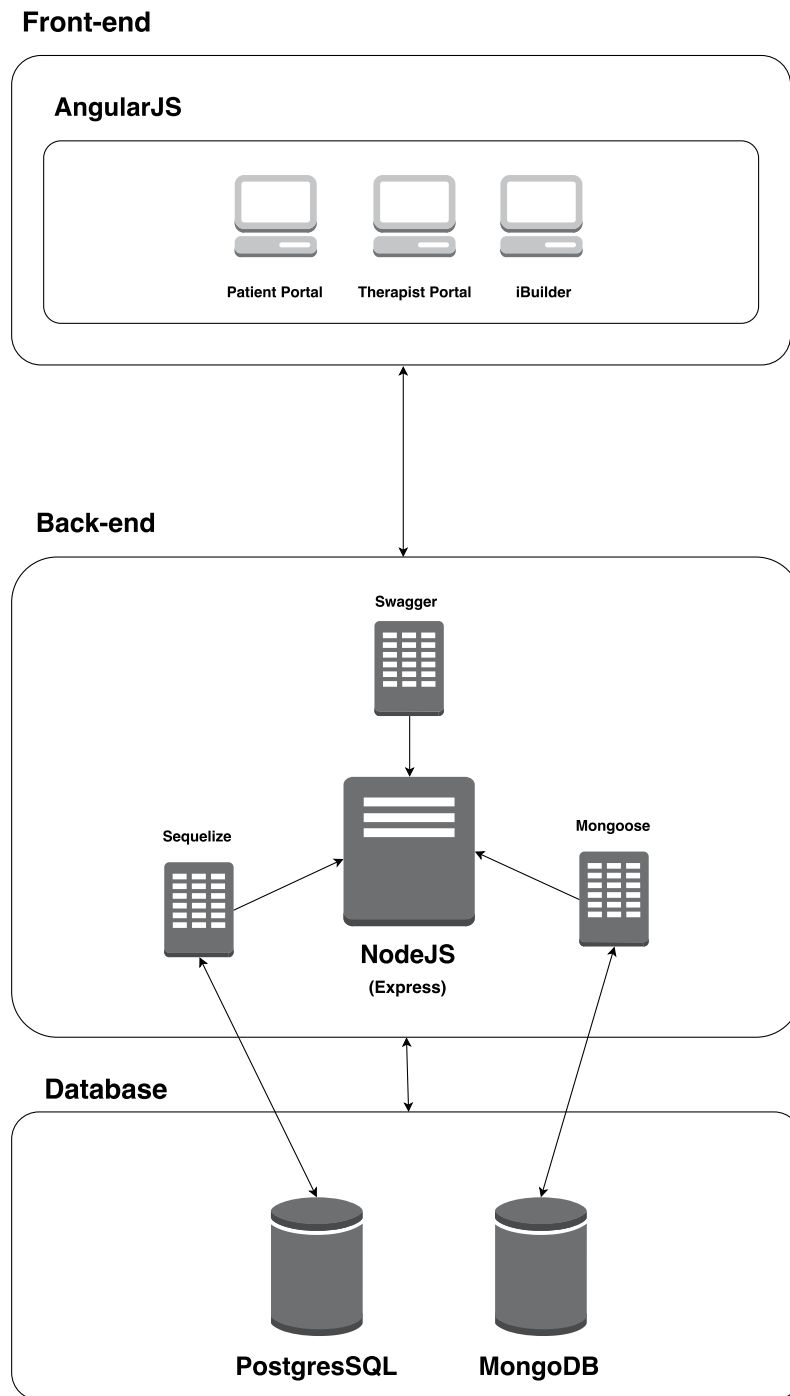


Figure 5.1: System architecture

### 5.2.1 Database

Although the database shares some parts with the old implementation we had to change the technology behind it. We approached it in two different ways and that will require two database systems: a relational database for storing the user's data and a non relational database for storing the treatment modules data.



For the relational database we used PostgreSQL. This is a powerful and reliable Relational Database Management System (**RDBMS**) and has more than 15 years of active development. It is developed by a worldwide team of volunteers that make this open-source system run on all major operating systems. PostgreSQL supports a large part of the Structured Query Language (**SQL**) standard and offers new features like the support for complex queries or **JSON** data types. [20]

In the non-relational database we will use MongoDB. This is the leading Non SQL (**NoSQL**) database and it is also open-source. This is a document-oriented database that provides scalability, availability, flexibility and performance. This database system offers a very easy and flexible schema-less object-oriented programming which allows to rapidly create and change structured, semi-structured and unstructured data. The data is stored in **JSON** format which makes it very easy to manipulate both in a web client or in a mobile device. [27]

### 5.2.2 Front-end

Nowadays we have a wide variety of choices for the front-end frameworks. Even if we focus only in Javascript frameworks we can choose from a set of simple, flexible and well-supported frameworks like AngularJS, EmberJS, BackboneJS or React. Much of these share the same implementation ideas, mostly what separates them is the way how they implement web components to separate the view from the business logic. Also, some of these tools also offer simple ways to develop for multiple platforms.

For this project we opted to use AngularJS. [19] This is by far the most used front-end framework and it counts with Google support as well as the support from a vast community. If we analyse some of the community numbers we can understand how this is. For example it counts with more than 104000 StackOverflow questions, more than 40000 stars on GitHub and more than 1500 third-party modules. It combines the use of HyperText Markup Language (**HTML**), Javascript and Cascade Style Sheets (**CSS**) for creating single-page applications. In order to facilitate the separation of concerns it uses the Model View ViewModel (**MVVM**) architectural pattern which helps to separate the Graphical User Interface (**GUI**) from the business logic.

### 5.2.3 Back-end

In order to make the development faster we also chose a Javascript framework for the server-side. We used NodeJS that is a Javascript framework built on Google Chrome's Javascript V8 Engine. It is, as required, an open-source framework and has a strong community behind it. Although NodeJS stands out by many of its features being the most important: [15, 32]

- **Asynchronous and Event Driven:** it uses an asynchronous and non-blocking architecture which means that the execution never waits for data. Instead it uses an event-driven mechanism that notifies when an asynchronous call ended in order for it to be processed;

- **Fast:** it is a very fast in code execution;
- **Single threaded:** it uses a single threaded event looping. The non-blocking event mechanism is very scalable comparing with traditional servers that create threads to handle requests. Thus NodeJS can handle much larger numbers of requests than other servers;

In order to simplify and make the development faster we also used some other useful libraries.

### **Express**

Express is a minimal and flexible Node.js framework for web and mobile applications. It provides middleware and a set of robust HyperText Transfer Protocol (**HTTP**) methods that helped on the construction of our **API**. Many other NodeJS libraries are based in Express because it provides simple ways for dealing with **HTTP** routes. [14]

### **Swagger**

In order to document our **API** we used Swagger. Swagger provides simple and powerful methods that help on representing an **API**. It uses Yet Another Markup Language (**YAML**) as syntax for creating interactive documentation. [37]

### **Sequelize**

Sequelize is a promise-based Object Relational Mapping (**ORM**) library for NodeJS. It provides a set of methods that help interacting with MySQL, MariaDB, SQLite and Postgres databases. We used it to facilitate the NodeJS interaction with the PostgreSQL database. [36]

### **Mongoose**

For the MongoDB we used a similar tool. Mongoose is an Object Document Mapping (**ODM**) library for NodeJS. It provides tools for creating schema-based solutions to model the database. Its many features include type casting, validation and query building. [7]

### **Other technologies used:**

#### **Ubuntu**

The above described technology needs a server to run. We chose the long term support version Ubuntu 14.04. This is an opensource Debian-based Linux operating system. It is used in personal computers, smartphones and servers. It is supported by Canonical and by a very strong and active community. This operating system is very stable and was used to host the developed components. [8]

#### **Apache**

To serve our front-clients we will use the Apache **HTTP** server. This is the number one **HTTP** server on the Internet and it runs on Linux and Windows operating systems. Apache is developed and maintained by an open community of developers. It provides secure and efficient methods that follows the current **HTTP** standards. [16]

## 5.3 Implementation

In this subsection we will go through the process of implementation of each of the layers.

### 5.3.1 Database

As referred earlier we changed the approach on how we deal with treatment modules data. This change is highly motivated by the way we created the treatments and the modules. Changing the process of creating modules to a way in which programmers are almost unnecessary, involves big changes on the data model. The current system data model works well because there was someone only responsible for the database layer.

In our approach we handle the tools for constructing the treatments to the psychologists. Apart from constructing the whole system base, a programmer will only be needed to provide support or to create new page elements. This means that instead of intervening directly in the creation of a new treatment his role will be only to provide the tools needed.

Dealing with an approach like this implies that the database is not fixed, on the contrary, the database must be flexible enough to support, if needed, the integration of new page elements. The biggest change comparing to the current Moodbuster system, is that we will handle the treatments, modules, pages and elements entities defined in chapter 4 in a schema-less format. We chose the **JSON** format to define these components schemas and also for storing the data.

The choice of the database system to store this data went to the MongoDB. PostgreSQL already supports the JSON type but every time we want to edit a single part of a JSON object we will need to get the whole object, edit and store it again in the database. For small objects this is not a big problem but the treatments and modules components can easily become big. MongoDB offers this functionality by default. In MongoDB we deal with the treatments, modules, pages and elements in **JSON** structures called collections.

For this proof of concept we started by defining three page elements. Two of the elements must handle two types of inputs: a simple input that we called 'TEXT-INPUT' and a list input that we called 'LIST-INPUT'. The 'TEXT-INPUT' is depicted in figure 5.1, the data stored is the element *type*, a *description* and a *placeholder* for the input box. The 'LIST-INPUT' element is depicted in figure 5.2 and stores the same data of the previous element, but it also stores a list of *default values* for the list and an *order* key to specify if the list items are ordered or unordered. The third element must handle all the content like texts, tables, images and other multimedia, we called this element 'TEXTAREA'. The schema for this element is depicted in figure 5.3 and includes the *type* key and a *content* key to store all the different content. Both video and images will be stored in this key, the videos stored will always be hosted in a third party service and the images will be converted and stored in base64<sup>4</sup> format.

---

<sup>4</sup>base64 is a scheme that allows converting binary data to text.

```
1 {
2   type: {
3     type: String,
4     required: true
5   },
6   description: {
7     type: String,
8     required: true,
9     index: {unique: true}
10  },
11  placeholder: {
12    type: String,
13    required: true,
14    index: {unique: true}
15  }
16 }
```

Listing 5.1: Mongoose input schema

The page schema, figure 5.4, contains four pairs of key-value. The group entity was mapped in the *group* key and will be used to mark the beginning of a group of pages. The step entity was also mapped to a page key and it is used to mark the page as a sequence of steps. The title is stored in *title* key. Finally, the elements generated by the schemas from figures 5.1, 5.2 and 5.3 are stored in *elements* array. This array stores all the elements and their order is thus guaranteed.

In the module schema of figure 5.5 we have mapped the module entity. It contains a key that stores the module *title*, a *tagId* to store a custom and unique identifier for the module, the languages that are stored in the *default language* and *languages* keys, being the last one an array of languages. Just like in the page schema the pages key stores all the module's pages by order. This schema also includes a key that represents the possible *states* of the module, the *author* that stores the author's username, and two date keys to store the creation date and the last update. As seen in the previous chapter each module is an independent structure. A treatment can be created and include one or more modules. Each module can be part of a unlimited number of treatments.

The treatment entity was mapped in figure 5.6. It includes some of the keys that we had seen earlier in the module schema like the *tagId*, *title*, *author*, *state*, *languages*, and dates of creation or edition. The *modules* key stores the treatment modules. When a module is added to the treatment we store a copy of the module in the modules array, guaranteeing the order of the modules.

The translation schema, figure 5.7 maps the translation entity defined earlier. The translations

```
1 {
2   type: {
3     type: String,
4     required: true,
5   },
6   description: {
7     type: String,
8     required: true,
9     index: {unique: true},
10  },
11  placeholder: {
12    type: String,
13    required: true,
14    index: {unique: true},
15  },
16  defaultValues: {
17    type: String,
18    required: true,
19    index: {unique: true},
20  },
21  order:{
22    type: Boolean,
23    require: true
24  }
25 }
```

Listing 5.2: Mongoose list schema

collection stores the translations by language. In the previous analysed schemas we seen some fields that required to be unique like the *title* of a module or the *description* of a list input element. These keys must be unique because they are translatable. The way we will handle the translations involves generating an unique identifier for each key that needs translation. These unique identifiers will be stored in the *content* object represented in the translation schema.

In order to guarantee integrity and validation of the data fields the values inserted in the collections mapped earlier are validated by custom functions. Also, for each new entry in a collection created with one of these schemas, Mongoose will also add a *\_\_id* key that stores an unique identifier.

The relational data model, figure 5.2, is very similar with the current Moodbuster data model. We converted it from the SQL Server database to the PostgreSQL. The only difference is in the *treatmentState* that has now a **JSON** type. Unfortunately the software used to create the

```
1 {
2   type: {
3     type: String,
4     required: true
5   },
6   content: {
7     type: String,
8     required: true,
9     index: {unique: true}
10  }
11 }
```

Listing 5.3: Mongoose textarea schema

```
1 {
2   group: {
3     type: String
4   },
5   step: {
6     type: Boolean,
7     required: true
8   },
9   title: {
10    type: String,
11    required: true,
12    index: {unique: true}
13  },
14  elements: []
15 }
```

Listing 5.4: Mongoose page schema

database schema<sup>5</sup> does not support the last version of PostgreSQL so it was impossible to represent the *treatmentState* attribute. We represented it separately in figure 5.8. This attribute must be of JSON type because it also needs to be flexible. The attribute will store all the patient's progress and responses. It includes two main keys: one for the current treatment and one for the patient's past treatments. Every time the therapist changes the patient treatment the new treatment is stored in the *current* key and the old one moves to the treatment structure into the *history* key. Also, the structure stores the treatment progress as well as the current module and page, this helps the patient resuming from where he stopped working. Inside the

<sup>5</sup>The software used was the Enterprise Architect 7 (<http://www.sparxsystems.com.au/products/ea/>).

modules key, the modules are stored by their *id* value. Each module contains the progress in the module and also the elements responses that are stored in the same way.

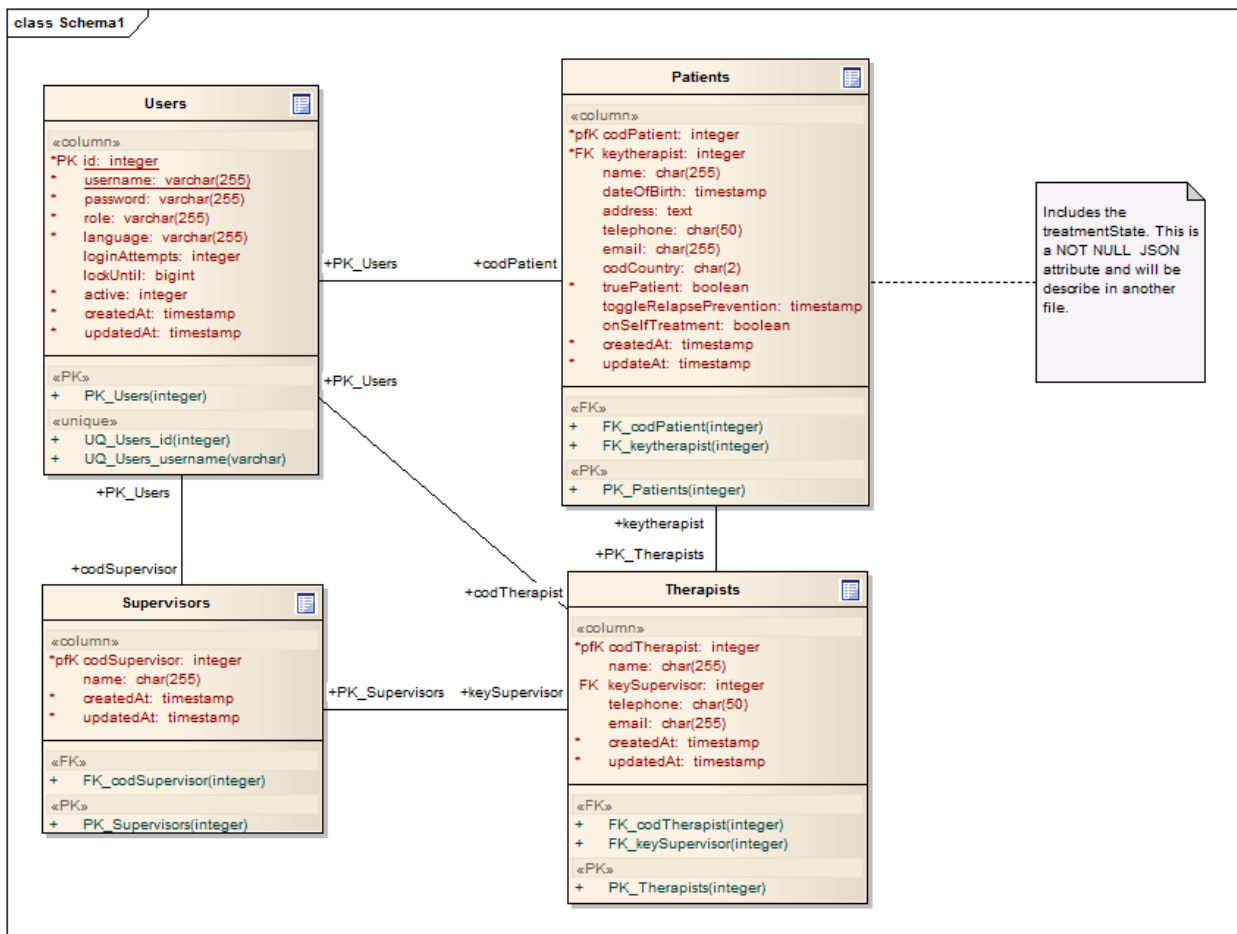


Figure 5.2: User's relational data model.

### 5.3.2 Back-end

The NodeJS back-end is responsible for the system's business logic. The main objective was to implement a secure layer of RESTful<sup>6</sup> web services that could be mapped in the form of an API. The API routes were defined using the Express library and through the Swagger library we generated a testable API entry point, see figure 5.3. Figure 5.3 also shows all the API routes classified by the Swagger tags, which facilitate identifying the routes for each component and user.

In order to secure the whole system a user must first login. If the login is successful the system generates and sends to the user a JSON Web Token (JWT)<sup>7</sup>. Each user only has access to specific routes:

<sup>6</sup>Representational State Transfer (REST) is the software architectural style of the World Wide Web (WWW). A REST API uses the GET, PUT, POST and DELETE HTTP methods.

<sup>7</sup>Industry standard RFC 7519 [?] method for representing claims securely between two parties.

- **All users:** can access the `/signin` route;
- **Therapists and Supervisor:** only have access to the Therapist Portal routes;
- **Patient:** only has access to the Patient Portal routes;
- **Module Manager and Translator:** only have access to the iBuilder routes.

Also, some of the routes are generic by portal but others are restricted by user. For example, the translator does not have access to the route that allows to create a module.

The **API** calls and responses are made in **JSON** format. The responses are composed by two key-value objects: *meta* and *data*. The *meta* key contains the response code and the *data* key contains the requested data.


Elements	Show/Hide	List Operations	Expand Operations
iBuilder	Show/Hide	List Operations	Expand Operations
Module Manager	Show/Hide	List Operations	Expand Operations
Modules	Show/Hide	List Operations	Expand Operations
Pages	Show/Hide	List Operations	Expand Operations
Patient	Show/Hide	List Operations	Expand Operations
Patient Portal	Show/Hide	List Operations	Expand Operations
Published Treatments	Show/Hide	List Operations	Expand Operations
Supervisor	Show/Hide	List Operations	Expand Operations
Therapist	Show/Hide	List Operations	Expand Operations
Therapist Portal	Show/Hide	List Operations	Expand Operations
Translations	Show/Hide	List Operations	Expand Operations
Treatments	Show/Hide	List Operations	Expand Operations
User	Show/Hide	List Operations	Expand Operations
POST 			
DELETE	/api/v2/user		
GET	/api/v2/user		
POST	/api/v2/user		
PUT	/api/v2/user		

Figure 5.3: System's API.

To help producing the treatments correctly we implemented some rules that will make the system work more smoothly:

- In order to publish a treatment all the modules must have at least all the treatment languages and must have the *state* marked as finished;



- In order to finish a module it must have at least one page. Each page of the modules must also have at least one element;
- In order to create a group of pages only the first page of the group needs to have the group name. The first page of each module must always have a group.

In order to guarantee that all the requirements in the back-end services were met we developed some integration tests. The implemented tests served to detect some of the implementation errors and were also a way of documenting the code. They tests tested the routes created, validated if the responses given were correct and if the data persisted correctly in the database.

### 5.3.3 Front-end

Regarding the front-end we will only analyse the implementation of the biggest challenges we encountered on developing the iBuilder portal. The other two portals were also reimplemented in AngularJS and replicate the functionalities of the current Moodbuster although with a slightly different design. Most of iBuilder, Patient and Therapist portals screen-shots can be seen in appendix C.

The iBuilder portal implemented includes all the interfaces designed in the previous chapter. Most of the pages implemented included simple HTML and Javascript parts that were easy and fast to implement. In this section we will analyse how the most important parts were implemented.

We started by developing a way of communicating with the back-end API, so we implemented multiple AngularJS services to handle the necessary connections like for the authentication, creation and edition of the treatments, modules, pages, etc.

As we seen previously on chapter 4 some of the interface components does not involve a high level of difficulty. The portal is mostly composed by tables that are easily created and maintained with AngularJS and several modals that help on creating and editing most of the components.

Regarding the aspect of the portal, as we opted by using a similar structure, we used parts of the Moodbuster CSS (which included Bootstrap<sup>8</sup>).

The implementation of the elements was the big challenge. We needed to do it in a modular way that allowed for them to be reused in the Patient and Therapist portal. To accomplish this we used the AngularJS directives. Directives act as a web component and include an HTML template and a Javascript controller. The result is depicted in figure 5.4, and shows the final implementation of the three proposed elements. The first element has a 'TEXTAREA' type, the second has a 'LIST-INPUT' type and the last has the 'TEXT-INPUT' type. The view depicted in the figure includes some components like dashed border and the reordering, delete and edit buttons, that are not part of the directive. Editing an element, as designed in chapter 4, is done

---

<sup>8</sup>Bootstrap is a popular CSS framework that allows to easily develop clean and responsibe webpages.

by clicking the edit button which opens an editing modal. Figure 5.5 depicts the three edit modals. The list and input edit modals allow to edit the elements fields in the database section. The textarea edit modal includes a text editor<sup>9</sup> that allows to introduce various types of data, including multimedia like images and videos.

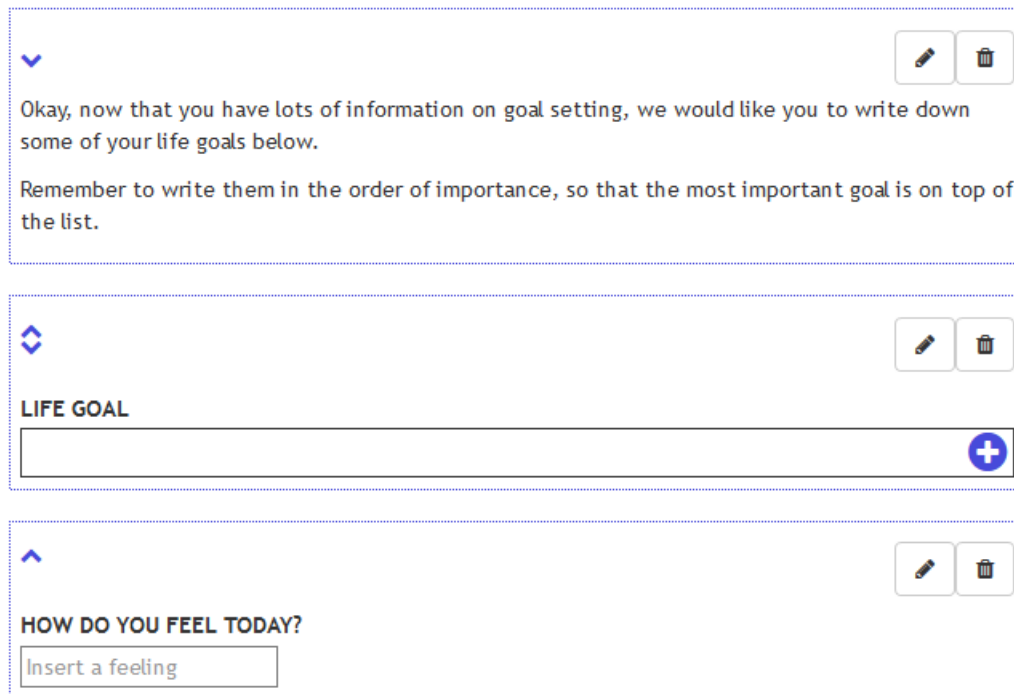


Figure 5.4: Elements.

One of the challenges that we encountered in the Design chapter was how to handle the edit and preview modes. In figure 5.6 is depicted the final solution. When the preview mode is activated, figure 5.6a, the page is presented in the same way it will be presented to the patient. If we change the page to edit mode, figure 5.6b, we can access all the edition controls. We are able to reorder, add, remove or edit the elements. Each element is highlighted by a soft dashed border that helps to identify the elements on the page.

Also, in web development we always encounter the challenge of supporting the wide variety of web browsers. In this project we had some problems to make some features to work in some of the browsers. Nonetheless, the final clients presented on this thesis work on the mostly used browsers: Chrome, Firefox, Edge, Internet Explorer and Safari.

## 5.4 Evaluation

In order to evaluate the developed system, we consulted two of the European Comparative Effectiveness Research on Internet-based Depression Treatment (**E-COMPARED**) psychologists.

<sup>9</sup>This editor was also used in the Moodbuster system in the translation tool. Its name is CKEditor and it is an open source What You See Is What You Get (**WYSIWYG**) editor.

(a) List edit modal.

(b) Textarea edit modal.

(c) Input edit modal.

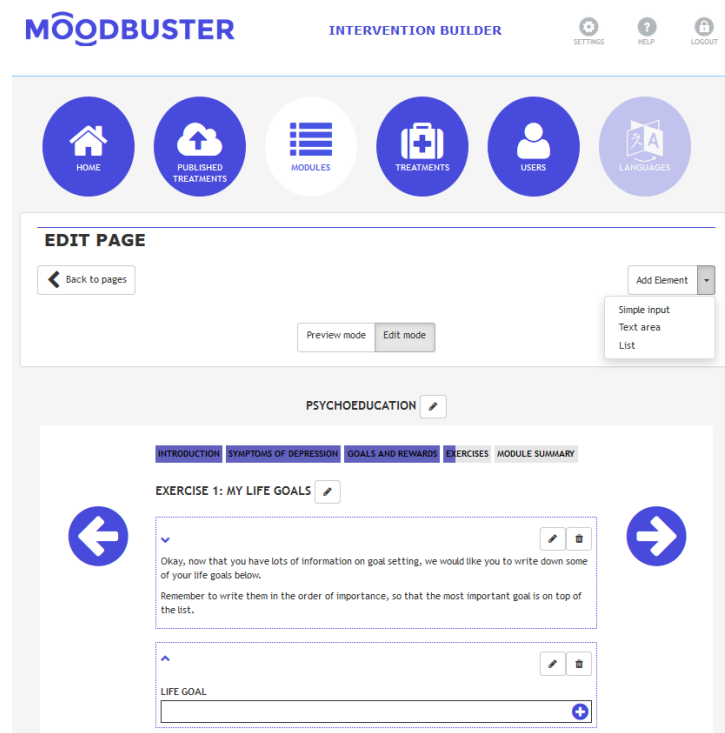
Figure 5.5: Edit modals

It is important to note that although the *iBuilder* portal was created for the use of psychologists just a tiny fraction of the them are responsible for the creation of new therapeutic modules. Most of the psychologists are more operational, so they will only interact with the patients, which means they will mostly use the Therapist portal.

Also, the new system will continue to be developed in the next months so we opted to ask only two of the psychologists for feedback. We proposed that they use the *iBuilder* in order to



(a) Page preview mode.



(b) Page edit mode.

Figure 5.6: Page modes.

create a treatment with the Introduction and Psychoeducation modules. Also, we asked them to, after publishing the module, enter the Therapist portal. In the Therapist portal they must add a new patient and enroll him in the developed treatment. In the end, they must enter the Patient portal with the credentials of the patient added in order to test the created module as a patient.

In order to assess their interaction with the system we used the Technology Acceptance Model 2 (TAM2). This model is presented in the form of a questionnaire to identify the reasons why many developed systems present lower levels of usage. TAM2 theorizes that the user's behavioural intention to interact with a system is determined by 8 beliefs: intention to use, perceived usefulness, perceived ease of use, subjective norm, voluntariness, image, job relevance, output quality and result demonstrability. [? ]

The questionnaire and the user's responses will be attached in the appendix D. The questionnaire is composed by several questions that must be qualified in a scale from 1 to 7, 1 being strongly disagree and 7 strongly agree. Some of the subjects asked in the questionnaire were not mandatory although both users responded to all the questions. The users mostly agreed in the usefulness of the system. Also, both strongly agreed that the system is important for their job and that the system provides a good output. Regarding the perceived ease of use their responses divided with tendency to disagree.

Although the questionnaire responses are important in this phase we were also searching for more detailed comments about the system. In the end of the questionnaire the users gave us some feedback about the overall use of the system. The feedback was mostly positive and highlighted the importance of the platform on treating depression and eventually other mental diseases. They also gave us some notes about some of the issues they encountered on using the platform and some features they think that would be helpful to have such as: a way of printing the modules or more detailed error messages.

## 5.5 Conclusion

In this chapter were presented some of the choices made during the implementation. The implementation phase was hard because it involved not only the implementation of the iBuilder portal and services, but also the reimplementing of the other two portals. The fact that the current Moodbuster system is poorly documented made it difficult to understand some of the core concepts. The technology choices helped on gaining some of the time wasted on understanding how every piece work.

Changing the process of creating modules resulted well. The iBuilder is capable of dynamically generating and delivering new treatments to the other two portals. Although there are several core functions of the Moodbuster to implement, the overall goal of having the programmers participating only in one phase has been accomplished. In the future, programmers will only participate in the support and in the creation of the new elements in the three architectural layers.

```
1 {
2   title: {
3     type: String,
4     required: true,
5     index: {unique: true}
6   },
7   tagId: {
8     type: String,
9     required: true,
10    index: {unique: true}
11  },
12  defaultLanguage: {
13    type: String,
14    required: true
15  },
16  languages: {
17    type: [String]
18  },
19  pages: {
20    type: [pageSchema]
21  },
22  state: {
23    type: String,
24    required: true
25  },
26  author: {
27    type: String,
28    required: true
29  },
30  createdOn: {
31    type: Date,
32    default: Date.now()
33  },
34  lastUpdate: {
35    type: Date,
36    default: Date.now()
37  }
38 }
```

Listing 5.5: Mongoose module schema

```
1 {
2   tagId:{
3     type: String,
4     required: true,
5     index: {unique: true},
6   },
7   title: {
8     type: String,
9     required: true,
10    index: {unique: true},
11  },
12  author: {
13    type: String,
14    required: true
15  },
16  state: {
17    type: String,
18    required: true,
19  },
20  languages: {
21    type: [String],
22  },
23  createdOn: {
24    type: Date,
25    default: Date.now()
26  },
27  lastEdit: {
28    type: Date
29  },
30  modules: [String]
31 }
```

Listing 5.6: Mongoose treatment schema

```
1 {
2   language: {
3     type: String,
4     required: true,
5     index: {unique: true}
6   },
7   content: {
8     type : Schema.Types.Mixed,
9     default : {}
10  }
11 }
```

Listing 5.7: Mongoose translation schema



```
1 {
2   "current":{
3     "tagId":string,
4     "progress": float,
5     "resume":{
6       "module": integer,
7       "page": integer,
8       "date": Date
9     },
10    "modules":{
11      "module_id":{
12        "progress": integer,
13        "started": Date,
14        "lastEdit": Date,
15        "element_id" : "element_response",
16        //rest of the elements
17      },
18      //rest of the modules
19    }
20  },
21  "history":{
22    "treatment_id":{
23      //same structure of current key
24    },
25    //rest of the treatments
26  }
27 }
```

Listing 5.8: Postgres treatmentState attribute

## Chapter 6

# Conclusion

In order to treat the depression disease we need tools that are able to scale. These must allow psychologists to treat higher numbers of patients and to adapt some of the treatments to individual patients and groups. Some of the existing tools, even those that do not work so well, are trying to help dealing with this problem. We need state of the art tools that are able to proliferate for the wide variety of patients. It is important not only to create and apply validated treatment methods but also to provide professional monitoring to the patients.

The scope of this work was to develop one of these tools. The tool was developed under the Stop Depression and the European Comparative Effectiveness Research on Internet-based Depression Treatment (**E-COMPARED**) projects. Although the developed tool included a redesign of an existing system it now offers a faster way of developing new treatments.

The result of this work is composed by an entirely new and secure portal called Intervention Builder (**iBuilder**). This portal offers some of the basic tools needed to create new treatments. It integrates two new versions of two effective portals on treating depression. The new versions of the Moodbuster Therapist and Patient portals include the tools needed for patients to work on the generated treatments, and also include the tools needed to assess the patients' condition throughout the treatment.

However, this system only includes the web clients. In the future, it is important to provide other ways of accessing these tools, thus we developed a vast set of web services that can work with different client versions (e.g. mobile platforms).

Developing this system provided a better insight in computer science and in the E-Mental Health (**eMH**) area. The preliminary evaluation of this work, provided by two psychologists, is a strong indicator that it is possible to make a positive impact on the life of those in need through the application of already known tools and techniques.

## 6.1 Future work

This project will continue for at least a year. Although we developed a stable system we will need to include some of the tools that already exist on the current system. We will not stop on developing what we believe to be the future of creating and providing treatments to cure depression.

The future work will comprehend the development of:

- all the necessary elements to generate all the modules available in the current system;
- a new reasoning system that could facilitate the psychologists job on assessing the patient state;
- data-mining techniques that could identify patterns that would help on treating depression in a more effective way;
- and publishing a standard, based on this work, to specify a structured way of creating treatments.

# Appendix A

## Use cases

As said in chapter 4, in order to fully document our system we developed the use cases for all the platforms. The uses cases presented next were gathered from the current Moodbuster system.

In figure A.1 we have all the Patient portal use cases. Figure A.2 focus on the Patient interaction with treatment modules.

Regarding the Therapist portal, figure A.3, depicts the portal overview. The figure depicts all the interaction from both the users. However, we need to go further on the Patients packages, figure A.4, to difference between the Therapist and Supervisor use cases. Both share the Edit patient package, figure A.5, where the Therapist has two use cases and the Supervisor has one.

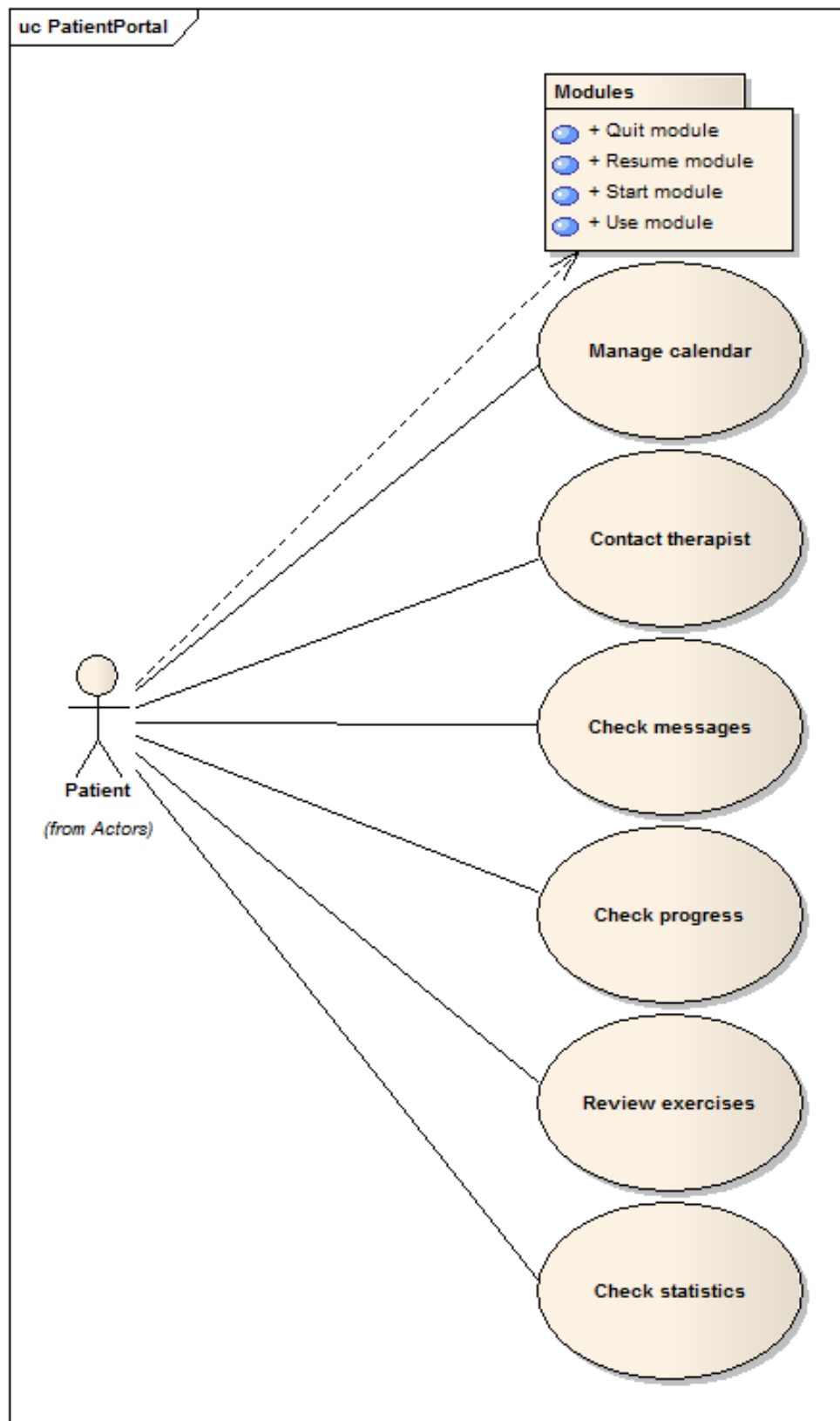


Figure A.1: Patient portal use cases overview.

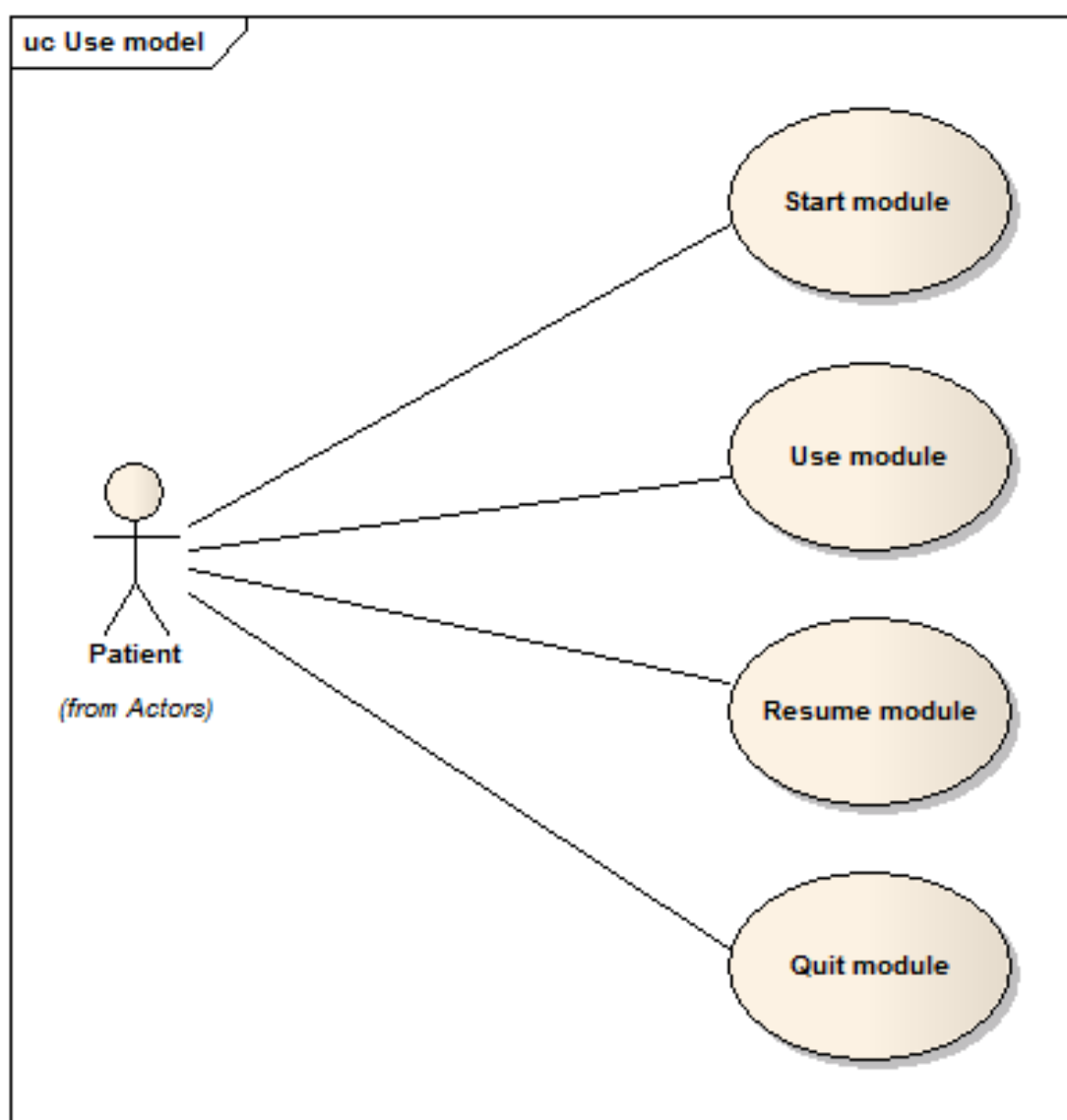


Figure A.2: Patient portal modules use cases overview.

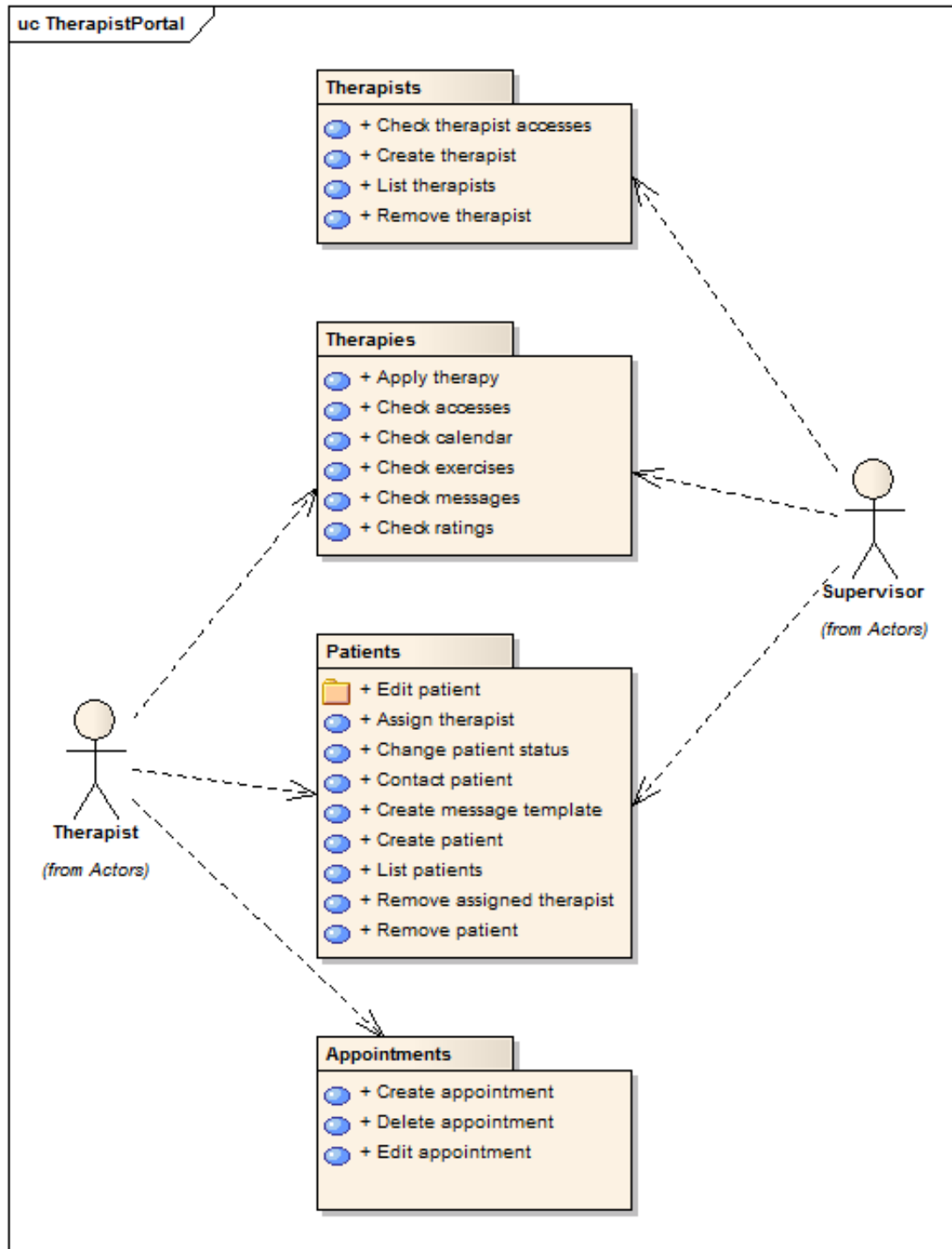


Figure A.3: Therapist portal use cases overview.

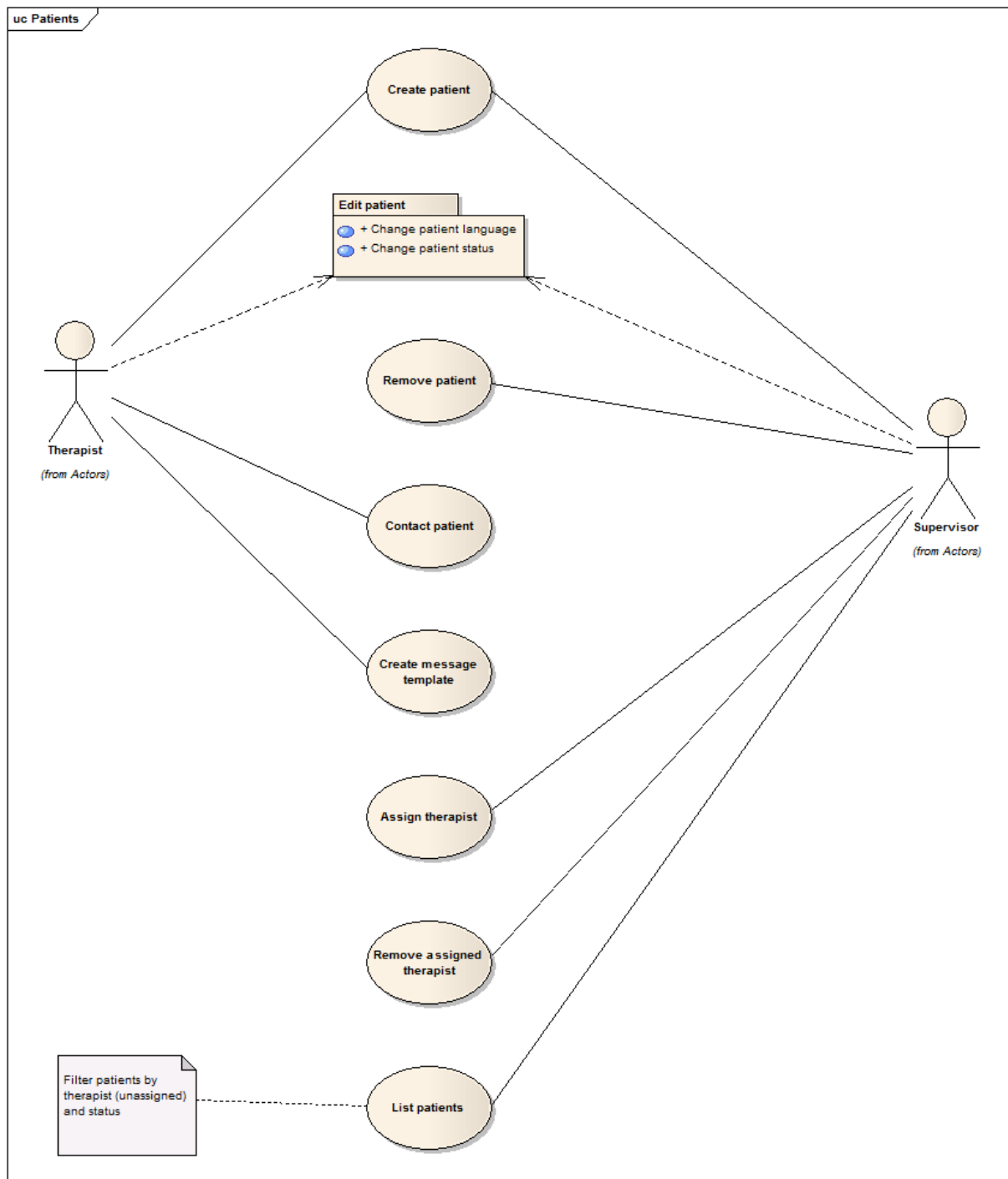


Figure A.4: Therapist portal patients use cases.



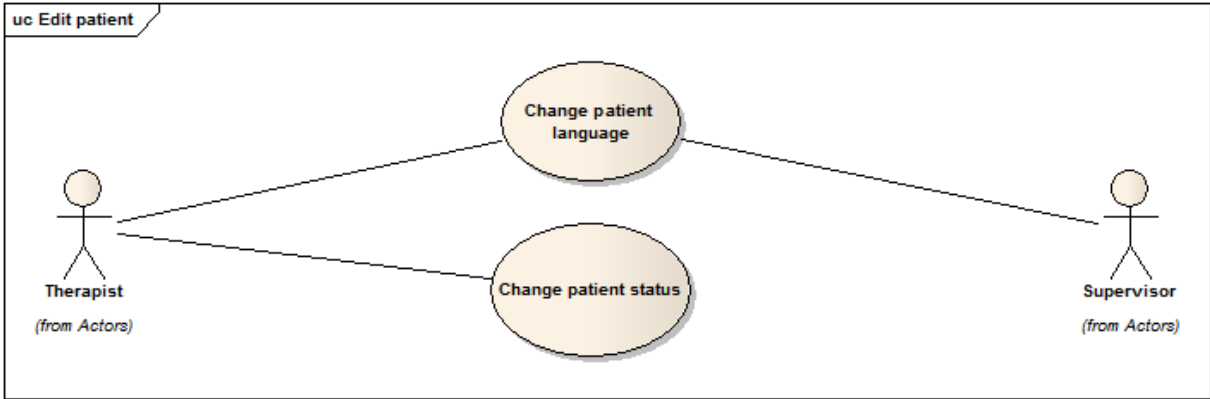


Figure A.5: Therapist portal edit patients use cases.

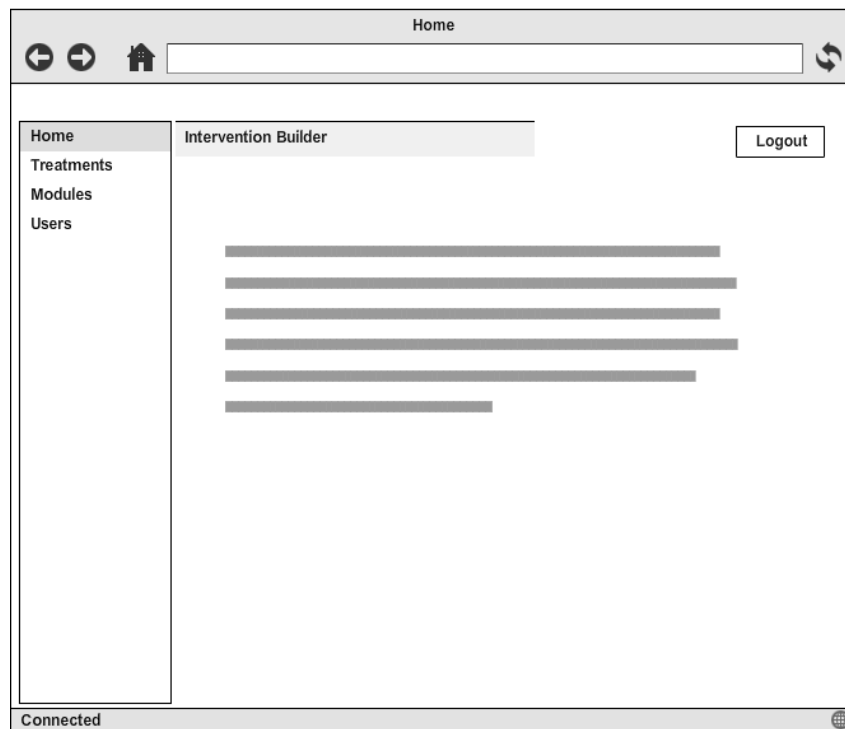
## Appendix B

# Detailed design process

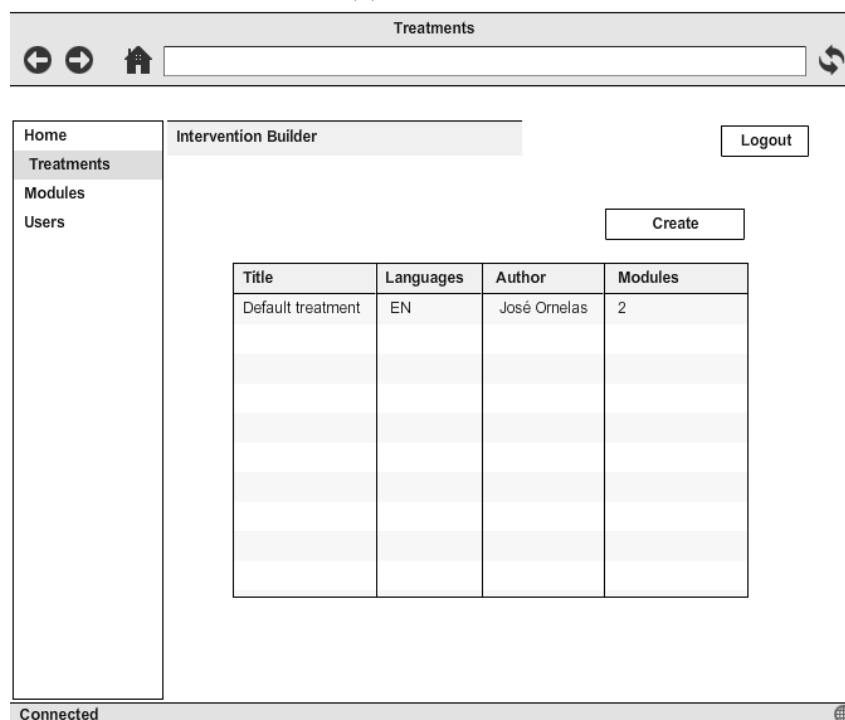
In chapter 4 we explained that the design was based on two approaches. The first approach included a not so clean design. Figures B.1, B.2 and B.3 depict the first (old) approach for the Intervention Builder (iBuilder).

The new approach presented in chapter 4, also includes the pages depicted in figure B.4.

We also implemented a new feature in the Therapist portal. This feature, figure B.5, provides a way of applying a treatment to a patient.

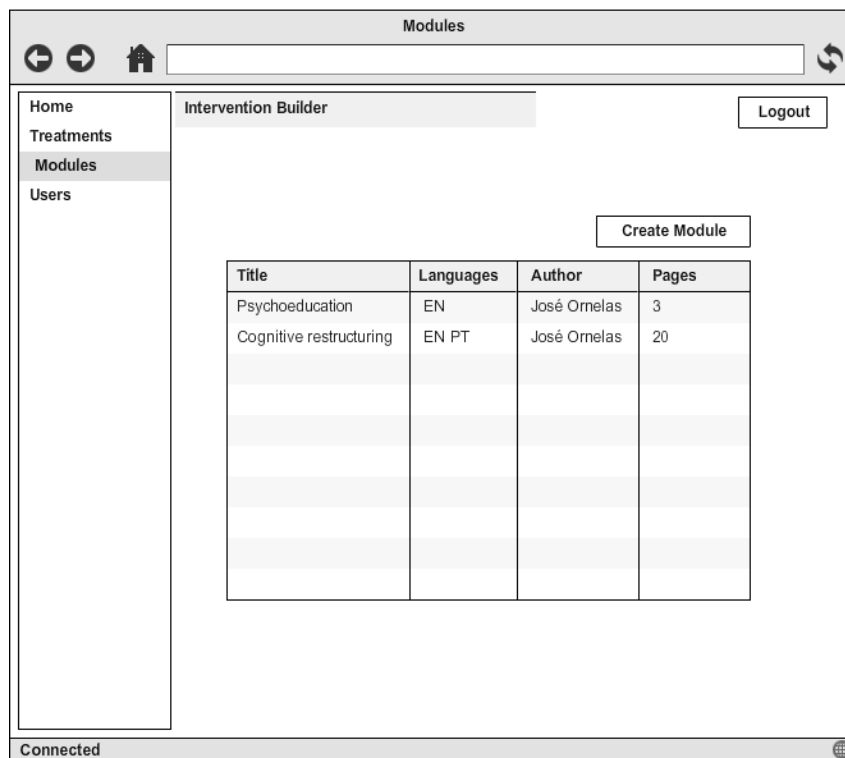


(a) Homepage.

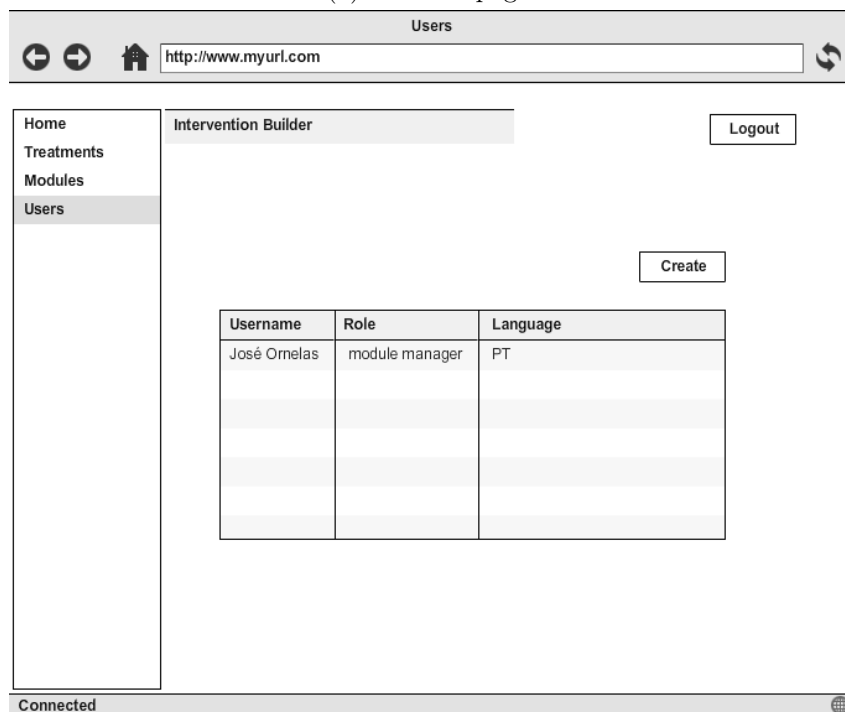


(b) Treatments page.

Figure B.1: Old UI sketches.

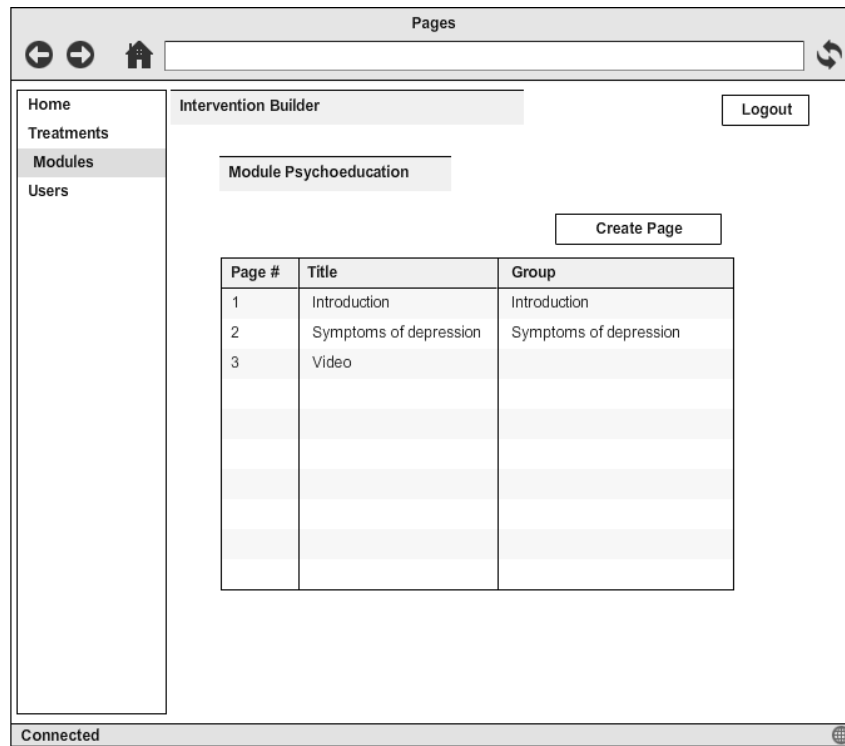


(a) Modules page.

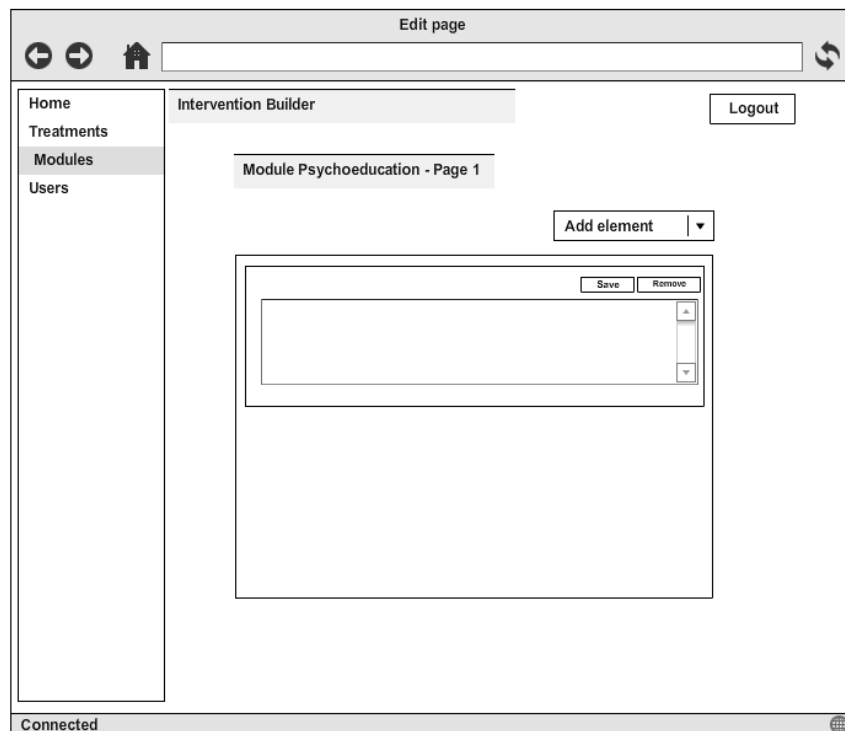


(b) Users page.

Figure B.2: Old UI sketches.

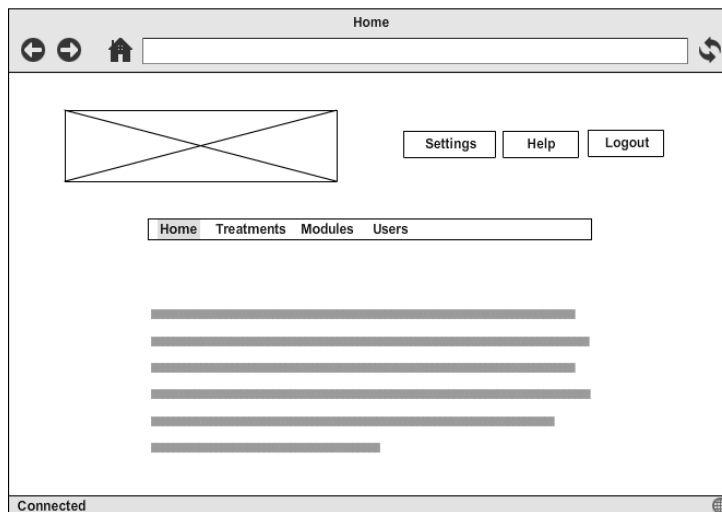


(a) Pages page.

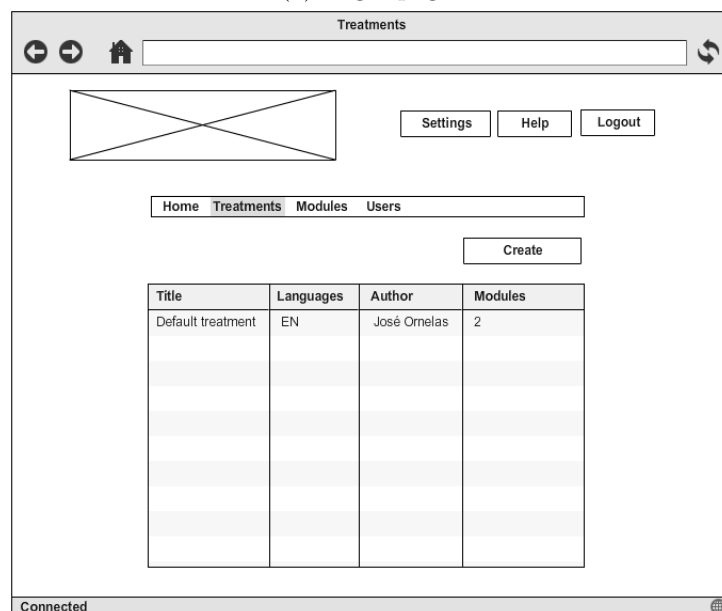


(b) Edit pages page.

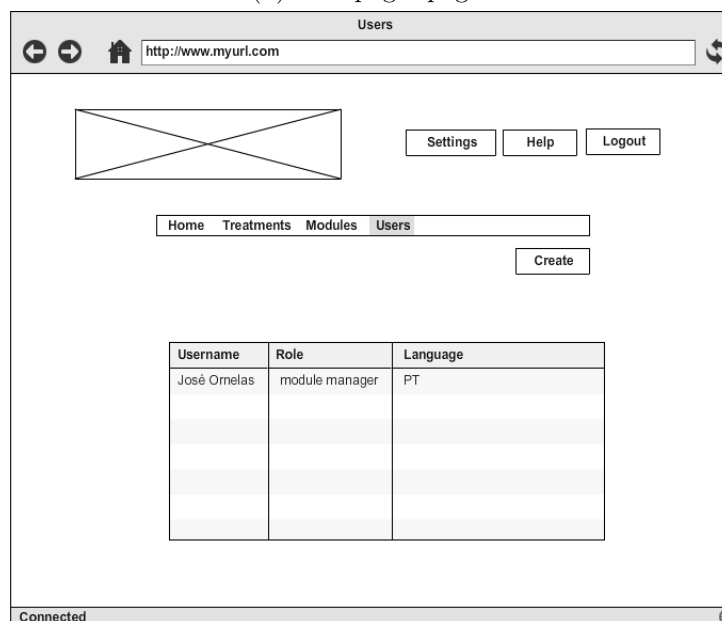
Figure B.3: Old UI sketches.



(a) Pages page.



(b) Edit pages page.



(c) Edit pages page.

Figure B.4: New UI sketches.

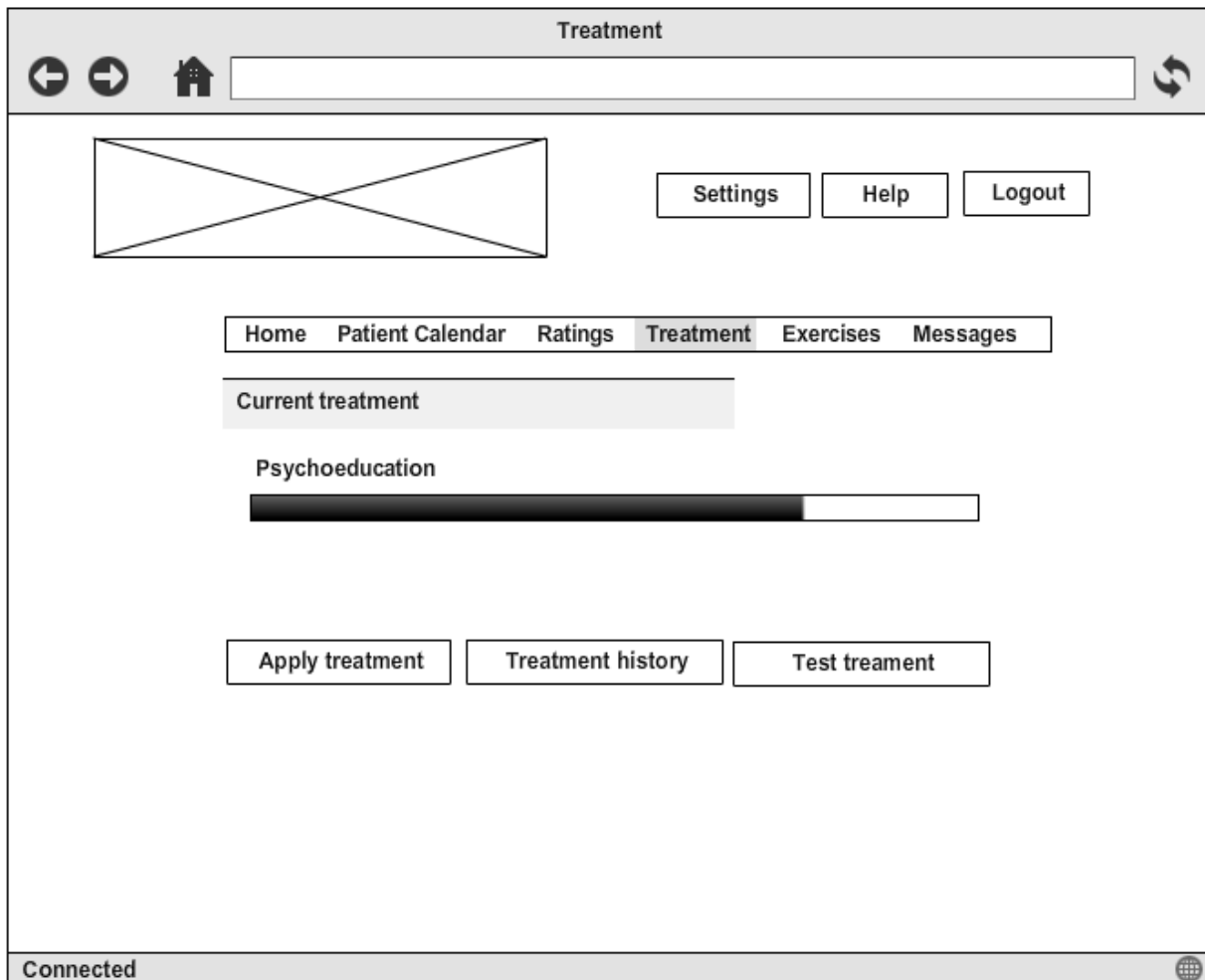


Figure B.5: Therapist portal treatment page.

# Appendix C

## Front-end portals

As referred in chapter 5 this appendix includes some of the three portals screen-shots.

### C.1 Intervention Builder (**iBuilder**)

In figures C.1 and C.2 is possible to see the rest of the **iBuilder** screen-shots. Please note that, the homepage contains a summary that explains briefly how the platform works. Also, we created a separated menu for published treatments, making it easier to access them. The rest of the images cover the treatments, modules and pages menus.

### C.2 Patient portal

Figure C.3 shows how the patient can check his therapy and exercises progress. It also shows a sample page from the Psychoeducation module created with the **iBuilder** portal.

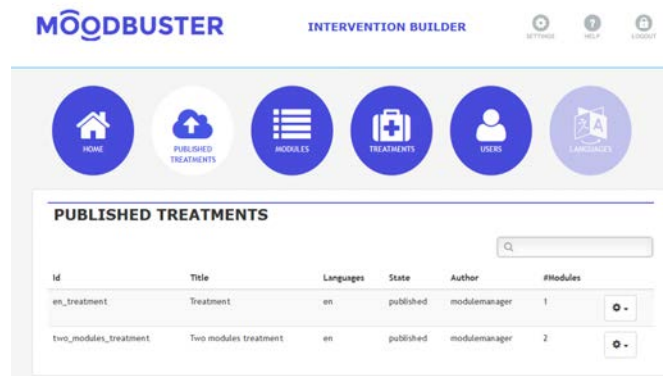
### C.3 Therapist portal

In the therapist portal we implemented a new feature. A therapist must be able to apply a published treatment to his patients. Figures C.4a and C.4b show how a treatment can be applied to a patient. Also, in figures C.4c and C.4d we can see the therapist pages to access the exercises solved by his patient.

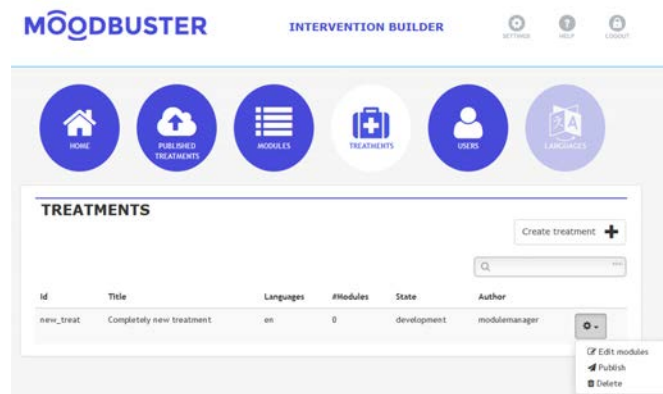




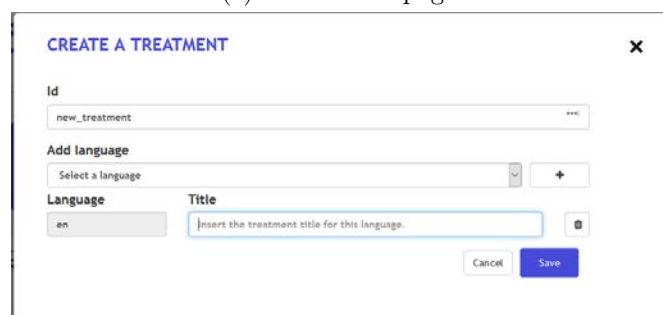
(a) Homepage.



(b) Published treatments page.

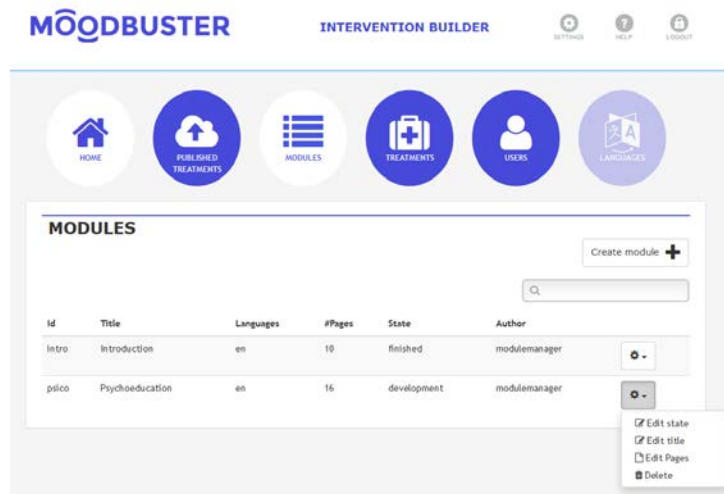


(c) Treatments page.

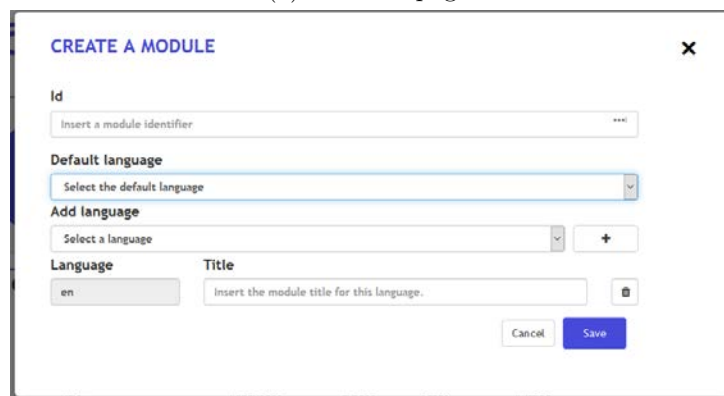


(d) Create treatment modal.

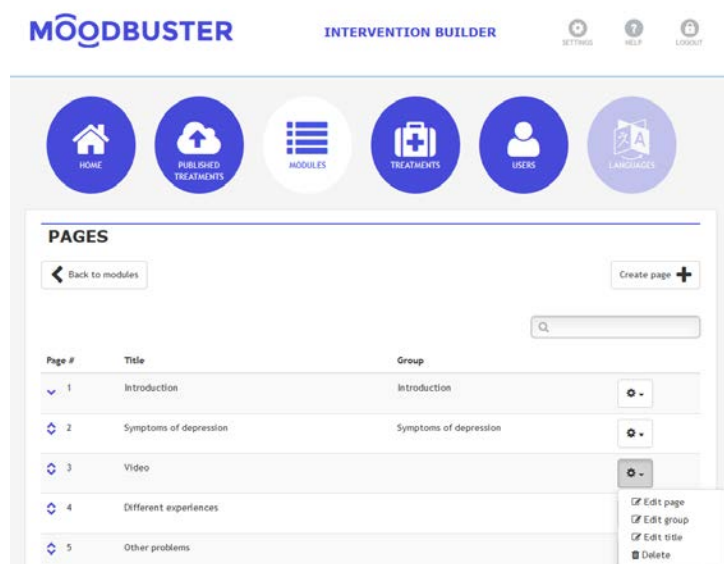
Figure C.1: iBuilder pages part 1.



(a) Modules page.



(b) Create modules modal.

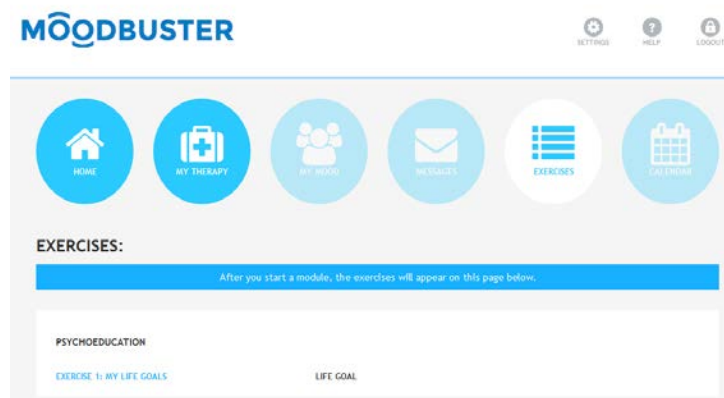


(c) Pages page.

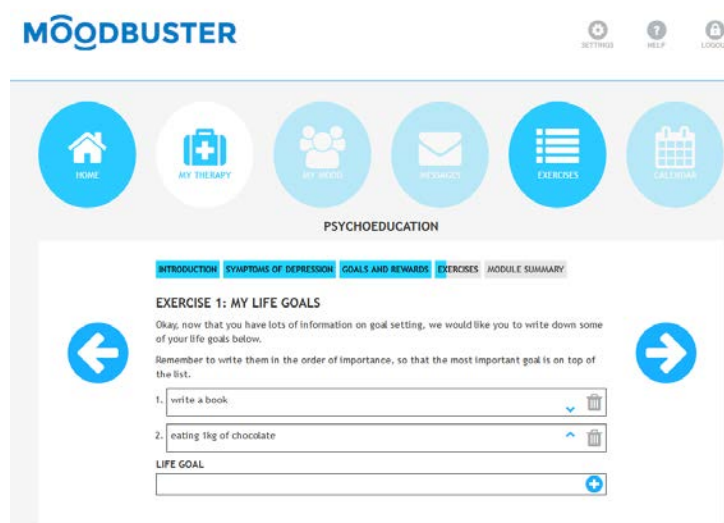
Figure C.2: iBuilder pages part 2.



(a) Therapy page.



(b) Exercises page.

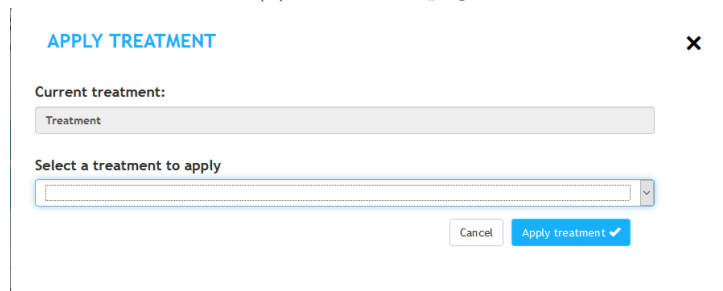


(c) Psychoeducation module page.

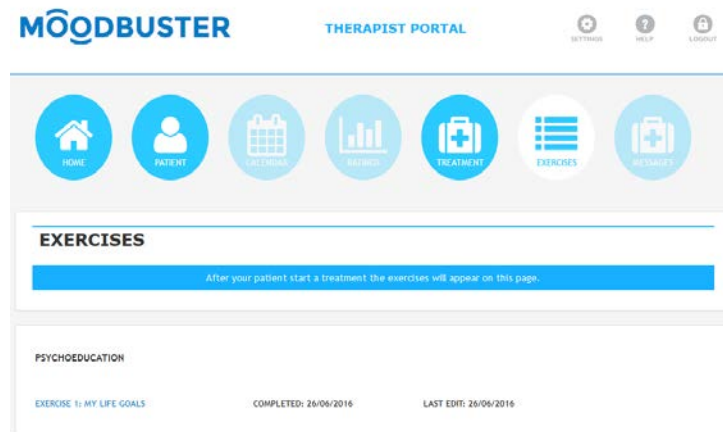
Figure C.3: Patient portal pages.



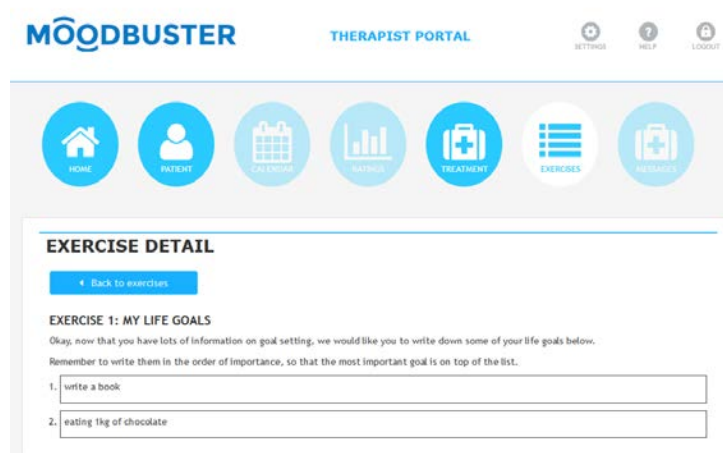
(a) Treatment page.



(b) Apply treatment modal.



(c) Exercises page.



(d) Exercise detail page.

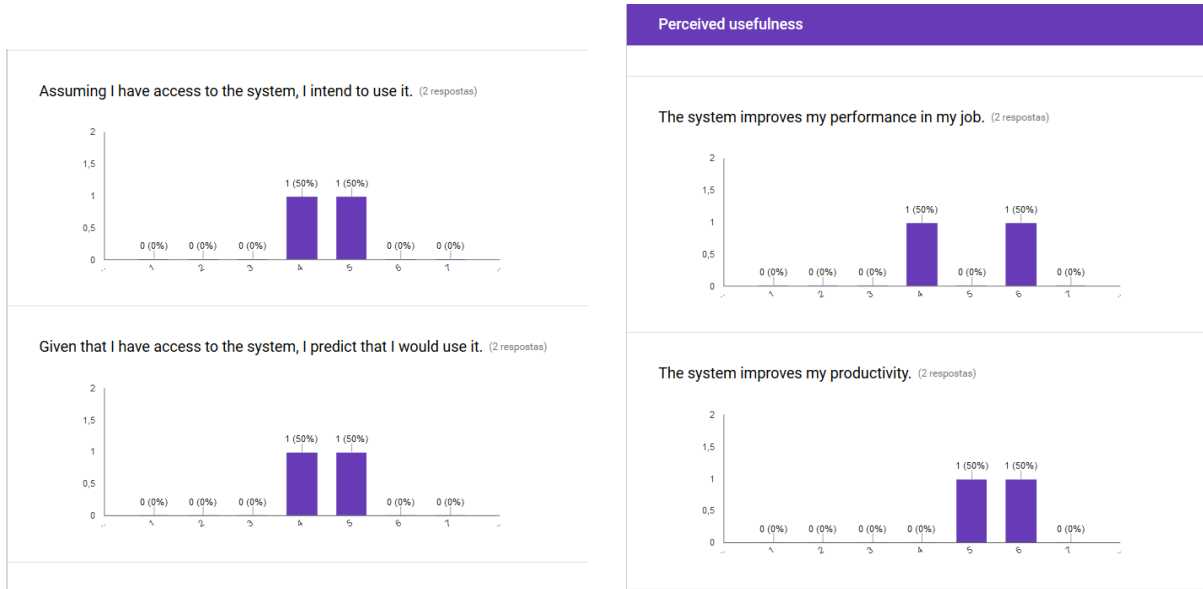
Figure C.4: Therapist portal pages.



## Appendix D

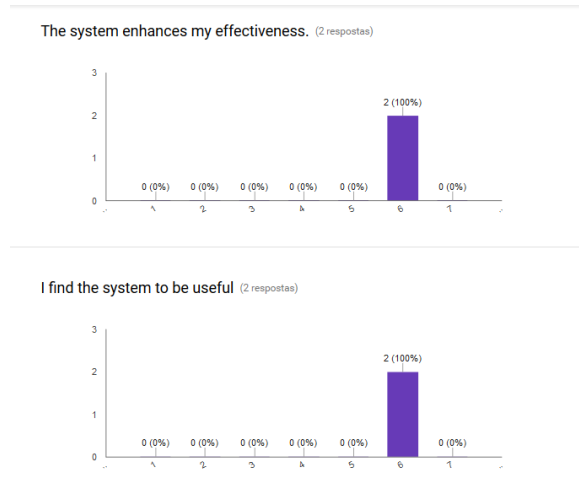
# Evaluation responses

As referred in chapter 5, this appendix presents the Technology Acceptance Model 2 (TAM2) questions and answers provided. Figures D.1, D.2, D.3 and D.4 depict the questionnaire questions and respective answers.



(a) Intention to use section.

(b) Perceived usefulness.

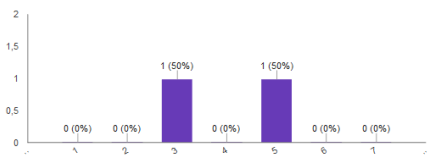


(c) Perceived usefulness.

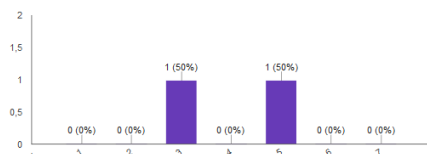
Figure D.1: Questionnaire answers and responses.

Perceived ease of use

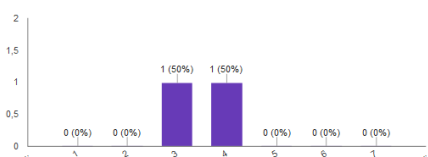
My interaction with the system is clear and understandable. (2 responses)



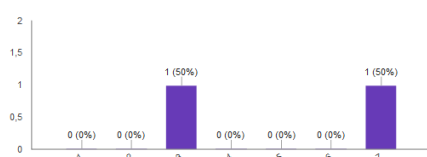
I find the system to be easy to use. (2 responses)



Interacting with the system does not require a lot of my mental effort. (2 responses)



I find it easy to get the system to do what I want it to do. (2 responses)

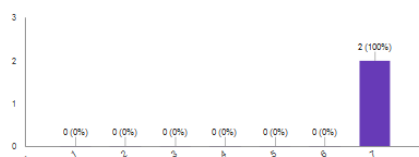


(a) Perceived ease of use.

(b) Perceived ease of use.

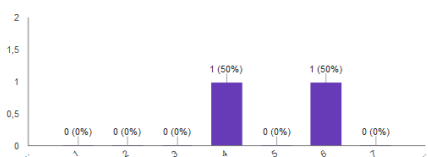
Voluntariness

My use of the system is voluntary. (2 responses)

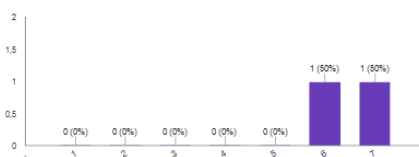


Subjective norm

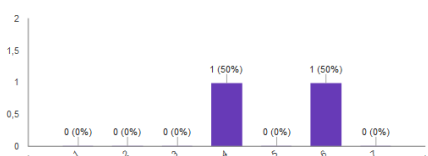
People who influence my behaviour think that I should use the system. (2 responses)



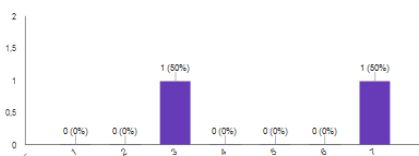
My supervisor does not require me to use the system. (2 responses)



People who are important to me think that I should use the system. (2 responses)



Although it might be helpful, using the system is certainly not compulsory in my job. (2 responses)

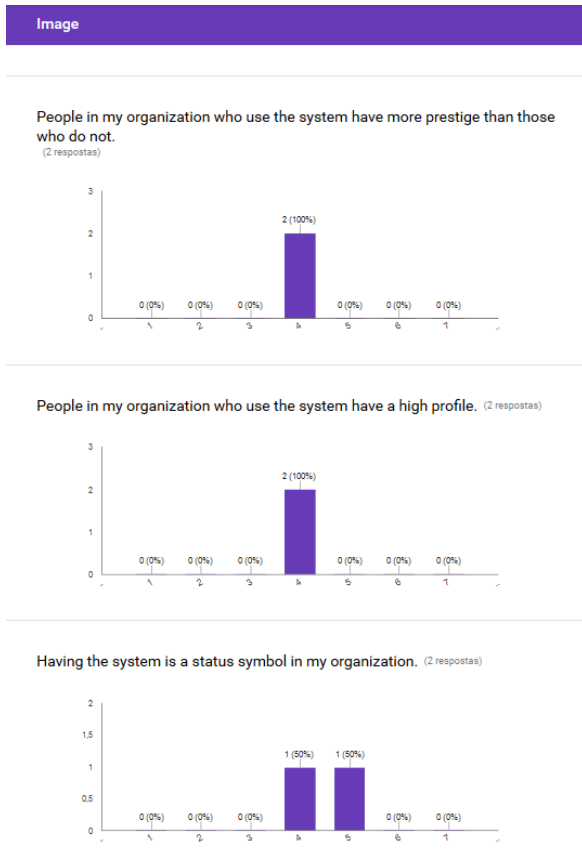


(c) Subjective norm.

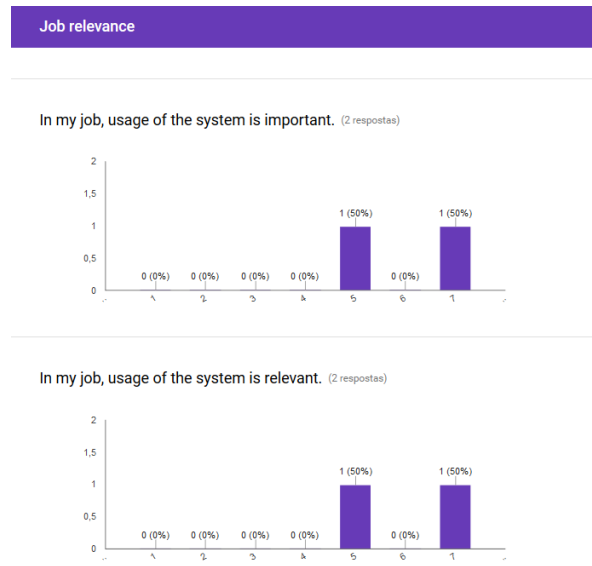
(d) Voluntariness.

Figure D.2: Questionnaire answers and responses part 2.

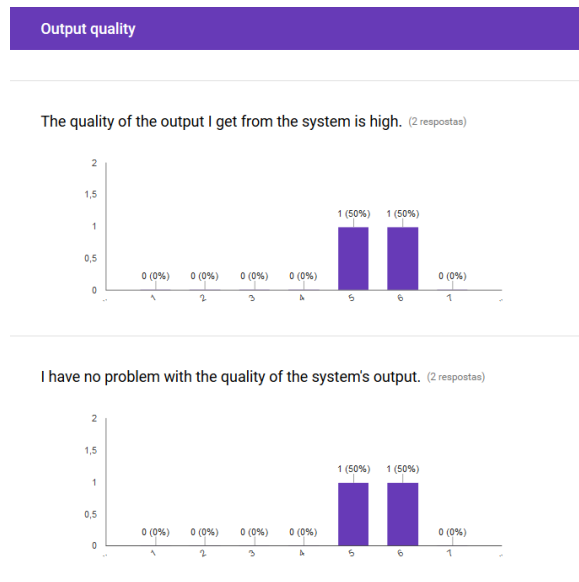




(a) Image.



(b) Job relevance.

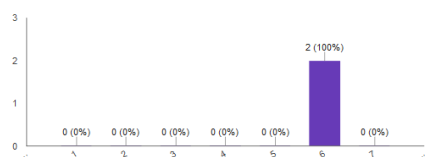


(c) Output quality.

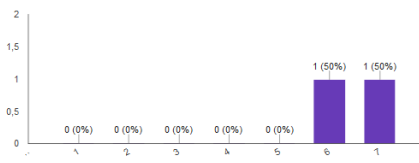
Figure D.3: Questionnaire answers and responses part 3.

**Result demonstrability**

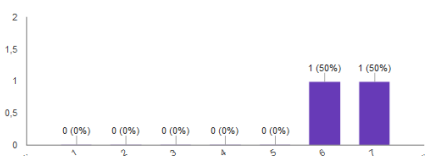
I have no difficulty telling others about the results of using the system. (2 responses)



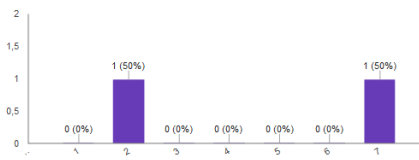
The results of using the system are apparent to me. (2 responses)



I believe I could communicate to others the consequences of using the system. (2 responses)



I would have difficulty explaining why using the system may or may not be beneficial. (2 responses)



(a) Result demonstrability.

(b) Result demonstrability.

**Comments (2 responses)**

Instruction were clear and the system responded quite well. I started with Edge, but that did not work well (modules were not listed after creation). In Chrome, all went Ok. Treatment / Module / Page editing procedures are clear. I like the simplicity of the WYSIWIG approach. A larger library of page elements would be helpful, of course, but this is a good start (but rename the Textare element to Text or something else because TextArea is a defined input field name). Each element worked like a sunshine, though. My compliments. Good work! Very relevant to make sure that MoodBuster will become relevant to the treatment of other disorders as well.

A few pointers for what I believe is a very promising system. And I know how much work is involved in creating a system that is easy to use. Well done!

Would be nice if Left clicking a module would open the module for editing. Same for pages and elements on pages.

Confirmation of empty pages in module when publishing treatment => would be nice to get warning earlier

Publish warnings too vague: 'One of the modules you added to the treatment is not finished'. Would be extremely useful to provide a link to the module or at least the name.

Treatments: would be nice if you could select the treatment and see all modules.

In patient mode: On 'Introduction according to JRI' last page one has to provide an answer to complete, but it is not clear where the question is or where the answer should be provided. I have provided dummy data in the list and in the 'Simple input here' box, but still cannot finalise the treatment.

When applying a second treatment this is not allowed, but it would be more user friendly if this warning was shown immediately when selecting 'Apply treatment'. Also, how can the therapist finalise a treatment on behalf of the patient?

(c) Comments.

Figure D.4: Questionnaire answers and responses part 4.



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