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An off-the-shelf platform for automatic and interactive text messaging using Short Message Service

Daniel Sabugueiro Oliveira

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Supervisor: Nuno M. Garcia, *PhD*
Co-supervisor: Graça Esgalhado, *PhD*

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Assisted Living Computing and Telecommunications Laboratory
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An off-the-shelf platform for automatic and interactive text messaging using Short Message Service

Resumo

Esta dissertação apresenta o desenho e construção de uma plataforma para a implementação de um sistema de troca de mensagens automáticas e interativas utilizando Short Message Service (SMS), também conhecido como mensagens de texto, criado para apoiar uma investigação no campo da psicologia. A investigação inclui investigadores do Departamento de Psicologia e Educação e do Departamento de Informática da Universidade da Beira Interior tornando-se um estudo multidisciplinar que tinha como objetivo avaliar se a exposição a mensagens de texto motivacionais, persuasivas e informativas poderia melhorar a auto-eficácia de estudantes inscritos em disciplinas de matemática da mesma universidade. A plataforma foi concebida para usar equipamento de baixo custo, contudo que permitisse a concepção de um sistema eficiente e robusto.

O código fonte do sistema SMS está disponível publicamente no website do Assisted Living Computing and Telecommunications (ALLab) [1].

Palavras-chave

Auto-eficácia; Plataforma de SMS; mensagens de texto; mensagens interativo; móvel; auto-regulação.

Resumo Alargado

Introdução

Nesta secção é apresentado o Resumo Alargado da dissertação intitulada *"An off-the-shelf platform for automatic and interactive text messaging using Short Message Service"* (Uma plataforma para mensagens automáticas e interactivas usando *Short Message Service*), em Português.

Tendo em consideração que já existem diversos estudos científicos com o uso de Short Message Service (SMS), o Departamento de Psicologia e Educação e o laboratório "Assisted Living Computing and Telecommunications Laboratory " (ALLab) do Departamento de Informática, ambos da Universidade da Beira Interior (UBI), decidiram desenvolver um estudo conjunto que deu origem a duas dissertações, esta inserida no mestrado de Engenharia Informática e outra inserida no mestrado de Supervisão Pedagógica.

O objectivo do estudo pretendia avaliar se SMS persuasivas, motivacionais e informativas podiam melhorar a eficácia de estudantes de disciplinas de matemática de quatro cursos de licenciatura, Engenharia Informática, Engenharia Electromecânica, Engenharia Electrotécnica e de Computadores e Optometria, em que algumas das SMS necessitavam de resposta.

Para isso, foi preciso definir e implementar uma plataforma SMS que permitisse resolver os seguintes objectivos:

1. Enviar SMS;
2. Receber SMS;
3. Receber respostas SMS de utilizadores e responder a essas respostas;
4. Enviar SMS a uma altura agendada;
5. Guadar todas as SMS trocadas.

Este resumo está organizado da seguinte maneira:

Introdução - faz uma introdução à dissertação, definindo o estudo que se pretende realizar, assim como o objectivo principal do mesmo e os objectivos presentes nesta dissertação;

Plataformas Similares – foca plataformas similares expressando as suas vantagens e desvantagens;

Metodologia – apresenta o método de investigação usado no estudo;

Analise de Requisitos e Arquitectura do Sistema – apresenta uma analise dos requisitos da plataforma SMS e a arquitectura de sistema escolhida;

Implementação e Resultados – detalha a implementação do sistema e apresenta os resultados alcançados;

Conclusões e Trabalho Futuro – a ultima secção deste resumo apresenta conclusões acerca do estudo no geral e trabalho futuro que pode enriquecer a plataforma.

Plataformas Similares

Nesta secção é apenas apresentada uma tabela que resume as características e funcionalidades pretendidas pela plataforma SMS a usar pelo estudo e as mesmas para possíveis candidatas à solução pretendida.

Plataforma	Enviar/Receber SMS	Resposta Automática	Agendar	Gratuita	Sistemas Operativos
Pretendido	✓	✓	✓	✓	Any
Ozeki	✓	✓	✓	✗	Microsoft Windows
Kannel	✓	✓	✓	✓	Linux / Unix
SMSgee	✓	✓	✓	✗	Microsoft Windows
SMSCaster	✓	✓	✗	✗	Microsoft Windows
LusoSMS	✗	✗	✓	✗	OS independent
ezSMS Gateway	✓	✗	✓	✓	Android

Metodologia

Nesta secção será detalhada a metodologia adoptada para realização deste estudo.

Participantes

Para um estudante poder ser participante no estudo, ele devia respeitar os seguintes requisitos:

1. Ter 18 ou mais anos;
2. Aceitar a nossa condição de não divulgação das SMS recebidas durante o período do estudo;
3. Aceitar o uso dos resultados obtidos no estudo;
4. Preencher um consentimento informado no qual aceitava as nossas condições previamente impostas;
5. Estar inscrito numa das disciplinas anteriormente referidas.

Com estes requisitos foram conseguidos 84 participantes com uma participação válida, dos quais 55 eram do sexo masculino e 29 do sexo feminino, todos a viver em Portugal Continental.

Instrumentos Utilizados

Para obtenção de resultados do estudo, foram usadas dois instrumentos, um questionário sociodemográfico e um questionário que pretende medir a auto-eficácia académica.

O questionário sociodemográfico pretende obter informações tais como o género, idade, disciplina em que está matriculado, número de telemóvel e preferido operador de rede móvel entre outras.

Procedimento

O estudo seguiu um processo dividido em três fases, o preenchimento de um questionário pré-estudo, o período de experiência e o preenchimento de um questionário pós-estudo. Ambos os questionários aqui descritos pretendem medir a auto-eficácia académica.

Os resultados foram calculados com base na comparação entre o questionário preenchido no pré-estudo e no pós-estudo.

Cronograma do estudo

Nesta subsecção é apresentado um breve cronograma das diversas etapas do estudo:

- O desenvolvimento da plataforma SMS teve como inicio o mês de Setembro de 2013 ao mês de Janeiro de 2014;
- A validação dos questionários que medem auto-eficácia académica teve como duração todo o mês de Janeiro de 2014;
- A aplicação do questionário pré-estudo teve como duração todo o mês de Fevereiro de 2014;
- O envio de SMS decorreu desde 27 de Fevereiro de 2014 até 13 de Junho de 2014 inclusive;
- A aplicação do questionário pós-estudo teve como duração de 14 de Junho de 2014 ao final do mesmo mês.

Analise de Requisitos e Arquitectura do Sistema

Nesta secção será apresentada a analise de requisitos e arquitectura de sistema da plataforma SMS que se pretendia desenvolver, apresentando os requisitos funcionais e não funcionais classificados como prioridade Alta, Média ou Baixa. Também são apresentados os *Stakeholders* e os utilizadores do sistema e diagramas de sequência que apresentam como o sistema deve reagir perante determinadas situações.

Stakeholders e Utilizadores do Sistema

Foram definidos como utilizadores do sistema os investigadores que estão a realizar o estudo e os estudantes nos quais o estudo incide. Quanto aos *Stakeholders*, foram encontrados três, os investigadores, os estudantes e os professores que no momento estavam a leccionar os cursos sobre o qual o estudo incide.

Ao nível dos requisitos funcionais e não funcionais, como dito anteriormente, estes são classificados como prioridade Alta, Média ou Baixa. Requisitos funcionais são requisitos fundamentais para o funcionamento da plataforma SMS a usar no estudo, enquanto que os não funcionais são requisitos que a não inclusão deles em nada impossibilita o uso da plataforma.

Diagramas de Sequência

Estes representam com o sistema deve interagir perante determinadas situações. Neste caso, três são apresentados, um para o caso em que a plataforma SMS recebe uma mensagem enquanto está a enviar mensagens em série, um para quando a plataforma está à espera de resposta de um determinado participante e ele responde algo fora das respostas possíveis e por fim, um para exemplificar o que deve suceder à ausência de resposta por parte de um participante após 24 horas de lhe ter sido enviado uma mensagem que requeira uma resposta.

Arquitectura do Sistema

A Arquitectura do Sistema está dividida em duas partes, hardware e software. A nível de hardware teve despesas de capital no valor de 600€ divididos por 300€ para um portátil, 100€ para uma Fonte de alimentação ininterrupta, 5€ para um hub USB e 75€ para três modems GSM (25€ por cada em média). A escolha dos três modems prendeu-se com a existência de três principais operadores móveis em Portugal, pelo qual se teve despesas operacionais de 120€ (30€ por mês, rondando os 10€ por cada operador). A nível de software existem diversos componentes que irão ser apresentados na secção seguinte.

Implementação e Resultados

Nesta secção será discutida a implementação do sistema, assim como resultados obtidos ao longo do estudo.

Implementação

Todo o software desenvolvido para a implementação do sistema usou a linguagem de desenvolvimento C#. A implementação é dividida por quatro componentes, os processos, uma aplicação web, uma base de dados e por fim uma aplicação que gere e executa as tarefas a realizar, i.e., mensagens a enviar *a posteriori*.

Em suma, os processos são o centro do sistema, sendo estes que gerem o envio e recepção de mensagens. Existem dois tipos de processos, uns somente para enviar e receber SMS e outros para gerir mensagens recebidas, i.e., se uma mensagem recebida é uma resposta de um participante, se é uma mensagem fora do contexto do estudo, etc.

A aplicação web permite criar agendamentos na aplicação que gera as tarefas (as executa) com informação acerca de mensagens para enviar a uma determinada data/hora definida para utilizador da mesma.

A base de dados contém toda a informação acerca das mensagens a enviar durante o estudo, bem como todas as mensagens recebidas e enviadas identificadas pelo recipiente ou emissor a que estão associadas.

Para terminar, a aplicação que gere e executa as tarefas criadas através da aplicação web trata de à data/hora decidida disponibilizar a informação das mensagens a enviar (recipientes, conteúdo da mensagem, etc.).

Resultados

Como resultados operacionais, o sistema esteve a funcionar durante 16 semanas, desde o dia 13 de Fevereiro de 2014, enviando e recebendo SMS sem qualquer transtorno.

Ao longo de estudo foi adquirida uma estatística acerca do número de respostas válidas contra as inválidas retornadas pelos participantes do mesmo, tendo 97% de respostas válidas e 3% de inválidas. Como última SMS do estudo foi decidido pedir aos participantes que partilhassem a sua noção de utilidade do estudo, obtendo 67.5% de respostas favoráveis contra 32.5% de respostas desfavoráveis.

Com isto podemos concluir que a plataforma construída para servir de base do presente estudo tinha todas as funcionalidades pretendidas e funcionou durante o tempo previsto sem qualquer problema, referindo ainda de que a maior parte dos participantes teve uma percepção favorável acerca da utilidade do estudo.

Conclusões e Trabalho Futuro

Nesta secção são apresentadas conclusões retiradas do presente estudo bem como trabalho futuro a realizar para melhorar a plataforma SMS.

Conclusões

Do conhecimento do autor, nenhum estudo que vise avaliar o factor de auto-eficácia com o recurso a SMS. Deste modo, é difícil fazer uma comparação com estudos prévios para tentar perceber se haveria melhorias possíveis tanto para a plataforma SMS como para o estudo em si.

A plataforma descrita nesta dissertação enviou e recebeu cerca de 7000 mensagens sem qualquer transtorno, deste modo, concluímos que se adaptou às necessidades propostas a um baixo custo e usando um portátil de gama baixa, tendo uma carga de trabalho de cerca de 100% a todo o momento.

Além disso, o conteúdo das mensagens e o pedido de resposta a alguma dessas mensagens foi elogiado por diversos participantes por ser simples, amigável e sem requerer grande tempo investido para participar no estudo, bem como o estudo tendo sido considerado útil pela maioria dos participantes.

Trabalho Futuro

Como trabalho futuro, foram encontrados alguns itens que vale a pena referir, como por exemplo a criação de mensagens agendadas para um grupo personalizado de recipientes, a criação de um melhor mecanismo para gerir respostas inválidas e por fim a conversão dos processos em serviços do sistema operativo.

An off-the-shelf platform for automatic and interactive text messaging using Short Message Service

Abstract

This dissertation presents the design and construction of a platform for the implementation of an automatic and interactive message exchanging system using Short Message Service (SMS), also known as texting, created to support a research on the Psychology field. The research included researchers from the Psychology and Education Department and the Computer Science Department from University of Beira Interior making it a multidisciplinary study. Its goal was to assess if the exposure to motivational, persuasive and informative SMS texts could improve the self-efficacy of mathematics students from that university. The platform was devised to use low cost off-the-shelf parts, yet allowing the design of an efficient and robust system.

The source code for the SMS system is publicly available at the Assisted Living Computing and Telecommunications (ALLab) website [1].

Keywords

Self-efficacy; SMS platform; texting; interactive messaging; mobile; self-regulation.

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Acronyms

ALLab	Assisted Living Computing and Telecommunications
ANACOM	Autoridade Nacional de Comunicações
API	Application Programming Interface
CAPEX	Capital Expenditure
CISIM2014	International Conference on Computer Information Systems and Industrial Management Applications
CSE	Computer Science and Engineering
DB	Database
DCS	Department of Computer Science
DPE	Department of Psychology and Education
ECE	Electrical and Computer Engineering
EE	Electromechanical Engineering
FAQ	Frequently Asked Questions
GMT	Greenwich Mean Time
GSM	Global System for Mobile Communications
ICERI2014	International Conference of Education, Research and Innovation
ICETC2014	International Conference on Education Technologies and Computers
LIFO	Last In, First Out
MNO	Mobile Network Operator
MSc	Master of Science
OPEX	Operational Expenditure
OPT	Optometry
OS	Operating System
PS	Pedagogical Supervision
RAM	Random Access Memory
SIM	Subscriber Identity Module
SMS	Short Message Service
UBI	University of Beira Interior
UPS	Uninterruptible Power Supply
USB	Universal Serial Bus
WAP	Wireless Application Protocol

Chapter 1

Introduction

Nowadays, in so-called developed countries, it is considered that information and communication technologies play an important role in current human-to-human interactivity.

In this regard is worth pointing out that Short Message Service (SMS) is one of the most broadly used communication mechanism for mobile phone users [5], especially since students use it constantly because of its convenience, availability and low cost, or sometimes zero cost, depending on the user's subscribed plan [6] [7]. With that in mind, two departments from the University of Beira Interior (UBI) came up with a research project that prompted a creation of a SMS exchange platform to research the impact on self-efficacy of university students through motivational, persuasive and informative SMS, leading to this dissertation.

This research led to the submission of two research papers accepted in two international peer reviewed conferences, one to be presented at the "13th International Conference on Computer Information Systems and Industrial Management Applications (CISIM2014)", Ton Duc Thang University, Ho Chi Minh City, Vietnam, November 5-7, 2014 [3] and the other already presented and published in the proceedings of "The International Conference on Education Technologies and Computers (ICETC2014)", Lodz University of Technology, Lodz, Poland, September 22-24, 2014 [2] and one abstract accepted to the "7th International Conference of Education, Research and Innovation" (ICERI2014), Seville, Spain, November 17-19, 2014 [8]. The research also led to an invitation to present the SMS platform on the "APDC - 24º Congresso das Comunicações" [9], Centro Cultural de Belém, Lisboa, November 19-20, 2014, sponsored by Autoridade Nacional de Comunicações (ANACOM) [10].

1.1 Background and Motivation

Up to now the SMS technology has been mostly used to send students educational content [11][12], persuasive and motivational quotes [13] or administrative information [14]. However, it hasn't really been used that much for research in the educational context, just now being analyzed how SMS can be used to help learning and teaching in higher education.

There has been research that tried to evaluate the association between academic accomplishment and self-efficacy, finding that self-effective students are more predisposed to be self-reliant, self-motivated, organized, and to undertake more difficulty learning tasks, work harder and be more persistent [15, 16, 17, 18], evaluating their own achievements in an attempt to maximize the productivity and efficacy of the learning process [19]. The students that have these characteristics are overall more probable to have higher academic performance, being natural that universities try to discover ways to help improve its students' self-efficacy. Actually self-efficacy is considered to influence academic motivation features like perseverance, effort, emotional reactions and activity choice [16].

A continuous analysis on how to use SMS messages in classrooms as a learning tool has been happening worldwide, primarily but not restricted to the language learning field, having been suggested that texting has the possibility to boost students learning since it allows them to learn at their own rhythm [20]. Students have even said that using SMS messages as a learning tool stops learning from being restricted by time and space [12].

Taking this into consideration, the Department of Psychology and Education (DPE) and the Assisted Living Computing and Telecommunications Laboratory (ALLab) of the Department of Computer Science (DCS) from UBI devised a multidisciplinary study that led to two dissertations, one for the Computer Science and Engineering (CSE) Master of Science (MSc) degree and another for the Pedagogical Supervision (PS) MSc degree.

The goal of the study was to assess whether persuasive and motivational SMS texts could improve student's efficiency in mathematics classes from four different undergraduate courses, CSE, Optometry (OPT), Electromechanical Engineering (EE) and Electrical and Computer Engineering (ECE), with some SMS texts requiring an answer.

1.2 Problem Description

The main point of the joint study, as mentioned above, is the assessment of whether students receiving persuasive and motivational SMS texts can improve the efficacy on their respective mathematics classes, however, for that to happen the study had another problem within. While that assessment of the impact of the experiment on students is the problem research handled by the DPE department, the design, implementation and operation of the system is the research problem of the CS team.

The main objectives defined for the platform were:

1. Send messages;
2. Receive messages;
3. Receive SMS responses from the users and reply to these user responses;
4. Send messages at a scheduled time;
5. Store all exchanged messages.

A Requirements Analysis was made to fully define all features and specifications that the platform needed to have to best address the study. This analysis is fully presented in chapter 4.

1.3 Document Organization

This dissertation is organized in six chapters and two appendices, structure like so:

> **Chapter 1** - *Introduction* - makes an introduction to the dissertation, presents the background and motivation for it, describes the problem and ends with the organization of the dissertation;

Chapter 2 - *Similar Platforms* - focuses on the study of similar platforms for sending and receiving SMS;

Chapter 3 - *Research Method* - presents the research method used, a definition of the participants and a Gantt chart of the study;

Chapter 4 - *Requirements Analysis and System Architecture* - provides an analysis of the requirements needed for the platform and presents the adopted system architecture;

Chapter 5 - *Implementation and Results* - details how the system was implemented and shows some of the achieved results;

Chapter 6 - *Conclusions and Future Work* - the closing chapter of the dissertation presents some conclusions regarding the study as a whole and gives some points regarding future advancements to be implemented in the platform;

Appendix A - *Message Flow Tables* - presents some tables with a real message flow;

Appendix B - *Papers* - contains the papers mentioned at the beginning of the document.

Chapter 2

Similar Platforms

2.1 Introduction

This chapter presents SMS platforms that are, to some extent, possible candidates to the desired system solution. It has the following structure:

Section 1 - *Introduction* - describes the content of this chapter along with its organization;

Section 2 - *Platforms for Sending and Receiving SMS* - presents several SMS platforms;

Section 3 - *Conclusion* - concludes the chapter with some final thoughts and a comparison table of the several platforms found.

2.2 Platforms for Sending and Receiving SMS

In this section several platforms for sending and receiving SMS will be presented, along with some pros and cons.

The list presented is as follows:

- Ozeki NG SMS Gateway;
- Kannel;
- SMSgee;
- SMSCaster;
- LusoSMS;
- ezSMS Gateway.

There were two key requirements of this solution:

(a) It should be free to implement and use at near zero cost;

(b) It had to be up and running by the beginning of the second semester, *i.e.*, before the end of January 2014.

These two restrictions made it impossible to test some of the found platforms, either because they were paid or because there was no time to asses its suitability to the purpose of this research.

2.2.1 Ozeki NG SMS Gateway

Ozeki NG SMS Gateway claims that it has one of the highest performances available, making it possible to send ”500 SMS messages / second (sending and receiving)”, along with others features. The list below expresses some of them [21]:

- 500 SMS messages / second (sending and receiving);
- 100 simultaneously connected applications;
- 64+ concurrent SMSC connections;
- Support for dual core and multiprocessor systems;
- Support for 32bit and 64bit architectures;
- Able to work 24/7;
- Capable of managing network failures;
- Message loop protection to avoid threats caused by auto-responding mobile messaging services;
- Auto-reply functionality.

However, since its a paid platform it was not tested.

2.2.2 Kannel

Kannel presents itself with being an open source Wireless Application Protocol (WAP) and SMS gateway [22]. It was developed in a Linux system and according to its development team, it should be fairly easy to port to any Unix-based Operating System (OS), although it still doesn’t have any Windows version which prevented the author of this dissertation to test it at the time.

As the Kannel web site does not provide a list of its features, it was decided not to test it, due to time restriction regarding the setup and implementation time.

2.2.3 SMSgee

SMSgee has two products available, the SMSgee PC SMS Gateway Server and the SMSgee PC SMS Bulk Sender [23]. The Gateway Server version has, among others, the following features:

- Send/receive SMS from PC using connected GSM device;
- Multiple UMTS/GSM device;
- Unicode SMS;
- Scheduled SMS;
- Auto-reply;
- Running as Windows Service;
- Compatible with Windows 2000,XP,2003 Server, Vista , 2008 Server.

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This is a paid service, and therefore, it was not tested.

2.2.4 SMSCaster

SMSCaster is another paid SMS platform for which the authors claim to have the following key features [24]:

- Convenient: Send & receive SMS right from your computer. Do not relies on an Internet SMS gateway;
- Low cost: No registration, no pre-pay and no need to buy SMS credit before start. Utilize your existing mobile phone;
- Phone book: Manage your contact list for different marketing campaigns into project files, with grouping support. Import existing data from a wide varieties of comma separated value and text file with the “Import Wizard”;
- Send personalized SMS: Send personalized SMS content to each recipient by inserting data from the phone book automatically.
- Unlimited SMS: You can send and receive unlimited number of sms during license period;
- Send in different languages: Support GSM 7-bit and UCS2 Unicode encoding with Auto Encoding Selection. Compose your SMS in many different languages: German, French, Dutch, Greek, Italian, Portuguese, Chinese, Japanese, Korean, Arabic, Cyrillic, etc;
- Responder: Auto reply to incoming SMS for pre-defined keywords and reply messages. (Enterprise Edition Only)

Being a paid service, it was not tested.

2.2.5 LusoSMS

LusoSMS is Portuguese paid SMS platform, that claims that its principal characteristic is the versatility and ease of implementation in any program that has the objective or need to send SMS. It lets its users to schedule SMS to be sent at a defined time, see a sent message history, send SMS with up to 300 characters, among others [25].

Once again, being a paid service it was not tested.

2.2.6 ezSMS Gateway

ezSMS Gateway [26] is a SMS gateway for Android, that enables its users to send SMS or conduct surveys easily. The creator claims the following:

- ”Send SMS. Use our send bulk SMS feature to alert your audiences on upcoming events, sales and promotions, advertising, announcement, reminder service, result information, group notice, alert, after sales follow up and much more...
- Manage Contact Group. Simple phonebook feature is available to group your customers. Customize SMS content for different group. It is not necessary to send SMS to all everytime but send it smartly;

- SMS Pooling & Feedback. Create a survey to collect marketing response, understand your audiences' preference, feedback, complaint and etc. Use our Auto Response feature to acknowledge them so that they don't feel unattended;
- System Integration. Turns survey into SMS member registration by using our HTTP callback. With this feature, you can process user response immediately over web server, update database, sending email or trigger logistic service."

2.3 Conclusion

In the previous section several SMS platform were presented, however, each one had its own strengths and weaknesses. A table which tries to summarize them versus the SMS platform needs that the study had to address is shown below (table 2.1).

Table 2.1: Platforms comparison table.

Platform	Send/Receive SMS	Auto-reply	Schedule	Free	Available OS
Wanted	✓	✓	✓	✓	Any
Ozeki	✓	✓	✓	✗	Microsoft Windows
Kannel (a)	✓	✓	✓	✓	Linux / Unix
SMSgee	✓	✓	✓	✗	Microsoft Windows
SMSCaster	✓	✓	✗	✗	Microsoft Windows
LusoSMS	✗	✗	✓	✗	OS independent
ezSMS Gateway	✓	✗	✓	✓	Android

(a) not enough information provided.

To summarize, there was no available SMS platform that addressed all the study needs at an adequate time frame for its implementation. However, it should be noted that some of these commercial solutions in some aspects far exceed non-commercial solutions, like the speed on sending/receiving SMS, limit of concurrent connections, *etc.*, but these were not requirements for the desired platform.

Chapter 3

Research Method

3.1 Introduction

In this chapter the research method will be explained. For that, the definition of the participants, the measures used, the research procedure and a Gantt diagram will be presented. It has the following structure:

Section 1 - *Introduction* - describes the content of this chapter along with its organization;

Section 2 - *Participants Definition* - presents a definition of the participants of the study;

Section 3 - *Measures Used* - presents the measures used to produce the results;

Section 4 - *Procedure* - presents the procedure on which the study was conducted;

Section 5 - *Research Gantt Diagram* - presents a Gantt diagram of the study timeline;

Section 6 - *Conclusion* - presents some conclusions about this chapter.

3.2 Participants Definition

Since our target audience were graduate students of some specific classes, along with volunteering themselves, they needed to fulfill some requirements:

1. Be 18 years old or older;
2. Accept our policies of no-disclosure of the SMSs received;
3. Accept to have his/her results anonymously used in the study;
4. Fill a informed consent accepting our study policies;
5. Be enrolled in one of the target classes.

From all the students that were to be invited only 84 had a valid participation, therefore, the next characteristics only correspond to them:

- All lived in continental Portugal, being 55 males (65.5%) and 29 females (34.5%). The average age was 20.35 years with a standard deviation of $\approx$2.90;
- All were enrolled in the targeted classes having a distribution per course of 48.8% from CSE, 32.1% from OPT, 15.5% from EE and 3.6% from ECE;
- From the 84, 46 (54.8%) were freshman.

3.3 Measures Used

There were two measurements used in the study, a socio-demographic questionnaire and a self-efficacy scale.

The socio-demographic questionnaire built by the DPE researchers was used to gather information from each student like gender, age, class, working status (full-time student vs part-time student), if it was his first time in that class and the grade history from mathematics classes from previous schools before applying to the university. The questionnaire also required that the student filled in his personal mobile phone number and his preferred Mobile Network Operator (MNO), only to be used if the student was drafted to receive SMSs.

On the other hand, the self-efficacy scale used was a Portuguese version of the Self-efficacy general academic questionnaire [27]. This scale had 9 items on a 5-point Likert scale (1=in total disagreement to 5=in total agreement). The final score could range from 9 to 45, with higher score meaning a higher level of self-efficacy.

3.4 Procedure

Normally engineering undergraduate students of UBI have low grades at mathematics classes, along with an above average dropout and unaccomplished rate. With this in view, these students were an evident choice for this study.

As mentioned before, the study was a joint collaboration from ALLab and the DPE, while the ALLab team handled the development of the SMS platform that needed to automatically and autonomously send SMS at specified times to the pre-given recipients and interact with its users when necessary, on the other hand the DPE team planned the procedure on what terms should the study be held. All the text messages sent through the platform were created by the research team, in line with information retrieved from selected literature. Each message had a flow identifier (`flow_id`) associated with it, and the `flow_id` was responsible for identifying each message for each course and identifying on what position of the flow of SMS a participant was.

The study followed a three stages process: a pre-study, the experiment, and a post-study. In the pre and post study, the students were asked to fill a socio-demographic and data questionnaire arranged and managed by the DPE researchers that along with other information asked them their mobile phone number and desired Mobile Network Operator (MNO) to communicate with, while the experiment stage used the tool discussed in this dissertation. The question on what was the desired for each student helped us try to maintain a cost-free SMS platform since almost all MNO have a plan with free SMS atleast to itself, and sometimes, even between other MNOs.

The pre-study stage began with contacting the teachers there were lecturing the mathematics classes to the research subjects. They were asked to collaborate in the study by making 20 minutes available in the first class of the semester so the researchers could present their study and invite students to participate in it. In this first contact, the first questionnaires (pre-study

ones) were filled in by the students that accepted to participate in the study, and were separated by course with the purpose of creating two groups, a control one and an experimental one where all courses were represented with around 60% to the experimental group and 40% to the control group since along the semester dropouts might occur. All students from each course where randomly drafted to one group or the other with the previous percentages in mind.

Around 300 hundred students were enrolled in the selected classes, however, only 184 filled the initial pre-study questionnaire, being a number that roughly matches the number of students the were attending their respective mathematics classes at the start of the semester, making the control group match 74 students and the experimental group the remaining 110. During the experimental stage, the experimental group students received SMS messages twice a week, while those on the coutrol group didn't. Some messages were just informative, persuasive or motivational, while others required an answer within a specific set of valid values, making the need for the platform to control which answer was given to each question for each student. There were two types of question, expecting a (Y)es/(N)o answer (*Sim/Não in Portuguese*), or an answer in a 1-6 Likert [28] scale. When a question was made using the Likert scale, the choices were specifically presented for each question they refer to, *e.g.*, 1 (totally false) to 6 (totally true), 1 (totally disagree) to 6 (totally agree), to give some examples.

At the end of semester the teachers were once again contacted and asked for some minutes to let their students fill in the same questionnaire as before, making this one the post-study questionnaire. To assess whether the study had some influence or not, an analysis of the scores from pre-study and post-study questionnaires from the control group and the experimental group were compared.

The real number used to make that comparison was 84 participants, 50 in the experimental group and 34 in the control group, since these were the only ones that filled both the pre and post study questionnaires.

3.5 Research Gantt Diagram

This section presents the research chronogram 3.1.

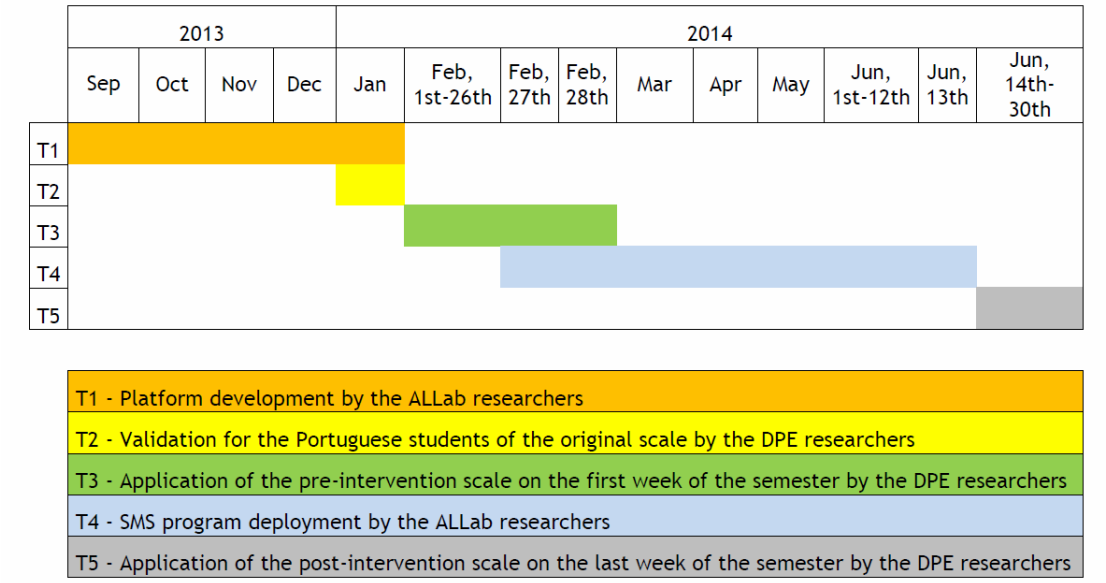

Figure 3.1: Gantt diagram.

As presented in the diagram, there were tasks that run in parallel and others that depended on other tasks to end first.

3.6 Conclusion

To summarize this chapter, the several components from who the research procedure depended were presented, them being the participants and the measures used. A Gantt diagram was also presented as the chronogram of all the steps that were fulfilled to achieve the end result of the study.

Chapter 4

Requirements Analysis and System Architecture

4.1 Introduction

This chapter presents the system requirements and architecture, showing the functional and non-functional requirements, who are the stakeholders and a brief presentation of the components that define it. It has the following structure:

Section 1 - *Introduction* - describes the content of this chapter along with its organization;

Section 2 - *Requirements Analysis* - presents the requirements, users and stakeholders of the system, and sequence diagrams depicting how the system acts to certain situations;

Section 3 - *System Architecture* - describes a definition of the system;

Section 4 - *Conclusion* - presents some conclusions about this chapter.

4.2 Requirements Analysis

The system was built taking into consideration the requirements and challenges posed by the psychology study it would be used for, therefore, creating functional and non-functional requirements that needed to be addressed. In the following subsections those will be listed along with a list of stakeholders and users of the system.

4.2.1 Stakeholders

In this study were identified three stakeholders for the proposed system, the researchers of this study, the teachers that lecture the courses and the students participating in the study.

The researchers used it to assess if the self-efficacy of the participating students can be improved with the use of SMS, the professors are interested in the study since it may improve its students grades and lower the dropout rate of the lectured courses and the students will receive SMS that have motivational, persuasive and informative texts that could help them learn better study methods and other important information.

4.2.2 System Users

The system had two users, the researchers and the students.

The researchers had several ways to interact with the system:

- Create, modify or delete the text contents for each message;
- List the message exchange history by the mobile phone number of a given student;
- Add new study participants;
- Schedule messages;
- Send personalized messages;
- Remove a participant from the study;
- Access to alert notifications if the system is expecting a valid answer from a participant and none is given in 24 hours.

As for the students, they were able to directly interact with the system by sending SMS to the system or receiving SMS from the system.

4.2.3 Functional Requirements

Using requirement analysis, several functional requirements were found. A list of these requirements is presented below. These are divided by priority, classified as high, medium or low priority.

High priority:

FR-HP-1 - The system needs to be able to send and receive SMS messages;

FR-HP-2 - The system needs to work uninterrupted and unattended;

FR-HP-3 - The system needs to be able to store all sent/received messages;

FR-HP-4 - The system needs to be able to let students communicate through their preferred MNO, avoiding costs to the student;

FR-HP-5 - The system needs to be interactive with the recipients of the messages since some messages require answers (question-response system);

FR-HP-6 - The system needs to abide the MNO fair use policies, by not sending large amounts of SMS texts in a very short period of time;

FR-HP-7 - The system needs to be able to send messages in batches to a predefined number of recipients;

FR-HP-8 - The researchers should be able to access all messages exchanged;

FR-HP-9 - The system needs to be able to send three types of messages, no answer expected, Yes/No answer and an answer in Likert scale from 1 to 6;

FR-HP-10 - The system needs to be able to handle incoming messages without hindering its message receiving or sending performance.

An off-the-shelf platform for automatic and interactive text messaging using Short Message Service

Medium priority:

FR-MP-1 - The system needs to be able to validate if a given answer is valid;

FR-MP-2 - The system needs to be able to reply fairly quickly (within 30 minutes after it received a SMS that requires an answer);

FR-MP-3 - The system needs prioritize replies to received messages over schedules messages;

FR-MP-4 - The system needs to be able to handle a heavy traffic load (high volume of messages at the same time);

FR-MP-5 - The system needs to be able to send a stream of messages at predefined times to each student;

FR-MP-6 - The system should be able to send messages between 18:30 and 20:30 from the mainland Portugal time zone, Greenwich Mean Time (GMT);

FR-MP-7 - The system should be able to check alert the researchers if a participant hasn't replied in 24 hours after a message expecting an answer has been sent;

FR-MP-8 - The system should be able to manually advance the message flow of a participant;

FR-MP-9 - The system should be able to add/remove participants from the study;

FR-MP-10 - The system should let the researchers access all messages exchanged for a given participant.

Low priority:

FR-LP-1 - The system should be able to schedule messages in a bulk.

FR-LP-2 - The system should be able to allow messages to contain all characters present in Portuguese writing, like "ç" and accents.

In the next subsection, the non-functional requirements are presented.

4.2.4 Non-functional Requirements

Following the classification of the functional requirements mentioned above, below the non-functional requirements are presented.

High priority:

NFR-HP-1 - The system should be able to prevent risk/abuse of it.

Low priority:

NFR-LP-1 - The system should be able to create and send customized messages;

NFR-LP-2 - The system should have user-friendly a web application;

NFR-LP-3 - The system should have a responsive design web application.

4.2.5 Sequence Diagrams

In this subsection some more complex sequence diagrams are presented. They depict cases that for example, go beyond simply receiving or sending a message.

4.2.5.1 Twenty Four Hours After a Sent Message

The following diagram (figure 4.1) shows how the system acts according to the reply of a participant within the predefined 24 hours range. If he/she replies, he/she gets some feedback directly correlated with his answer and the system advances the participant `flow_id` to the next one, if not, the system shall alerts the researchers so one of them can manually advance his `flow_id`.

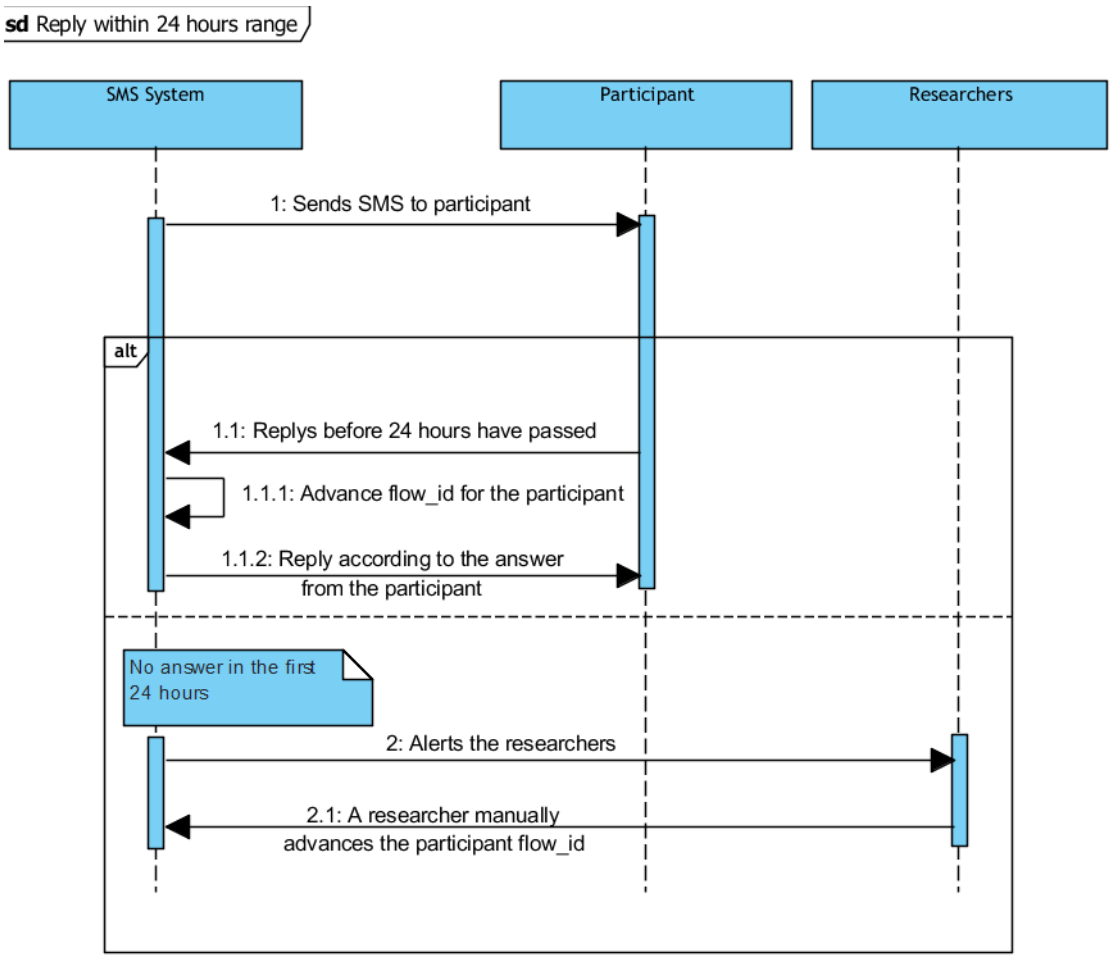

Figure 4.1: How the system acts after 24 hours of a sent message.

4.2.5.2 Receive a Message While Sending Schedule Messages

If the system receives a SMS while sending scheduled messages, it will stop sending them as soon as possible to give a higher priority to the received message reply. After it sends the reply, it will continue to send the remaining scheduled messages (figure 4.2).

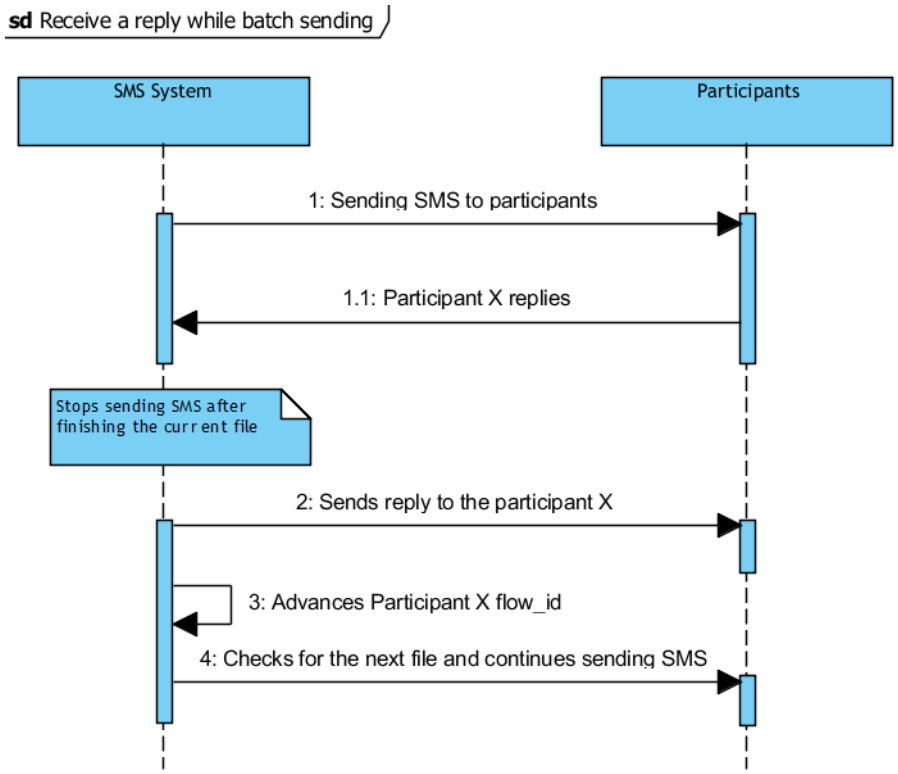

Figure 4.2: How the system acts if it receives a SMS while sending scheduled messages.

4.2.5.3 Receive an Invalid Answer After a Sent Message

Below is presented how the system acts if it sends a message expecting a answer within a certain range and it receives an invalid reply (figure 4.3).

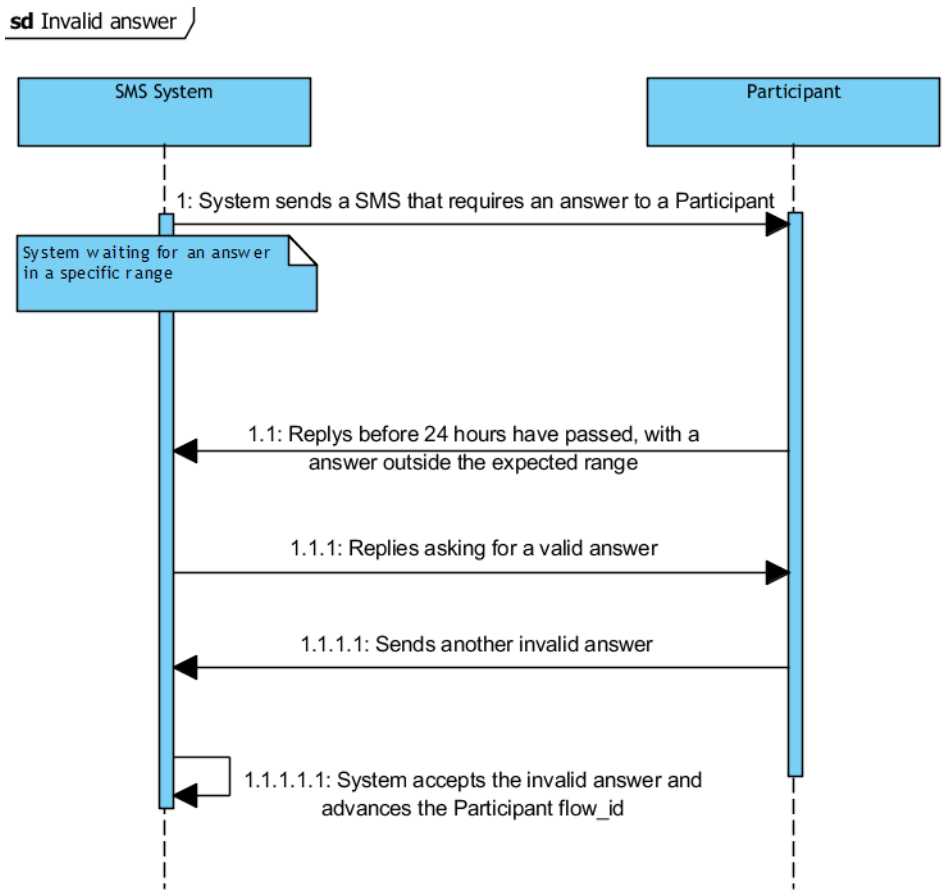

Figure 4.3: How the system acts if it receives two invalid SMS to the same question.

4.3 System Architecture

In this section the System Architecture is presented. The architecture resides on a combination of Software and Hardware that can be seen in figure 4.4, and it is worth mentioning that the MSc CSE student (the author of this report) made all the choices on how the architecture should be done, although it was based on the requirements defined by the MSc student from the DPE.

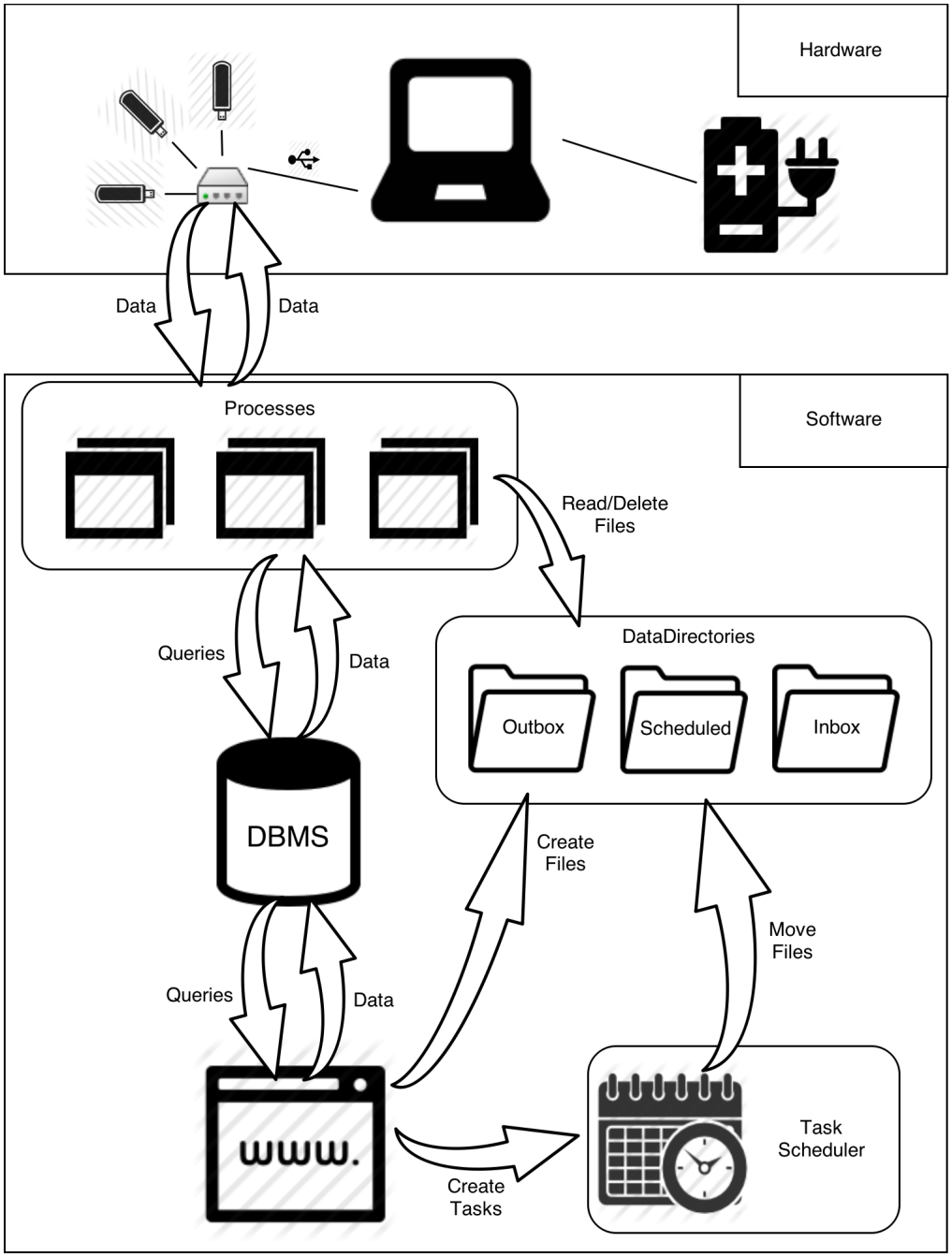

Figure 4.4: System Architecture diagram, adapted from [2].

To comply with the requirements defined above, a mechanism to control the message flow for each student was needed, *i.e.*, as each student responds on its own time, the message being processed for a particular student may be different from the message of the student that precedes him/her in the message queue.

The stream of SMS messages as well as the list of destinations were inserted as elements of a database (DB). The questions themselves, the admissible answers and the message flow were defined based on psychological validated literature as expressed in studies aiming to evaluate self-regulated learning and/or self-efficacy in the same population [29][30], which will be explored in this report. To manage this flow of messages, a script was created which connected

questions with their validated answers, and when admissible, gave predefined replies according to admissible options presented to the study subjects.

After this process, discussed in more detail on chapter 5, the script advances to the following question.

4.3.1 Hardware

As to the hardware used, it was decided to use three Global System for Mobile Communications (GSM) modems, one for each major Portuguese MNO: MEO [31] (formerly known as TMN), Vodafone [32] and NOS [33] (formerly known as Optimus) (all trademarks and brands are property of their respective owners). This choice of operators was made because the researchers were confident that almost all students had subscribed to one of the free SMS plans that each MNO offers, which guaranteed that the research would be carried out with no costs to the end user, even when answers were required. The modems were connected to a laptop (figure 4.5) via a powered Universal Serial Bus (USB) hub, because the modems were too large to connect directly to the laptop and because that allowed extra power needed to support the modems, since the hub has an external power supply. To assure that the laptop was always ready to exchange SMS, an Uninterruptible Power Supply (UPS) was added to the hardware to increase power supply resiliency.

The setting and operation of the solution costed 600€, as follows: Capital Expenditure (CAPEX) summed 480€ by adding 300€ for the small laptop used, 100€ for the UPS, 5€ for the USB hub, and 75€ for the three GSM modems (25€ each in average); Operational Expenditure (OPEX) summed 120€ (30€ per month), to allow the payment of 10€ per each MNO subscription (these values refer to early 2014 and include all legal taxes but not electricity expenses). Each Subscriber Identity Module (SIM) card was purchased with a free SMS plan, so sending messages had no cost.

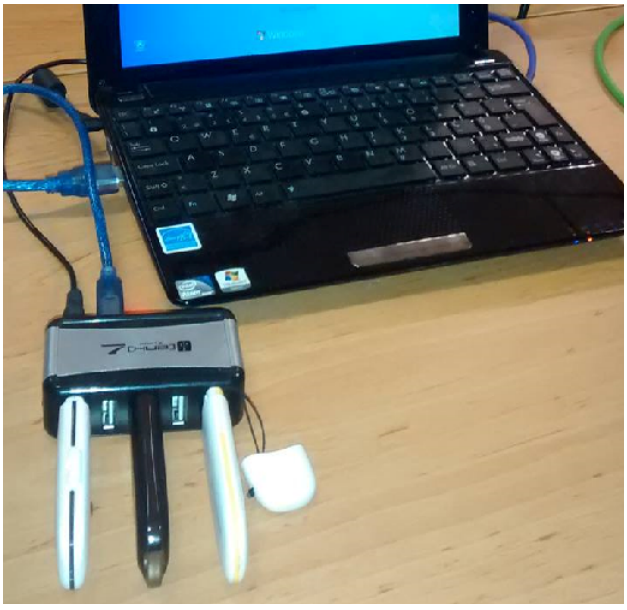

Figure 4.5: System's hardware [2].

4.3.2 Software

The send/receive and handling of received SMSs were assigned to different processes (programs), each one accessing its respective MNO directory (figure 4.6), this way a user would always receive SMSs from the MNO that he/she wanted to.

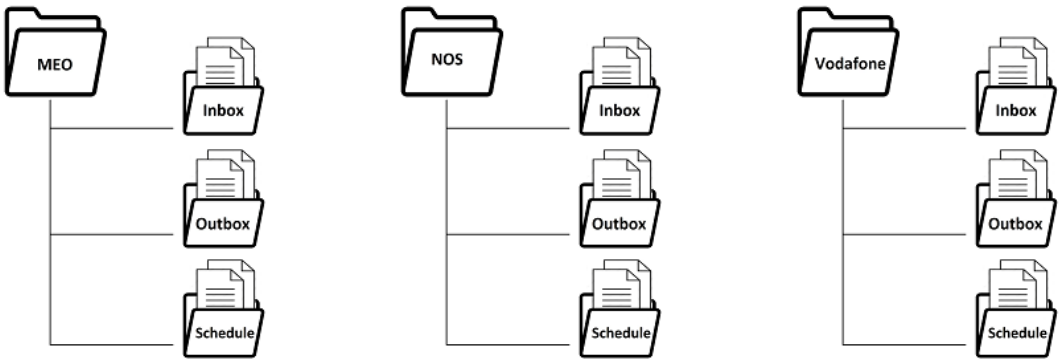

Figure 4.6: Directories tree for each Mobile Network Operator [3].

The laptop mentioned above ran six processes: three for sending/receiving SMSs for each MNO and three for handling the received ones for each MNO. All six interacted with the DB, the computer's file system and the ones sending/receiving SMSs used the respective MNO GSM modem via USB to sweep for incoming messages, retrieving and storing them in the respective directory in the directory tree of each MNO ("Inbox"). These three were also aware of changes of its respective "Outbox" directory, sending the pending outgoing messages as soon as it found them and had availability to do so. The system also relied on a web application, a DB and a task scheduler.

A more thorough explanation of the tasks performed by all software components can be found on chapter 5.

4.4 Conclusion

In this chapter a system requirements analysis and a system architecture were presented. The students participating in the study and the researchers were presented as being both system users and stakeholders, and the teachers lecturing the classes as just stakeholders. About the system requirements and architecture, the combination of hardware and software choices that compose the SMS platform were without too much detail, since that will be discussed in the next chapter.

Chapter 5

Implementation and Results

5.1 Introduction

In this chapter the implementation and tests of the system will be presented, along with the obtained results. It has the following structure:

Section 1 - *Introduction* - describes the content of this chapter along with its organization;

Section 2 - *System Implementation* - presents the components of the system, processes, web application, database and task scheduler;

Section 3 - *Results* - presents the results of the study;

Section 4 - *Conclusion* - presents some conclusions about this chapter.

5.2 System Implementation

The next subsections will further explain all software components of the system. All the software was developed using C# since it enables developers to easily create applications that run on the .NET Framework, there was a previous experience with this language and framework and also because the development and implementation phases of the project were done very early in the project start.

5.2.1 Processes

The choice to create two different processes for each MNO resulted from the analysis made to the time spent between exchanging SMS messages, handling of received messages, including creating an answer if needed, saving the message, etc., since it wasn't desirable that the solution stopped exchanging SMS texts each time it had to handle received texts (as stated in FR-MP-2 and FR-MP-3, subsection 4.2.3), whether they came from students, or operators (promotions, balance alerts, *etc.*). It was decided to call each of the processes *"SMS Gateway"* (send/receive) and *"Auto-reply Agent"* (manage received messages). Along with time management, the other rationale for the separation of these two processes was to allow a layer of isolation between the management of the messages on the GSM modems (inbound and outbound), the management of messages received from a user, and the implementation of the necessary interactivity feature (as stated in FR-HP-5 and FR-HP-10, subsection 4.2.3).

The *"SMS Gateway"* searches for new files in the "Outbox" directory of the assigned MNO. If it finds a new file it will process it by sending the SMS text (as soon as possible) to the recipient(s) contained in the file, processing files in a "Last In, First Out" (LIFO) by the reversed order of creation time stamp for each file. Since the modem cannot send and receive messages at the

same time, it was decided to insert a delay between the dispatch of each message, not only to keep the buffers from overflowing and resulting in a faulty service, but also to allow incoming messages buffered at the MNO system to be delivered to the GSM modem/SIM card and download them to a file in the ”Inbox” directory created for this purpose (figure 4.6). The SMSLib [34] library was implemented in the gateways to easily exchange messages through the GSM modems, since it is an Application Programming Interface (API) available and tested in the Microsoft .Net Framework .

The *”Auto-reply Agent”* handles the received messages by always watching the ”Inbox” directory for new files. If it finds one or more files it will decide how to handle them according to our specifications: store it, delete it or answer it.

Internally, each of the outgoing message files has the following structure (figure 5.1): FLOW_ID*MESSAGE*LIST_OF_RECIPIENT_NUMBERS. In the example in figure 5.1 we can see that `"230"` represents the flow id of that message, the text to be sent spans from `"SMS30UBI:"` until `"participaste."` and `"+351000000000"`, `"+351111111111"` and so on are the recipients' phone numbers.

```
230*SMS30UBI: Esta é a última mensagem. Numa escala de 1 (nada útil)
a 6 (muito útil), indica o número que consideras reflectir a utilidade
do programa de SMS em que participaste. *+351000000000*+351111111111*+
351222222222*+351333333333*+351444444444*+351555555555*+351666666666*+
351777777777*+351888888888*+351999999999
```

Figure 5.1: Outgoing message example (in Portuguese, phone numbers anonymized [3].

Since the *”SMS Gateway”* can only process one file at a time and the Frequently Asked Questions (FAQ) available in the SMSlib web site [34] states that if the library is being used with GSM modems, the rate at which it can send SMS is about 6 messages per minute (a message each 10 seconds), it was decided to use a random interval of 10 to 15 seconds in order to respect the fair use policy that each MNO demands from its users and that the list of recipients for each file is never larger than 10, because by limiting the amount of messages the system can send at once, there is a guarantee that no high priority message has a delay of more than 150 seconds before being sent (as stated in FR-MP-2 and FR-MP-3, subsection 4.2.3).

As each individual message is part of a predefined flow, and each user may interact with the system at different points of each flow, the messages have to be identified by a flow identifier (*flow id*). The flow id identifies the message that is being sent, giving also information as to if this message is waiting for an answer and the auto-reply to be delivered if a received answer is valid. The degree of interactivity of the system is limited to one question, several possible answers, and several corresponding replies, *i.e.*, the dialog between the user and the system is limited to the depth of question-response-acknowledgment messages (figure 5.2). Nevertheless, more complex flows can be devised and stored at the DB, without any influence to the complexity of the other parts of the system itself.

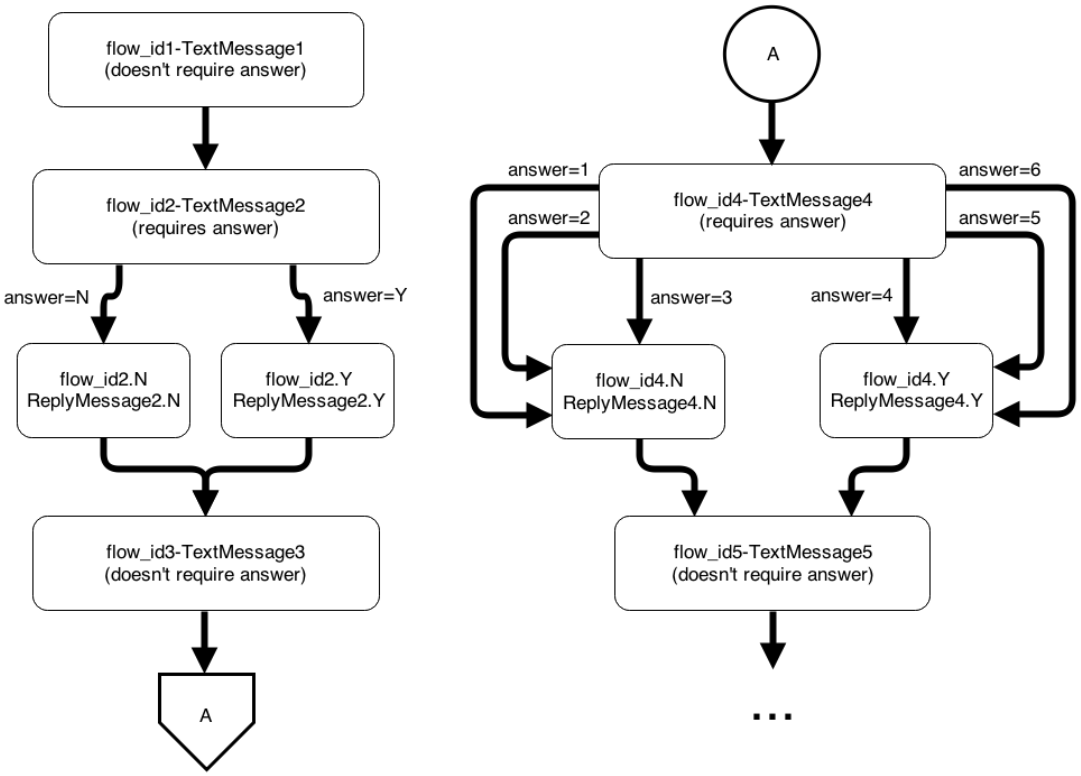

Figure 5.2: Abstract example of message flow [3].

Inside a message file, the numbers in the list of recipients are separated by the same control character used to separate the other fields (* in this example). The real control character is an extended ASCII character, chosen because it is highly improbable that it would be used in the text of a message, preventing a risk/abuse of the system (as stated in NFR-HP-1, subsection 4.2.4). Message text is encoded in UCS2, a Unicode encoding that uses a 16-bit character format and allows accented characters along with other special ones commonly used in Portuguese writing (like c with cedilla 'ç', as stated in FR-LP-2, subsection 4.2.3), in spite of losing the maximum length for each message (from 160 to 70 characters).

A scheme for the processing of messages is presented in figure 5.3 and consists of the system sending a message, leaving the system waiting for an answer. Assuming that the message is received by the recipient, two scenarios may occur: (1) the recipient sends one of the required response answers, this message is processed and a new message (the corresponding auto-response) is issued; (2) the recipient responds when no reply was expected: the response message is stored at the DB for further inspection and an alarm is raised in the control panel of the system, allowing the unexpected reply to be viewed by the system's administrator. If a response is expected but the user does not respond in a period of 1440 minutes (24 hours), the system administrator can decide what to do, for example, advance the flow of the user or send the message again (as stated in FR-MP-8, subsection 4.2.3).

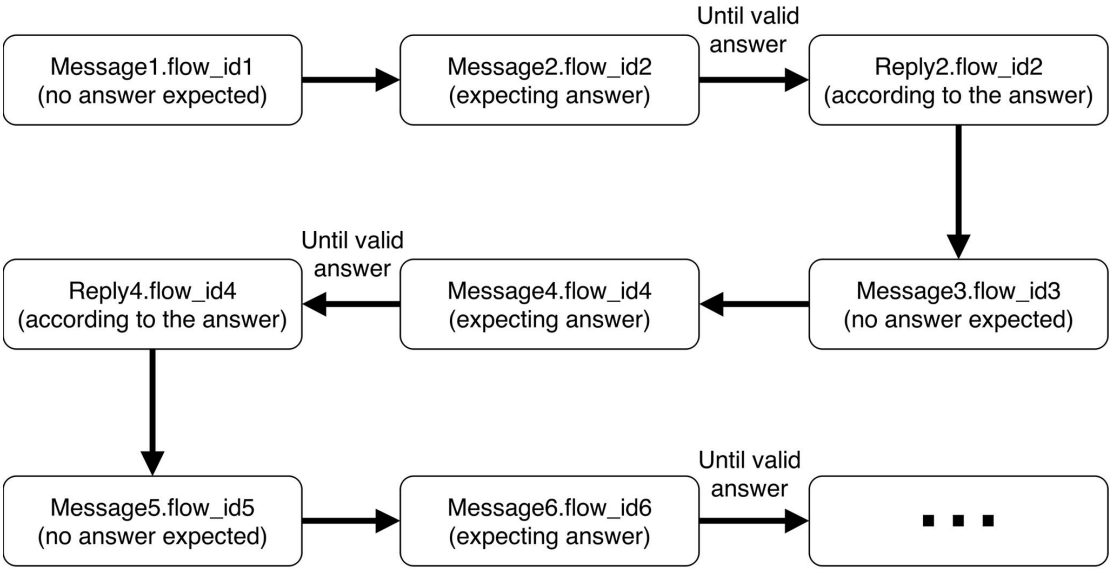

Figure 5.3: Stream of interactive messages [2].

In both figure 5.2 and 5.3 the "..." means that the system will move on to the next message or will end if no other messages are pending.

5.2.2 Web Application

The main objective of the application (figure 5.4) is to manage the scheduling of outgoing messages using a task scheduler, or preparing a message to be sent immediately, by creating files which contain the information needed to send a SMS. Since in this study the same message may be sent to several students at the same time, it was decided to create batches of files and each file has at most ten recipients for the previously presented reasons. This way, the thread processes a file with up to ten recipients and does this in an exclusive manner, *i.e.*, uninterruptedly, not considering for example, the dispatch of a message that may have a higher priority. Yet, as there are several processes running in parallel, there may be the case where all three modems are sending messages at the same time.

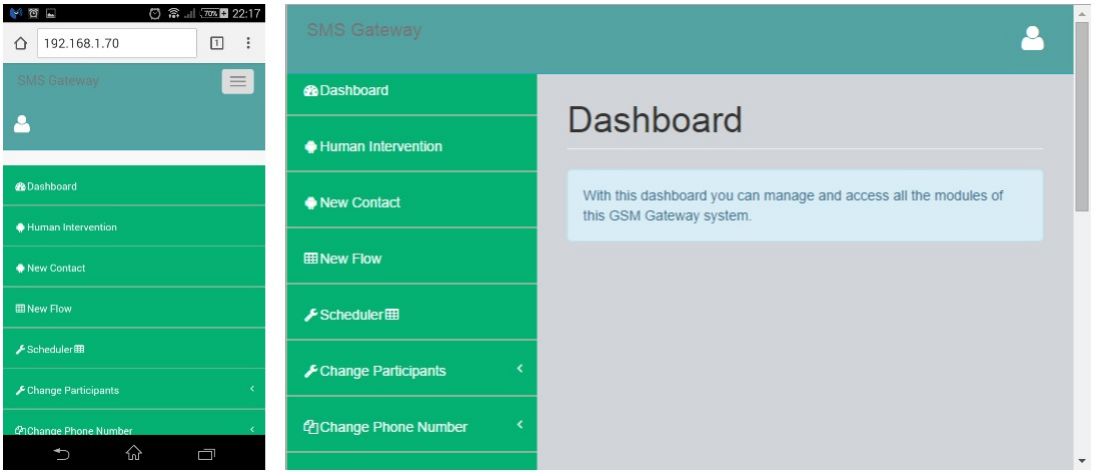

Figure 5.4: Web application in a mobile phone (left) and in a PC (right), using [4] template.

The outgoing files are created in the respective MNO ”Outbox” folder if it’s a message to be sent immediately or in the ”Scheduled” folder if it’s a message destined to be sent later, usually, at a predefined time. When a scheduled message is created, the web application also creates the respective task in the Scheduler, including the details concerning the file’s original location, when to move it, and to what directory it should be moved. In this study it was decided that the initial messages should always be sent between 18:30h and 20:30h, as not to disturb classes or the sleep of the recipients.

Although it was not an important requirement, the application had a responsive design functionality for better viewing in all resolutions (as stated in NFR-LP-3, subsection 4.2.4).

5.2.3 Database

Microsoft SQL Server was chosen since it has an easy integration with the web application, because it uses the same platform, the .NET Framework, and it was used to save users information such as message recipients, messages flow, log the messages exchanged with each user, courses’ information, among other aspects. Its structure is shown in figure 5.5.

The following tables are responsible for the message flow control:

- *Fluxo_EI* – Has information about the flow identifier of each message, along with the respective message, response for a positive answer, for a negative answer and the type of message, *i.e.*, if the message requires or not an answer;
- *Fluxo_saida* – Saves the sent message for each recipient, together with the respective timestamp, the flow at which corresponds and if the recipient has replied to the message;
- *Fluxo_entrada* – Used to store received messages for each recipient, along with the respective time stamp, the flow at which it corresponds and the text received.

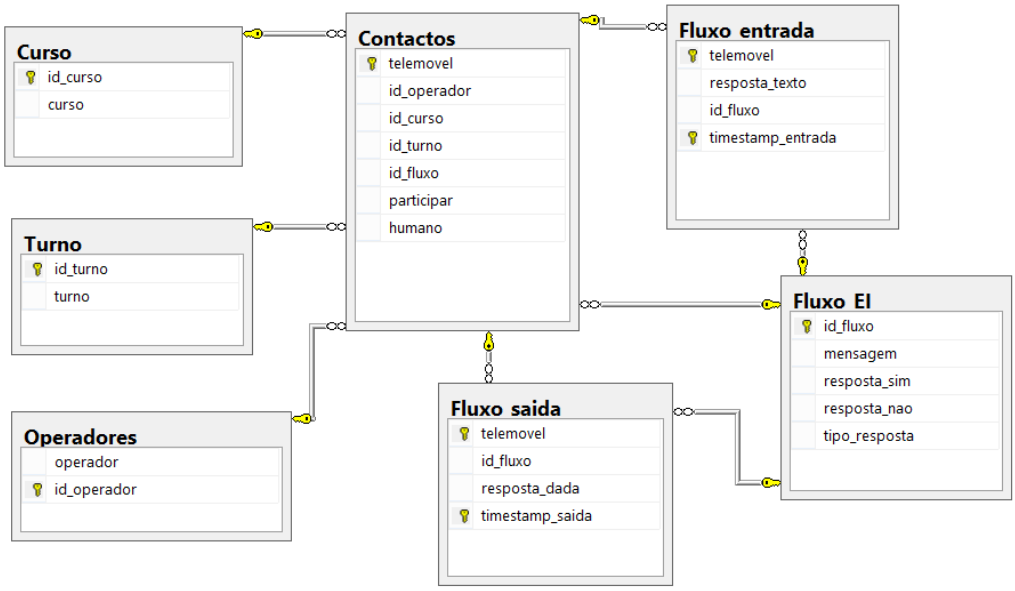

Figure 5.5: Database table structure.

5.2.4 Task Scheduler

This component creates tasks via the web application consisting of the following: for a given task, when the scheduled time arrives, the task scheduler will move the file defined in the task from the ”Scheduled” directory to the respective ”Outbox” directory, which will then be found by the process that handles the outgoing messages (*”SMS Gateway”*), sending them to the respective recipients.

It was decided to use the task scheduler available in the laptop OS, Windows 7, Version 6.1, Build 7601: Service Pack 1, on the grounds that this was more than adequate for the needed feature, therefore avoiding the creation of a proprietary task scheduler. This decision was also possible because the computer used for this task was dedicated to this study alone and no other scheduled tasks were added by other software components.

5.3 Results

As operational results, the system had an uptime of 16 weeks, from 27th of February 2014 to 13th of June 2014 without any crashes, sending messages at the scheduled time and replying when needed. There were some cases in which the participants didn’t reply in the established 24 hours, so the researchers chose to advance their flow manually before the next scheduled message was due to be sent, so they could be kept in the study (as stated in FR-MP-7 and FR-MP-8, subsection 4.2.3).

The SMS sent had varied types of text, some were informative, persuasive, other were motivational, but all with the purpose of improving the self-efficacy of the experimental group participants. Since some messages required an answer and others did not, the percentage of valid versus invalid answers was analyzed. As seen in figure 5.6, the percentage of valid responses close to 97% versus the 3% for invalid ones.

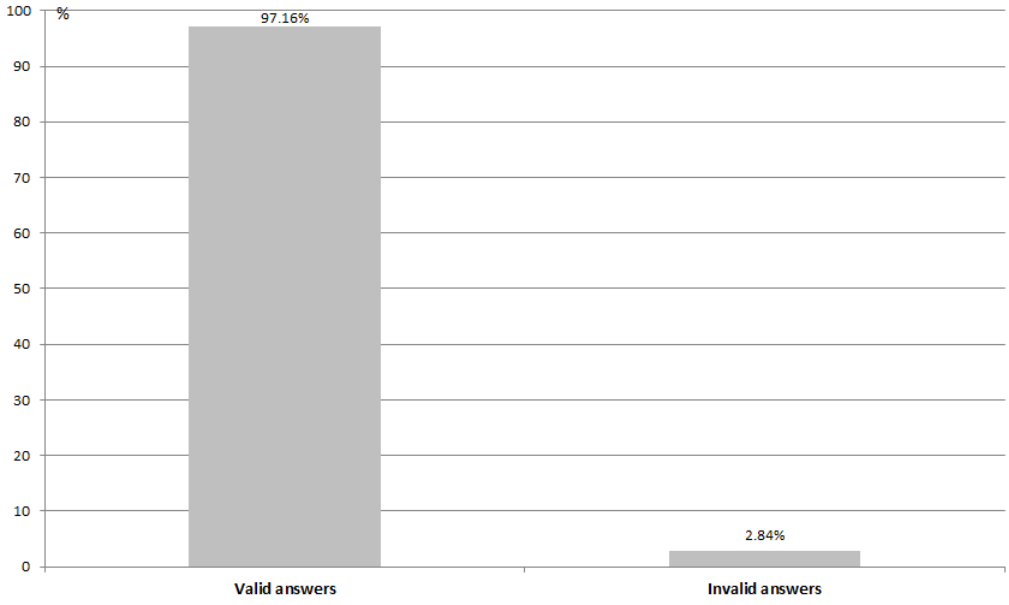

Figure 5.6: Validity of students’ answers to all interactive questions [2].

With that, we can conclude that the participants understood each question and what type of answer was expected.

The assessment of the utility of this study was the final question sent to each participant, where the reply was given according to a Likert scale (1-6), being 1 not useful and 6 very useful. The majority of the participants (67.5%) viewed the study as useful, considering that replies 1 to 3 were a negative feedback (32.5%) and 4 to 6 a positive feedback (figure 5.7).

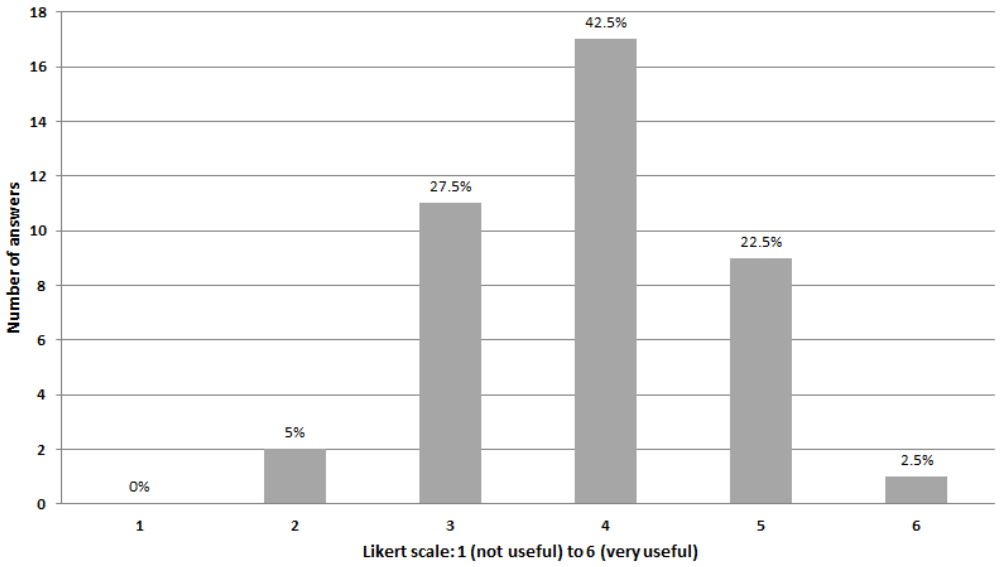

Figure 5.7: Experimental group participants' perception of program's utility. [2]

Analyzing the number of valid versus invalid answers for each question, we can conclude that invalid answers were restricted to certain questions. Invalid answers appeared mostly in questions 2, 6, and 13, leaving the others with none or close to none invalid answers (figure 5.8).

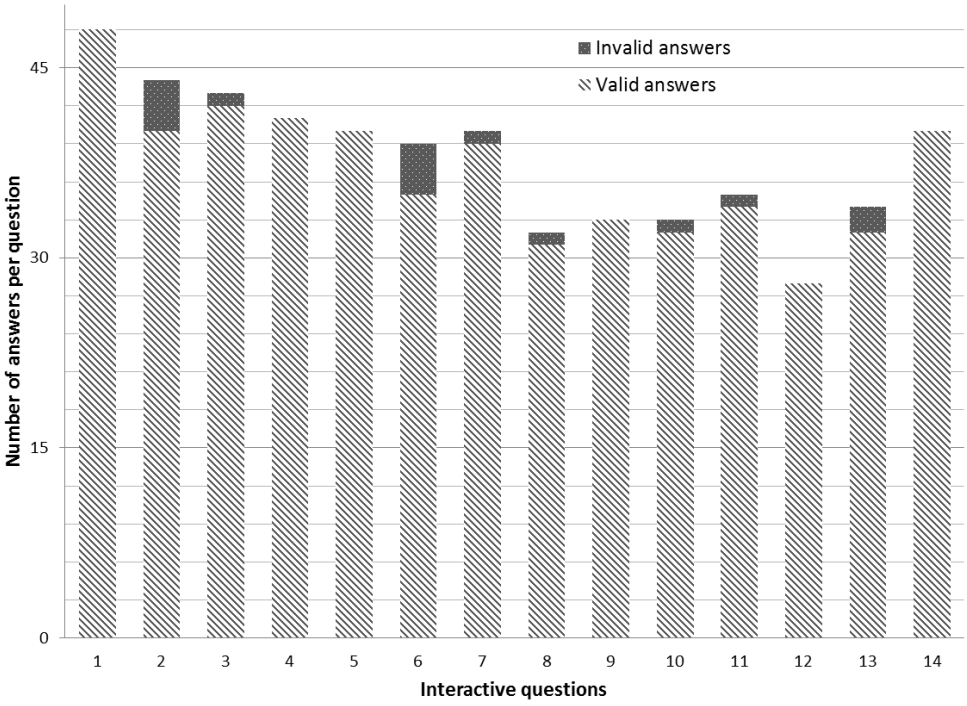

Figure 5.8: Validity of students' answers by question. [2]

It should also be noted that invalid answers weren't limited to a certain type of question (Yes/No or Likert scale), hindering a perception of the liking for either type. These results will lead to a more careful analysis of the questions 2, 6 and 13, as to try to improve its error ratio on a future research.

A real message flow is presented in the Appendix A.

5.4 Conclusion

In this chapter the implementation and obtained results were discussed. From the available data it can be concluded that the defined requisites and the chosen implementation resulted in an adequate match, as the system proved to be efficient, reliable and effective, and its usefulness was acknowledged by the majority of the users.

Chapter 6

Conclusions and Future Work

6.1 Conclusions

To the best knowledge of the author, no study aimed to analyze the self-efficacy improvement using an SMS program is known. With that said, the innovative features of this research do not allow it to be compared with other studies, and assess what could be improved. Still one can only wonder if parameters like the number of messages to be sent each week, the participants sample size, the study duration or some control over message reception and reading could be improved. Although the final results of the psychological study are not the focus of this report, it appears that the SMS program didn't affect the self-efficacy of the participant students, yet, the majority of the participants who received the texts, considered the program useful.

As for the system described in this dissertation, some conclusions can be drawn as to the functionality of the support platform. Taking into consideration the fact that the system was built using old off-the-shelf parts and components, allowed for a cost free communication between the system and the users, that we have sent and received a considerable number of messages, reaching almost 7000, and didn't violate any of the fair use policy of the MNO subscribed plans, we conclude that the system ran as expected and can be considered to have performed well and overall gave the necessary responses to the study's needs, having an uptime of 100% and zero system crashes. Yet, one student complained that he couldn't read the texts, even when we thought to have made all the necessary preparations for them to be readable by all types and models of mobile phones. However when further questioned he told the researchers he was using a very old mobile phone that he no longer had with him, making it impossible to identify what would've been the problem and a possible solution to it. All this was achieved using a low-end laptop, with a Intel Atom N450 processor running at 1.66GHz, 2GB of Random Access Memory (RAM) and a 64-bit operating system, having a workload of almost 100%.

Moreover, the design of the messages and the request for replies was praised by several test subjects for being simple, user-friendly and not being too time consuming.

It should be pointed out that the simplicity of this system allows for it to be easily adapted to other studies, subjects, businesses or could even be used to create reminders about whatever one wants, not being limited to students nor to academic environments and that the developed software for sending/receiving SMS (*"SMS Gateway"*) and handling the received ones (*"Auto-reply Agent"*) source code is available at the ALLab [35] MediaWiki [1].

Finally it should be mentioned that while no significant self-efficacy statistical difference was obtained between the pre-intervention and post-intervention stages, most of the experimental group students had a positive perception about the study, classifying it has useful, having an average of 4 in a Likert 1 to 6 scale, being 1 not useful and 6 very useful.

6.2 Future Work

As concluded, the simplicity of the system allows it to be easily adapted. However, in the scope of this study in particular, there is still room for some improvements that weren't required and/or asked for. Some of them are as follows:

- Perform a pre-test to assess if every recipient receives a readable SMS;
- Let users create accounts that can be used to log-in to their personal area;
- Make the system autonomously able to schedule messages after a given time has passed since the last sent message or it has received a valid answer to a certain question;
- Make the system able to schedule messages for a custom group of recipients;
- Create a better mechanism to handle and reply to invalid received messages;
- Create a better mechanism to handle and reply to non-expected received messages;
- Convert the processes into OS services.

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Appendix A

Message Flow Tables

This Appendix presents the real flow of messages sent and received messages to and form a particular anonymous student.

A.1 Sent Messages

This section presents three tables that contain the outgoing messages sent to a student, including its message flow id and timestamp.

A.1.1 Sent Messages Table 1

Table A.1: Example of a sent message flow (table 1, in Portuguese).

Message `flow_id`	Text	Timestamp
401	SMS1UBI: Bem-vindo! Para um bom rendimento em Cálculo II é importante organizares o teu tempo de estudo.	2014-02-27 18:55:20.887
402	SMS2UBI: És capaz de obter sucesso nesta disciplina. O teu rendimento depende sobretudo do teu esforço. Consideras esta afirmação verdadeira? Responde numa escolha de 1 (nada verdadeiro) a 6 (totalmente verdadeiro).	2014-03-01 19:06:19.463
403	SMS3UBI: O teu rendimento académico depende da tua capacidade para te organizares.	2014-03-03 18:55:19.617
404	SMS4UBI: Frequentas as aulas regularmente e recorres ao horário de atendimento para esclareceres as dúvidas? Responde Sim ou Não (S/N).	2014-03-06 18:57:38.640
405	SMS5UBI: Antes de cada aula, revê a matéria: faz resumos, resolve os exercícios e se tens dúvidas procura a ajuda do (a) teu (tua) professor(a) ou de colegas.	2014-03-10 20:15:52.633
406	SMS6UBI: No moodle encontras informação sobre os critérios de avaliação, datas de avaliação e horário de atendimento. Conheces estas informações? Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa à tua situação.	2014-03-13 20:24:11.873

A.1.2 Sent Messages Table 2

Table A.2: Example of a sent message flow (table 2, in Portuguese).

Message id_flow	Text	Timestamp
407	SMS7UBI: Se optaste por realizar mais do que um teste, vais ter uma avaliação em breve. Organiza o teu tempo para reveres todos os conteúdos e colocares as dúvidas ao (a) teu (tua) professor (a) com antecedência.	2014-03-16 20:05:58.840
408	SMS8UBI: Como te correu o teste? Responde com um número numa escala de 0 (não fiz), 1 (muito mal) a 6 (muito bem).	2014-03-20 20:12:00.887
409	SMS9UBI: Mantém um estado de ânimo apropriado para trabalhar.	2014-03-24 20:00:43.237
410	SMS10UBI: Ao pensares ou realizares testes de avaliação sentes-te muito ansioso (a)? Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa à tua situação.	2014-03-27 20:53:00.147
411	SMS11UBI: Para o sucesso na aprendizagem é fundamental dormir e descansar o suficiente.	2014-03-31 20:05:21.267
412	SMS12UBI: Procuras estudar num local adequado - luz, temperatura, ventilação, ruídos, materiais à mão, etc…? Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa à tua situação.	2014-04-03 20:34:31.777
413	SMS13UBI: Para manteres a concentração nas aulas e nas tarefas de estudo, mesmo que haja coisas mais interessantes para fazeres há estratégias que podes utilizar.	2014-04-07 20:18:32.807
414	SMS14UBI: Utilizas técnicas e estratégias para estudar melhor: tiras apontamentos, elaboras formulários e resumos com a informação mais importante? Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa à tua situação.	2014-04-10 20:26:22.430
415	SMS15UBI: Desejamos-te uma Páscoa Feliz!	2014-04-17 19:56:32.917
416	SMS16UBI: Mantém em dia o teu estudo. Revê os apontamentos; procura outras fontes: pesquisas na internet, na biblioteca da UBI, trabalho em grupo.	2014-04-22 20:26:36.900
417	SMS17UBI: Se optaste por realizar mais do que um teste, vais ter uma avaliação em breve. Organiza o teu tempo para reveres todos os conteúdos e colocares as dúvidas ao (a) teu (tua) professor (a) com antecedência.	2014-04-24 20:21:56.367
418	SMS18UBI: Como te correu o teste? Responde com um número numa escala de 0 (não fiz), 1 (muito mal) a 6 (muito bem).	2014-04-28 20:25:30.833

A.1.3 Sent Messages Table 3

Table A.3: Example of a sent message flow (table 3, in Portuguese).

Message id_flow	Text	Timestamp
419	SMS19UBI: Ao memorizares partes da matéria, tentas compreender como se resolvem os exercícios? Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa à tua situação.	2014-05-03 20:24:03.097
420	SMS20UBI: Lembra-te: o sucesso/rendimento académico depende sobretudo do teu esforço. És capaz!	2014-05-05 20:26:30.817
421	SMS21UBI: Sabes que a inteligência envolve diferentes habilidades que se podem aumentar e desenvolver com o esforço e a aprendizagem? Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa à tua situação.	2014-05-08 20:39:23.183
422	SMS22UBI: Mantém em dia o teu estudo. Revê os apontamentos; procura outras fontes: pesquisas na internet, na biblioteca da UBI, trabalho em grupo.	2014-05-12 20:36:12.263
423	SMS23UBI: Para te lembrares do que estudaste usas resumos com palavras tuas sobre os procedimentos que te ajudam a recordar o que aprendeste? Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa à tua situação.	2014-05-15 20:27:56.810
424	SMS24UBI: Ao estudar integra informação de diferentes fontes: apontamentos da aula, livros, trabalhos práticas, exercícios, etc...	2014-05-19 20:33:46.267
425	SMS25UBI: A matéria desta disciplina é importante para a tua formação e para a aprendizagem noutras disciplinas. Numa escala de 1 (discordo totalmente) a 6 (concordo totalmente), escreve o número que indica a tua posição.	2014-05-22 20:30:48.713
426	SMS26UBI: Se ao estudar te surgirem dúvidas ou dificuldades que não consegues resolver sozinho(a) procura a ajuda dos colegas e do (a) professor (a).	2014-05-26 20:10:05.527
427	SMS27UBI: Aproveita bem o tempo que estiveres a estudar.	2014-05-29 21:10:25.703
428	SMS28UBI: Vais ter uma avaliação. Organiza o teu tempo para reveres todos os conteúdos e colocares as dúvidas ao (a) teu (tua) professor (a) com antecedência.	2014-06-02 20:25:24.027
429	SMS29UBI: Como te correu o teste? Responde com um número numa escala de 0 (não fiz), 1 (muito mal) a 6 (muito bem).	2014-06-05 20:54:04.607
430	SMS30UBI: Esta é a última mensagem. Numa escala de 1 (nada útil) a 6 (muito útil), indica o número que consideras reflectir a utilidade do programa de SMS em que participaste.	2014-06-12 18:46:50.983

A.2 Received Messages

In this section, the respective answers will be listed.

Table A.4: Example of a incoming message flow.

Message id_flow	Text	Timestamp
402	4	2014-03-01 20:31:09.480
404	sim	2014-03-06 19:00:01.280
406	S	2014-03-13 20:25:38.343
408	4	2014-03-20 20:26:24.277
410	S	2014-03-27 20:55:30.160
412	S	2014-04-03 20:35:51.610
414	S	2014-04-10 20:27:55.547
418	1	2014-04-28 20:26:58.430
419	S	2014-05-03 20:26:02.240
421	S	2014-05-08 20:40:39.770
423	S	2014-05-15 20:29:37.580
425	4	2014-05-22 20:32:44.740
429	6	2014-06-05 20:55:28.960
430	5	2014-06-12 18:48:38.347

By pairing the messages sent and receive with the same *"Message id_flow"*, one is able to see what answer the student gave to each question.

Appendix B

Papers

This appendix shows the papers accepted for the ”13th International Conference on Computer Information Systems and Industrial Management Applications (CISIM2014)”, Ton Duc Thang University, Ho Chi Minh City, Vietnam, November 5-7, 2014 and ”The International Conference on Education Technologies and Computers (ICETC2014)”, Lodz University of Technology, Lodz, Poland, September 22-24, 2014, in sections CISIM2014 and ICETC2014 respectively. Section ICERI2014 consists of the abstract accepted to the ”7th International Conference of Education, Research and Innovation” (ICERI2014), Seville, Spain, November 17-19, 2014.

B.1 CISIM2014

An Off-the-Shelf Platform for Automatic and Interactive Text Messaging Using Short Message Service

Daniel Oliveira[1], Diana Oliveira[3], Nuno M. Garcia[1,2,4], and Graça Esgalhado[3]

[1] Computer Science Department, University of Beira Interior, Covilhã, Portugal
[2] Instituto de Telecomunicações, Covilhã, Portugal
[3] Psychology and Education Department
Universidade da Beira Interior, Covilhã, Portugal
[4] Universidade Lusófona de Humanidades e Tecnologias, Lisbon, Portugal
danieloliveira@it.ubi.pt, dianapsoliveira@gmail.com,
ngarcia@di.ubi.pt, mgpe@ubi.pt

Abstract. This paper describes the design and construction of a platform for the implementation of an automatic and interactive message handling system through the use of Short Message Service (SMS), also known as texting, devised to be used as support of a Psychology study. The platform was devised to use low cost off-the-shelf parts, yet allowing the design of an efficient and robust system. The research that prompted the platform's construction included researchers from the Psychology and Education Department and the Computer Science Department of the University of Beira Interior. The study's goal is to assess psychological changes of the research subjects after exposure to motivational SMS texts. The paper describes the strategies adopted to design the architecture of the platform and the setting in place of the system, including the description of the used software and hardware. The source code of this system is publicly available at the Assisted Living Computing and Telecommunications (ALLab) website.

Keywords: SMS, messaging, mobile, off-the-shelf, psychology, self-regulation, self-efficacy.

1 Introduction

It is considered that information and communication technologies play a major role in all aspects of current human interactions in the so-called developed countries and in particular for young humans.

Nowadays, mobile devices seem to be the first choice of graduate students to communicate, organize, actualize and eventually learn [1], in particular if smart phones are considered. When taken into account that only a very small percentage of students are not avid texters, we can assume that text messaging is one of the most privileged ways they use to communicate [2]. That might be why, even though the use

K. Saeed and V. Snášel (Eds.): CISIM 2014, LNCS 8838, pp. 489–500, 2014.

of this technology is still taken with caution by colleges and lecturers, in the past decade there have been several studies concerning the use of Short Message Service (SMS) in an educational context. So far SMS technology has been used to send students administrative information [3], some educational content [4,5], or to send persuasive and motivational quotes [6], just to name some of its applications. Yet, there's not much research in this particular area, therefore we are just starting to analyze how SMS may be used as a tool to support teaching and learning in higher education.

With that in mind, in the context of research in the areas of Computer Science (CS) and Pedagogical Supervision (PS) at the University of Beira Interior (UBI) it was devised a joint research to study whether persuasive and motivational SMS texts could be used to increase the student's performance in mathematics classes, of students from four different undergraduate courses. This was done through a study that focused in establishing the effects of the SMS intervention in the student's self-regulated learning, general academic self-efficacy and learning strategies, and involved the definition of the architecture supporting that study.

This paper focuses mainly in the description of the computational issues of the study, although some other topics will be introduced to contextualize. As the results of the psychology study are not available at this time, it's not the goal of this paper to present conclusions regarding the impact of the use of the platform in the study subjects. The remainder of the paper is organized as follows: this paragraph concludes section 1; Section 2 presents a very brief overview of the state of the art; Section 3 describes the system's architecture; Implementation is discussed in Section 4; Section 5 concludes the paper, and references and acronyms are shown in the final part.

2 State of the Art

Globally, in the last decade, the telecommunications field has experienced a great increase not only in network coverage, but also in technological innovation [7]. Furthermore text messaging is now so popular, it is being used by people of all ages and technology expertise, and among university students texting is generalized [2,4].

Importing something as widespread as SMS and adapting it as a tool for teaching and learning purposes is only natural [2] considering we're not introducing something entirely new to colleges and classrooms.

Today's students use mobile phones and SMS, inside and outside school, therefore, the research was developed to assess whether SMS could have a motivational impact, as suggested by previous research [4,8].

In recent years, colleges and other higher education institutions have tried to come up with ways to introduce mobile phones in ways that may enhance lecturers supported in pedagogy. This means that from a pedagogical perspective, there may be opportunity to raise student engagement, considering the subjects studied at a higher education level [7] and use pervasive technologies such as the SMS.

The popularity of SMS is believed to have inspired some lecturers to explore their use in the educational context [9]. Besides studies that connect the usage of SMS with weight loss [10,11] and smoking cessation [12], in recent years investigators from the educational field have turned their sights into how this technology can be used in a producible way in their own work places: high education institutions. We can find

such studies in many parts of the world, but as not to be exhausting some examples of such usage can be found in the following research: [3] published a study on how SMS could be used to send administrative content to students; [4,5] that focused on how to send educational contents through SMS; authors in [13] focused not only in the delivery of educational content, but also on how that might affect student engagement to class assignments; and [14] focused on how SMS exchange in class could increase its interactivity.

The development of the platform used in this study was made taking into consideration the requirements defined by the main stakeholders, the Pedagogical Supervision Master of Science (MSc) student and their supervisors. Although we found some commercial solutions that fulfilled some of the requirements, we didn't find an integrated solution that complied with them all and since we had a tight budget and tight time schedule to start the study, creating our own system architecture from the ground up was the obvious choice, especially when taking into consideration that there was previous expertise in this area and several in-house projects had been already developed at an experimental level.

3 System Architecture

The system was build taking into consideration the requirements and challenges posed by the psychology study it would be used for: (1) the system needs to work uninterrupted and unattended; (2) the system needs to address Mobile Network Operator (MNO) fair use policies, by not sending large amounts of SMS texts in a very short period of time; (3) the students have to receive a stream of messages at predefined times; (4) some messages require answers making this an interactive question-response system.

To comply with the requirements, a mechanism to control the message flow for each student was needed, *i.e.*, as each student responds on its own time, the message being processed for a particular student may be different from the message of the student that precedes him/her in the message queue.

The stream of SMS messages as well as the list of destinations were inserted as elements of a database (DB). The questions themselves, the admissible answers and the message flow was defined based on psychological validated literature as expressed in studies aiming to evaluate self-regulated learning and/or self-efficacy in the same population[17,18], which will be explored outside this paper.

To manage this flow of messages, a script was created which connected questions with their validated answers, and when admissible, gave predefined replies according to admissible options presented to the study subjects. After this process, discussed in more detail in the architecture section the script advances to the following question.

As to hardware it was decided to use three Global System for Mobile Communications (GSM) modems, one for each major Portuguese MNO: MEO (formerly known as TMN), Vodafone and NOS (formerly known as Optimus) (all trademarks and brands are property of their respective owners). This choice of operators was made because the researchers were confident that almost all students had subscribed to one of the free SMS plans that all MNO offer, which guaranteed that the research would be carried out with no costs to the end user, even when answers were required.

The modems were connected to a laptop via a powered universal serial bus (USB) hub, because the modems were too large to connect directly to the laptop and because that allowed extra power needed to support the modems, since the hub has an external power supply. To assure that the laptop was always ready to exchange SMS, an Uninterruptible Power Supply (UPS) was added to the hardware to increase power supply resiliency. The setting and operation of the solution cost 625€, as follows: Capital Expenditure (CAPEX) summed 505€ by adding 300€ for the small laptop used, 100€ for the UPS, 5€ for the USB hub, and 75€ for the three GSM modems (25€ each in average); Operational Expenditure (OPEX) summed 120€ (30€ per month), to allow the payment of 10€ per each MNO subscription (these values refer to early 2014 and include all legal taxes but not electricity expenses). Each Subscriber Identity Module (SIM) card was purchased with a free SMS plan, so sending messages had no cost. The architecture of the system is shown in Fig. 1.

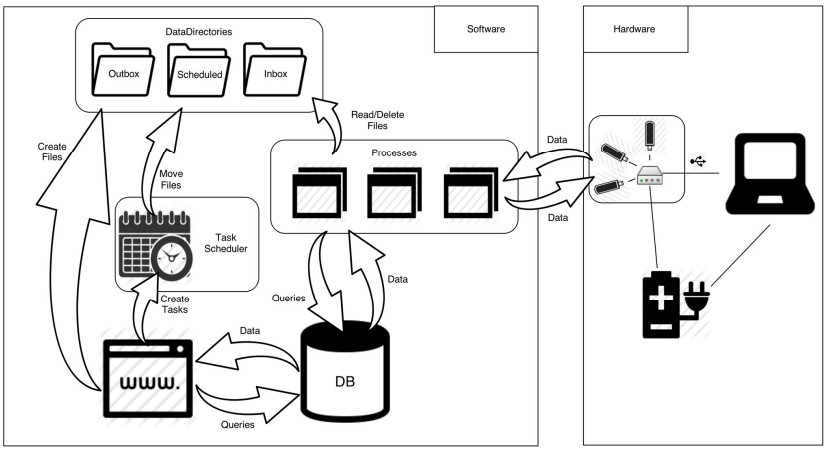

Fig. 1. System architecture diagram

Concerning software, a decision was made to assign the SMS exchange functionalities and the handling of the received SMS's to two separated processes, both sharing access to the three directories created for each MNO (Fig. 2). Because each process only has access to the directories of the assigned operator, each user only receives SMS sent from the operator. As depicted in Fig. 1, the computer runs six processes, each interacting with the DB, the computer's file system and one of the MNO GSM modems. One group of processes is in charge of processing the received messages and replies and implementing the interactive feature of the system. The other group of processes is in charge of sweeping its associated GSM modem, looking for incoming messages and retrieving and storing these messages in the respective Inbox folder. This group of processes is also in charge of sweeping the Outbox folder and sending the found outgoing messages to its associated GSM modem. More details on the tasks performed is given in Section 4.

The system also relies on (Fig.1):

- a web application to schedule the SMS's, add/remove users and disable the dispatch of messages to a given user, among others functionalities;
- a DB to store the messages (*text*) to be scheduled, the auto-reply messages, the users' information, the replies received from the users and all additional support tables;
- a task scheduler that creates the tasks requested from the web application.

No comparison between this solution and others available is given because most of them aren't neither free not open-source, which prevents comparability concerning, the underlying used architecture.

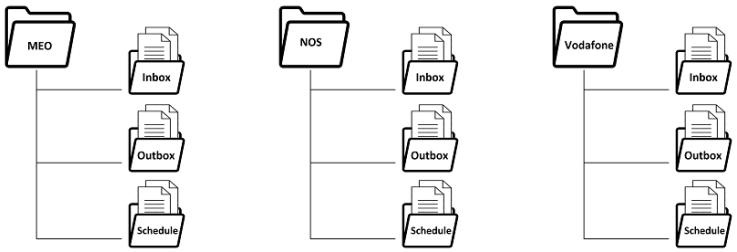

Fig. 2. Directories tree for each Mobile Network Operator

4 Implementation

The research started when MSc students from the DPE decided to develop their dissertations on the impacts of new technologies in the educational environment, but only the study entitled "The efficacy of the intervention through SMS in the learning's self-regulation and general academic self-efficacy in ungraduated students" will be mentioned.

The study focus on the use of SMS with persuasive and supportive messages to students from different courses: Computer Science Engineering, Electromechanical Engineering, Electrical and Computers Engineering and Optometry - Vision Sciences, which have in common poor academic performance and high dropout rate on their respective mathematics class. A three stages process was followed: a pre-study, the experiment, and a post-study. Both in the pre and post studies, the students were invited to fill a socio-demographic and data questionnaire prepared and managed by the DPE researchers and the experiment itself involves the use of the tool targeted by this paper. This study also included other relevant questions such as the students' mobile phone number and the desired MNO it would communicate with.

The pre-study started by initially contacting teachers who lectured math to the research subjects. The teachers were asked to collaborate and to make available 20 minutes of their first class of the semester for the researchers to invite students to participate in their study. Afterwards, the complete questionnaires were separated by course and class for the purpose of creating an experimental and a control group,

where all classes and courses were represented: students were randomly rafted to one of the groups, by course and class.

Around 300 students were invited to participate, but only 184 filled the initial pre-study questionnaire; this roughly corresponds to the number of students met when visiting the classes at the start of the semester.

Considering that along the semester dropouts might occur, we didn't sort the students equally between our experimental and control group, instead we sorted 110 students (60%) to the experimental group and the other 74 (40%) to the control group.

During the experiment stage, while students normally attended classes, students rafted to the experimental group received a SMS twice a week, on Mondays and Thursdays and those of the control group didn't.

At the end of the semester the teachers lecturing the mathematics class were again contacted and the students were invited to fill the same questionnaire, by course and by class.

Regarding the computational side of the work, there were several decisions that led to the system architecture being discussed. All the software was developed using C# since it enables developers to easily create applications that run on the .NET Framework and there is previous experience with this language and framework.

At a later time, outside the scope and goal of this paper, researchers will compare scores between what students responded on the questionnaires pre and post-study, aiming to analyze differences between the experimental and control groups, in an attempt to assess whether receiving the texts modified the way students answered to the same set of questions.

4.1 Processes

The choice to create two different processes for each MNO resulted from the analysis made to the time spent between exchanging SMS messages, handling of received messages, including creating an answer if needed, saving the message, etc., since it wasn't desirable that the solution stopped exchanging SMS texts each time it had to handle received *texts*, whether they came from students, or operators (promotions, balance alerts, *etc*.). It was decided to call each of the processes "SMS Gateway" (send/receive) and "Auto-reply agent" (manage received messages). Along with time management, the other rationale for the separation of these two processes was to allow a layer of isolation between the management of the messages on the GSM modems (inbound and outbound), the management of messages received from a user, and the implementation of the necessary interactivity feature.

The "SMS Gateway" searches for new files in the "Outbox" directory of the assigned MNO. If it finds a new file it will process it by sending the SMS text to the recipients contained in the file, processing files in a first in first out manner using for this the time stamp for the creation of the file.

Since the modem cannot send and receive messages at the same time, it was decided to insert a delay between the dispatch of each message, not only to keep the buffers from overflowing and resulting in a faulty service, but also to allow incoming messages buffered at the MNO system to be delivered to the GSM modem and retrieved and stored in the respective folder ("Inbox" folder). To further take advantage

of the delay, this time lapse is used to verify if any other message has been received at the modem, and if so download it from the SIM card to a file in the Inbox directory created for this purpose, (c.f. Fig. 2). The SMSLib [15] library was implemented in the gateways to easily exchange messages through the GSM modems, since it is an Application Programming Interface (API) available and tested in the Microsoft .Net framework.

The "Auto-reply agent" handles the received messages by always watching the "Inbox" directory for new files. If it finds one or more files it will decide how to handle them according to the system specifications: store it, delete it or answer it.

Internally, each of the outgoing message files has the following structure: FLOW_ID*MESSAGE*LIST_OF_RECIPIENT_NUMBERS. In the given example "230" represents the flow id of that message, the text to be sent spans from "SMS30UBI:" until "participaste." and +351000000000, +351111111111 and so on are the recipients' phone numbers, as shown in Fig. 3. The asterisk character "*" was used as field delimiter.

```
230*SMS30UBI: Esta é a última mensagem. Numa escala de 1 (nada útil)
a 6 (muito útil), indica o número que consideras reflectir a utilidade
do programa de SMS em que participaste. *+351000000000*+351111111111*+
351222222222*+351333333333*+351444444444*+351555555555*+351666666666*+
351777777777*+351888888888*+351999999999
```

Fig. 3. Outgoing message example (in Portuguese, phone numbers anonymized)

The list of *text* recipients is never larger than 10, in order to allow the GSM modems to receive incoming messages as the FAQ available in the SMSLib webpage suggests that if the library is being used with GSM modems the rate at which it can send SMS is about 6 messages per minute (a message each 10 seconds). However a compromise was reached to send each message with a random interval of 10 to 15 seconds in order to respect the fair use policy that each MNO demands from its' users. By limiting the amount of messages the system can send at once, it is guaranteed that no high priority message has a delay of more than 150 seconds before being sent. This is particularly relevant as the study aimed to implement a responsive interactive system to the user's point of view, thus allowing that, in the worst case scenario if a user's response is inversely buffered and all users respond at the same time to the received message, no user is left without response for more than 40 seconds.

As each individual message is part of a predefined flow, and each user may interact with the system at different points of each flow, the different messages have to be identified by a flow identifier (*flow id*). The *flow id* identifies the message that is being sent, giving also information as to if this message is waiting for an answer and what is the auto-reply to be delivered if the received answer is valid. The degree of interactivity of the system is limited to one question, several possible answers, and several corresponding replies, i.e., the dialog between the user and the system is limited to the depth of question-response-acknowledgment messages (Fig. 4). Nevertheless, more complex flows can be devised and stored at the DB without any influence to the complexity of the other parts of the system itself.

Inside a message, the numbers in the list of recipients are separated by the same control character used to separate the other fields (* in this example). The real

control character is an extended ASCII character, chosen because it is highly improbable that it would be used in the text of a message, preventing a risk/abuse of the system. Message *text* is encoded in UCS2, a Unicode encoding that uses a 16-bit character format and allows accented characters along with other special ones (like c with cedilla 'ç'), in spite of losing the maximum length for each message (from 160 to 70 characters).

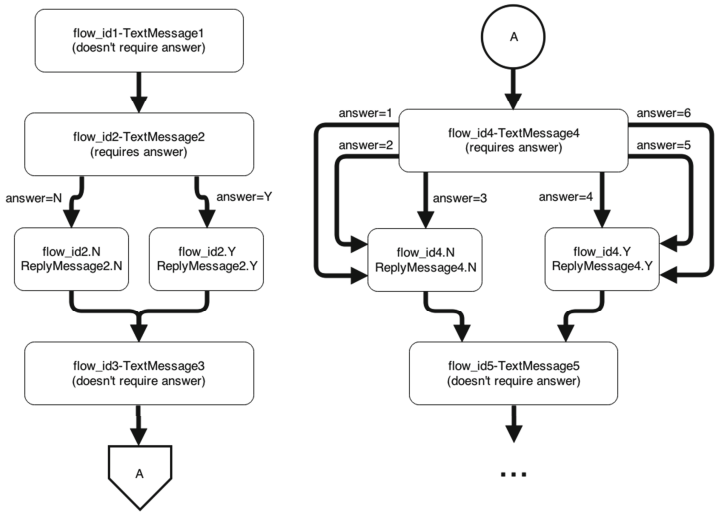

Fig. 4. Abstract example of message flow

A scheme for the processing of messages is presented in Fig.5 and consists of the system sending a message, leaving the system waiting for an answer. Assuming that the message is received by the recipient, two scenarios might occur: (1) the recipient sends one of the required response answers, this message is processed and a new message (the corresponding auto-response) is issued; (2) the recipient responds when no reply was expected: the response message is stored at the DB for further inspection and an alarm is raised in the control panel of the system, allowing the unexpected reply to be viewed by the system's administrator. If a response is expected but the user does not respond in a period of 1440 minutes (24 hours), the system administrator can decide what to do, for example, advance the flow of the user or send the message again (Fig.5).

4.2 Web Application

The application's main objective is to manage the scheduling of outgoing messages using a task scheduler, or preparing a message to be sent immediately, by creating files which contain the information needed to send a SMS. Since in this study the same message might be sent to several students at the same time, it was decided to

create batches of files and each file has at most ten recipients. This way the process processes a file with many recipients and does not consider an interruption to allow, for example, the dispatch of a message might have a higher priority. Yet, as there are several processes running in parallel, there may be the case where all three modems are sending messages at the same time.

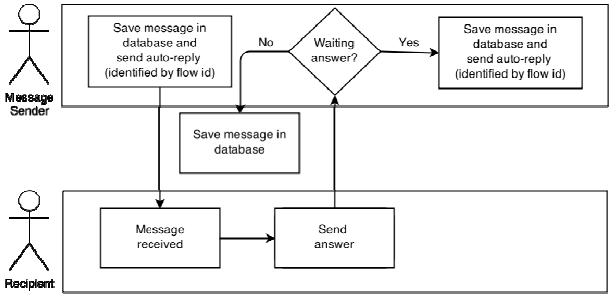

Fig. 5. Message flow scheme

The referred files are created in the respective MNO "Outbox" folder if it's a message to be sent immediately or in the "Scheduled" folder if it's a message destined to be sent later, usually, at a predefined time. When a scheduled message is created, the web application also creates the respective task in the Scheduler, including the details concerning the file's original location, when to move it, and to what directory it should be moved. In this study it was decided that the initial messages should always be sent between 18:30h and 20:30h, as not to disturb classes or sleep of the recipients.

4.3 Database

Microsoft SQL server was chosen since it has an easy integration with the web application (uses the same platform, the .NET framework), and it was used to save users information (message recipients), messages flow, log the messages exchanged with each user, courses' information, among other aspects, and its structure is shown in Fig. 6.

The following tables are responsible for the message flow control:

- Fluxo_EI – Has information about the flow identifier of each message, along with the respective message, response for a positive answer, for a negative answer and the type of message (if the message requires an answer or not);
- Fluxo_saida – Saves the sent message for each recipient, together with the respective timestamp, the flow at which corresponds and if the recipient has replied to the message;
- Fluxo_entrada – Used to store received messages for each recipient, along with the respective timestamp, the flow at which it corresponds and the text received.

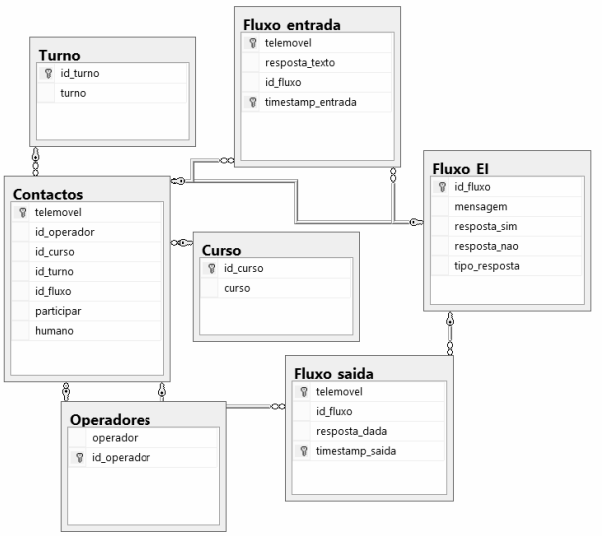

Fig. 6. Database table structure

4.4 Task Scheduler

This component creates tasks via the web application consisting of the following: for a given task, when the scheduled time arrives, the task scheduler will move the file defined in the task from the "Scheduled" directory to the respective "Outbox" directory, which will then be found by the process that handles the outgoing messages ("SMS Gateway"), sending them to the respective recipients.

It was decided to use the task scheduler available in the laptop operating system (Windows 7) on the grounds that this was more than adequate for the needed feature, therefore avoiding the creation of a proprietary task scheduler. This decision was also possible because the computer used for this task was dedicated to this study alone and no other scheduled tasks were added by other software components.

5 Conclusion and Future Work

Although the final results of the psychological study are neither the focus of this paper, nor available at this time, we may draw conclusions as to functionality of the support platform.

The auto-reply response time was generally perceived as very quick by the developers and the users, especially considering that it was an academic solution using low cost off-the-shelf hardware and simple software. Yet, one student complained that he couldn't read the *texts*. However when further questioned he told the researchers he was using a very old mobile phone that he no longer had with him, making it impossible to identify a possible solution to this problem. In future tests, the researchers will

devise a pre-test to confirm that every subject is able to receive messages in a readable format.

Taking in consideration that we have sent and received a considerable number of messages (almost 7000), we conclude that the system ran as expected, having an uptime of 100% and zero system crashes. All this was achieved using a low-end laptop (Intel Atom N450, 1.66GHz clock, 2GB of RAM and a 64-bit operating system), having a workload of almost 100%. Moreover, the design of the messages and the request for replies was praised by several test subjects for being simple, user-friendly and not being too time consuming. The developed software source code is available at our research laboratory's MediaWiki [16]. The fact that the system was built using old off-the-shelf parts and components, and even so allowed for a free communication between the system and the users, makes it clear that the system was the exact response the requirements set. The system aimed not to abuse the MNO network with massive SMS messages and the fair use principle that applies to each of the subscribed plans was not violated.

It should be pointed out that the simplicity of this system allows for it to be easily adapted to other studies, subjects or businesses, not being limited to students or even academic environments (with the respective login account creation and credentials).

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B.2 ICETC2014

A validated multidisciplinary study on the assessment of SMS messages as a mean to improve Self-Efficacy in university students

Diana Oliveira, Graça Esgalhado
Department of Psychology and Education
University of Beira Interior
Covilhã, Portugal
dianapsoliveira@gmail.com, mgpe@ubi.pt

Daniel Oliveira, Nuno M. Garcia
Instituto de Telecomunicações *and*
Department of Computer Science
University of Beira Interior
Covilhã, Portugal
danieloliveira@it.ubi.pt, ngarcia@di.ubi.pt

***Abstract* — This paper describes a multidisciplinary study that included teams from the Psychology and from the Computer Science departments on the use of interactive Short Message Service messages to assess psychological changes in self-efficacy of Engineering students exposed to motivational and persuasive texts. The paper presents the definition of the platform, the configuration and setting in place of the system that handled the exchange of automatic and interactive messages with the research subjects, as well as the implementation and results of the Psychology study. The assessment of the results of this experiment, also presented, were obtained by comparing scores of self-efficacy questionnaires given, pre and post study, to both an experimental and a control group.**

Keywords—Self-efficacy; SMS platform; texting; interactive messaging.

I. INTRODUCTION

During the last decades, self-efficacy, the capacity to organize and execute actions in order to reach set goals, or a measure certainty in being able to perform a given task [1], has become an effective predictor of students' motivations and significant learnings. In fact, self-efficacy believes are credited with influencing aspects of academic motivation such as activity choice, effort to undertake tasks, persistency and emotional reactions [2].

Various researchers have tried to analyze the relation between self-efficacy and academic achievement. Research implies that self-effective students are more willing to undertake learning tasks, even those with a higher degree of difficulty, to work harder, are more persistent [1,2,3,4], organized, self-reliant, self-motivated and these students evaluate their own performance in an attempt to maximize efficacy and productivity of the learning process itself [5] . The students which possess these traits are overall more likely to be more academically accomplished, so it is only natural that universities might try to find ways of improving students' self-efficacy.

Over the last decade mobile phone technology has become an important tool for most citizens' everyday life, which easily explains the interest in using these devices in the university campus [6]. It is acknowledged that smartphone and other mobile devices are widespread through the students' population, so the interest in bringing cell phones to the class room is meant to answer not only students demands as their own lack of motivation [7].

Short Message Service (SMS) is one of the most used mobile phone applications [6]. *Texting* is so popular today that it is used daily by people of all ages and technological knowledge. Because *texting* is usually free of charge, a lot of people prefer texting to phone calls [8]. Students use SMS all the time [9,10] because of its availability, convenience and low cost [11], and researchers such as [8] consider that SMS usage in the class room should even be encouraged as a means of communication, when justifiable.

Research on the introduction of texting in the class room as a learning tool is happening all over the world, predominantly but not limited to the field of language learning. It has been suggested that texting has the potential to enhance students learning by allowing students to learn at their own pace [12]. Students themselves have said that, by using texts as a learning tool, the learning process stops being limited by space and time [13], while storing study materials as a text allows them to read the contents again and again [9], and receiving small pieces of information is more practical [14].

Typically, freshman engineering degree students at the University of Beira Interior (UBI), have a high dropout and failure rate at maths class turning these students into the obvious choice for this study. By comparing students' scores on the General Academic Self-efficacy Scale [15] pre and post SMS program, the study aimed to learn whether the use of an off-the-shelf platform for automatic and interactive text messaging using Short Message Service, could improve the of the students.

The present study was developed by a multidisciplinary team from the Department of Psychology and Education (DPE) and the Assisted Living Computing and Telecommunications Laboratory (ALLab) of the Department of Computer Science (DCS) of UBI. The DPE members previously validated the scale applied pre and post program and applied said scale at the

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beginning and at the end of a 16 weeks period, more or less equivalent to a whole semester. The ALLab team was responsible for developing an off-the-shelf platform for automatic and interactive text messaging using Short Message Service, which had to take into consideration the requirements of the psychological study. The motivational and persuasive text messages sent to students through the program developed by DCS were devised by all the researchers according to data collected from selected literature. To the authors' best knowledge this is an innovative approach to the assessment of SMS messages as a mean to improve self-efficacy in university students.

The remainder of this paper is organized as follows: this paragraph concludes section I, the Introduction, where motivations, framework and research goals were outlined; section II follows, describing the research method used; section III presents the architecture of the implemented SMS platform; section IV presents the psychological tools used; section V describes and discusses the results obtained; and finally, section VI concludes the paper presenting conclusions and future work.

II. RESEARCH METHOD

A. Participants

Participants in this study had to meet the following inclusion criteria: being 18 years old or older and being enrolled in the classes targeted by this research. Because participation was voluntary, a total of 84 participants from all four degrees were used: this number includes students that participated in all stages of the program without dropping out.

Participants are characterized as follows: all students live in continental Portugal and 55 are males (65.5%), while the remaining 29 were females (34.5%). The age mean score for the participants was 20.35 years with a standard deviation of ±2.90.

All the participants were enrolled in an undergraduate degree, and the distribution by degree was as follows: 48.8% from Computer Science Engineering (CSE), 32.1% from Optometry (OPT), 15.5% from Electromechanic Engineering (EE) and 3,6% Electrotechnic and Computer Engineering (ECE).

UBI follows the Bologna Process which means that these undergraduate studies regular scope consists of 3 years. From the total of participants, 46 (54.8%) are freshman, having enrolled at UBI in 2013. The remaining students 38 (45.2%) are repeating the maths disciplines targeted in this research; 21 (63.6%) are enrolled in the 2nd year and 12 (36.4%) are enrolled in the 3rd and last year of their respective courses.

After the participants filled the pre-intervention scale they were divided into the experimental and the control group. Participants were randomly rafted by degree and class for representation purposes. Because the maths classes had a history of high student dropout when rafting students the experimental group ended up with 50 students (59.5%) and the control group 34 (40.5%).

B. Measures

1. Socio-demographic questionnaire

The DPE researchers built a socio-demographic questionnaire for this research, which intended to gather information concerning age, gender, degree, class, student status (first time in the course or repeating student), work status (full time student or half time student), and data concerning his grade history in secondary school both in maths and in the classes used to apply to university. Additionally participants were required to inform the researchers on their preferred cell phone operator and voluntarily give their personal cell phone number, only for the purpose of exchanging the program texts with the students rafted to the experimental group.

2. General Academic Self-efficacy Scale [15]

Self-efficacy was measured using the Portuguese version of the Self-efficacy general academic questionnaire [16]. This scale contains 9 items on a 5-point Likert scale (1=in total disagreement to 5=in total agreement). A sum of all s cores yield a total score that ranges from 9 to 45; higher scores indicate higher self-efficacy. The Cronbach consistency coefficients of the adapted Portuguese form was 0.890, and a principal components factor analysis with varimax orthogonal rotation revealed only one factor structure, as found in the original study.

C. Procedure

The research resulted from a proposition by students aiming to develop their dissertations about the impacts of new technologies in the educational environment.

After defining the aim and framework of this 3 stages research (pre-intervention, intervention, and post-intervention), the researchers contacted the Department of Mathematics to schedule the data collection, with students from the courses of CSE, EE, ECE and OPT, where their mathematics class had poor school performance and high dropout rate.

The research was devised as an experimental research with an experimental and a control group set. A set of two variables was used. An independent variable: whether students received or not the SMS in the program's scope, and a dependent variable: university students' self-efficacy.

Permission for participation was obtained by contacting the professors that taught those classes, asking to have the questionnaires filled during the class. Finally these students themselves were invited to participate in the research, and in case of acceptance fill the pre-program questionnaire. Completion of the questionnaires was anonymous and there was a guarantee of confidentiality. The instrument was administered to the students while in the math classes.

The research's chronogram was as follows:

- October 2013 to January 2014: platform development by the ALLab researchers;

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- January 2014: validation for the Portuguese students of the original scale [16] by the DPE researchers;

- February 2014: application of the pre-intervention scale on the first week of the semester by the DPE researchers;

- February to June 2014: SMS program deployment, over the course of 16 weeks, by the ALLab researchers;

- June 2014: application of the post-intervention scale on the last week of the semester by the DPE researchers.

III. Architecture of the Implemented SMS Platform

The system built for this research had to respond to certain specifications as follows: (1) students will be able to communicate with their preferred Mobile Network Operator (MNO); (2) the system will respond in a short time and dispatch messages quickly; (3) the system will oblige with MNO fair use rules; (4) the system will maintain a database (DB) to register all exchanged SMS; (5) the system will give interactive responses when adequate; (6) the system will validate or invalidate students responses according to message content; (7) the system will send messages at predefined days and times. The system never used its full capacity to send messages as this could be a violation of the MNO's fair use policy, therefore requisites (2) and (3) are antagonic, i.e., the system sends messages as fast as possible without resembling that it is a machine that is sending the messages.

Complying with this set of rules it was decided that the stream of SMS messages as well as the list of destinations for those messages would be uploaded to a database.

To manage the stream of messages it was necessary to create a script, which stated that specific types of system's questions would require the student to give a valid specific type of answer (Yes/No, or in a Likert scale of 1-6), and according with this answer the system would give a specific reply (X, if student answered N (no) or 1-3; Z, if student answered Y (yes) or 4-6), as shown in Fig. 1:

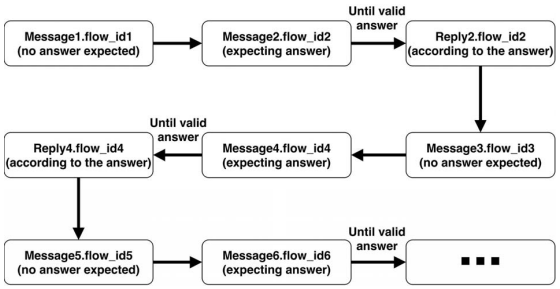

Fig. 1: Stream of interactive messages.

The implemented system architecture required not only the use of specific software but also the combination of hardware (Fig.2):

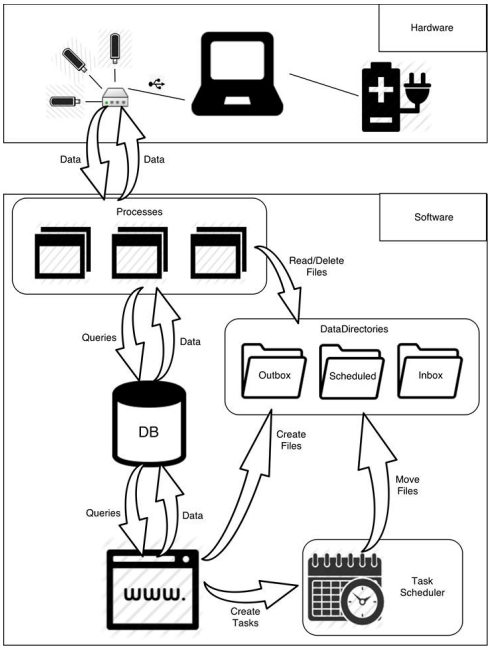

Fig. 2: System architecture diagram.

In what concerns the hardware, a decision was made to use three Global System for Mobile Communications (GSM) modems, one for each major Portuguese MNO: MEO, Vodafone and NOS (former Optimus)*, according to the expected choice of operator made by the participants. Choosing to have these 3 MNO allowed for students not to be charged their replies, no matter what operator they had subscribed for.

Because the modems were too large to connect directly to a laptop, a universal serial bus (USB) hub was used. These allowed the modems to receive extra power needed to support them, since the hub has an external power supply.

To make sure that the laptop was always ready to exchange SMS texts, a Uninterruptible Power Supply (UPS) was connected to it. The overall solution cost was as follows: Capital Expenditure (CAPEX) 505€ - small laptop 300€, UPS 100€, USB hub 5€ and three GSM modems 75€ (averaging 25€ each); Operational Expenditure (OPEX) 30€ per month (10€ payment per MNO subscription. It should be added that in the MNO subscription costs early 2014 values are indicated, including legal fees but not electricity. System's hardware is shown in Fig.3:

Fig.3: System's hardware.

* all trademarks and brands are property of their respective owners

Concerning software, a choice was made to have one process assigned to exchange functionalities of SMS messages, processing the received messages and the required answers and implementing the interactive feature of the system, and another process handling the received SMS messages, sweeping its associated GSM modem, looking for incoming messages and retrieving and storing these messages in the Inbox folder. This group of processes is also in charge of sweeping the Outbox folder and sending the found outgoing messages to its associated GSM modem. Both processes access three directories created for each of the three MNO (Fig.4).

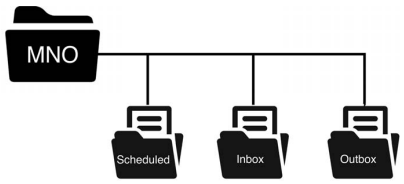

Fig. 4: Directories tree for each Mobile Network Operator.

The compartmentalization in directories for each MNO guarantees that each user only exchanges SMS with the chosen operator. This way the laptop runs six instances, each interacting with the database, the computer's file system and one of the MNO GSM modems.

The system has other components such as: (1) a web application to schedule the SMS's, add/remove users and disable the dispatching of messages to a given user, among others functionalities; (2) a DB to store *texts*, the auto-reply messages, the users' information, the replies received from the users and all additional support tables; and (3) a task scheduler that creates the tasks requested from the web application.

All the software was developed using C# because there was a previous experience with this language and framework. The operating system used was Windows 7, Version 6.1 (Build 7601: Service Pack 1). The architecture of the system is better explained in [20].

IV. Results and Discussion

Researchers such as [15,16, 17, 18, 19] have used self-efficacy scales to assert university students self-efficacy, aiming to establish relationships between this construct and others such as self-concept, academic locus of control, internet addiction, stress or academic success. Most studies on this subject rely on a pre and post-intervention score comparison, and in this matter this study follows the same frame. Furthermore, [6,7,8,9,10,11,12,13,14] developed research concerning the use of mobile phones and SMS in an academic setting, however they wanted to measure knowledge retention and used SMS text messages to send class content, which wasn't what this study aimed to do.

The measure used to compare self-efficacy scores was validated to the Portuguese university students. The original author tested the instrument with a sample of 1179 university students, and obtained an excellent Cronbach alpha (α =0.903). When validating this instrument for Portuguese university students a 0.890 Cronbach alpha was obtained for a sample of 707 university students, making this instrument adequate for future use in studies involving Portuguese university students.

Because of a non-normal distribution of the sample of 84 university students from UBI, non-parametric tests were used. The size of the sample might have influenced the need to use the non-parametric tests.

Between the pre and post scales the mean score increased. However no statistical relevant difference was found between the control group and the experimental group for the pre-intervention stage (U=755.500; p=.479) and post-intervention stage (U=728.500; p=.338), which is clearly expressed i n Table1:

Table 1: Mean scores comparison by group and pre and post intervention.

	Group	Mean
Total Self-efficacy pre-intervention	Experimental	43.97
	Control	40.11
Total Self-efficacy post-intervention	Experimental	44.49
	Control	39.27

The SMS intervention used different types of *texts*, varying between informative, motivational or persuasive, to promote an improvement in experimental group participants' self-efficacy. Some messages didn't require an answer from the participants while others either required a Yes/No answer or a choice of number from a 1-6 Likert scale. When using the Likert scale the options are presented specifically for the question they refer to: e.g. 1 (totally false) to 6 (totally true)/ 1 (I totally disagree) to 6 (I totally agree), to name some examples.

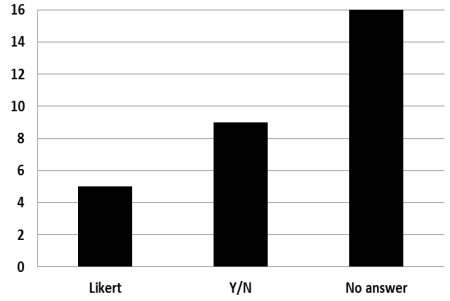

Fig.5a: Questions sent to EE and ECE students.

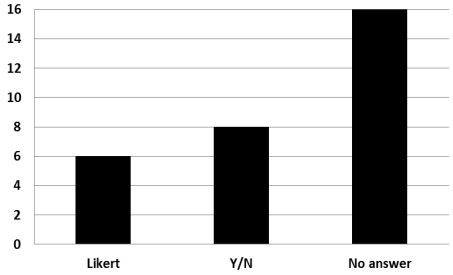

Fig.5b: Questions sent to CSE and OPT students.

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The number of each type of message was different according to the degree the participant was enrolled in. When building the script of the messages exchange we considered: (1) EE and ECE students had the maths class simultaneously, so participants from the two degrees received the exact same texts; (2) Messages should be personalized by course taking into account evaluation dates for each course. Of the total of 30 messages sent to the participants, in what concerns the types of messages, all courses received 16 non-response messages, but while EE and ECE received 9 Yes/No questions and 5 Likert scale questions, CSE and OPT received 8 Yes/No questions and 6 Likert scale questions (Fig. 5a and Fig.5b).

The differences in number of message by type derives from the necessity of adapting the messages to the number of weeks of the intervention while taking into account how messages related to evaluation moments had to be sent before and after those dates. All experimental group participants received two messages per week at specific days and time.

An example of each type of interactive message is shown (in Portuguese) in Fig.6:

```
SMS2UBI: És capaz de obter sucesso nesta disciplina. O teu rendimento
depende sobretudo do teu esforço. Consideras esta afirmação verdadeira?
Responde numa escolha de 1 (nada verdadeiro) a 6 (totalmente
verdadeiro).

SMS22UBI: Para te lembrares do que estudaste usas resumos com palavras
tuas sobre os procedimentos que te ajudam a recordar o que aprendeste?
Responde S (sim) ou N (não), de acordo com a opção que melhor se adequa
à tua situação.
```

Fig.6: Interactive messages formulated in a Likert scale (1-6) and in Yes/No form, respectively.

The validity of the responses given to the interactive questions was one of the tasks of this research. Firstly validity was analyzed by the total of questions posed. Only 2.83% of answers given weren't valid against 97.2% of valid answers (Fig.7). This seems to indicate questions and answer options were understood by the participants.

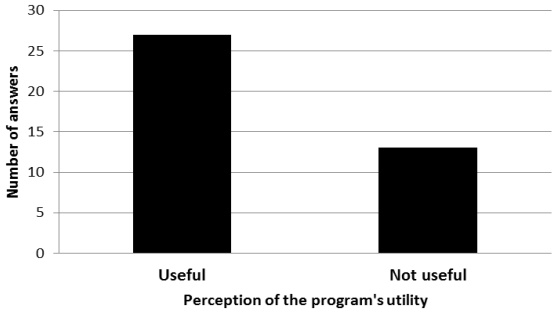

Fig.7: Validity of students' answers to all interactive questions.

When analyzing validity of answers by question, it is observable that invalid answers are limited to certain questions. Also invalid answers aren't limited to the type of questions because they appear independently of the option being Yes/No or a Likert scale, which makes it impossible to say participants shown a particular liking for one type of option (Fig.8):

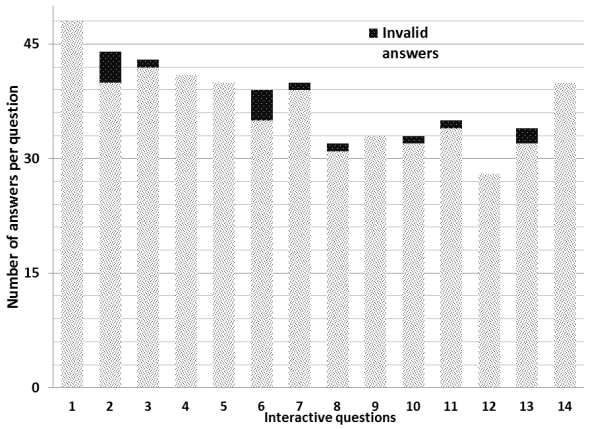

Fig.8: Validity of students' answers by question.

Finally it should be referred that even though no statistical significant difference in self-efficacy scores was observed between the pre-intervention and post-intervention stages, the experimental group students perceived for the most part the SMS program as useful as shown in Fig. 9 (10 students didn't answer this question):

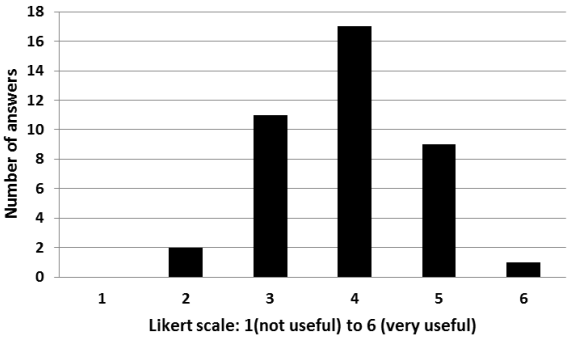

Fig.9: Experimental group participants' perception of program's utility.

The platform designed for this study performed as expected, suffering no crashes. The messages were prepared to be received and readable by all types and models of cell phones, and an informal user sample survey allows the conclusion that all messages were delivered both to and from the experimental group.

V. Conclusions and Future Work

There is extensive research on the two separate components of the conducted study (evaluating academic self-efficacy and SMS academic applications), however, the authors know no other research aimed to analyze self-efficacy improvement through the use of an SMS program as in the present study.

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Therefore, this research is innovative in the sense that integrates a self-efficacy assessment and a SMS motivational mechanism. Yet, this means that the authors were unable to compare the study's results with previous research. Even so, it is felt that there is much space to improvement and that further studies should try to evaluate whether changes should be made in aspects such as: (1) sample's size; (2) number of SMS messages; (3) Control over the reception and reading of messages; (4) program duration. Lastly it should be mentioned that this study was part of a bigger assessment that also included a learning strategy scale and a study processes scales. The three scales together formed a 117 questions questionnaire, which might have been too big to maintain students' attention and motivation during the filling process.

In what refers to the psychological study it was concluded that even though students' self-efficacy doesn't appear to be affected by the application of a motivational SMS program, the majority of the students receiving the *texts* considered the program useful.

Taking into consideration that the built platform exchanged a considerable number of messages and had an uptime of 100% and zero system crashes, it is considered it performed well. It should be repeated that the computer system used was built using old off-the-shelf parts and components, allowed a free communication between the system and the users, and overall gave the necessary responses to the study's needs. The design of the messages and the replies request was praised by several test subjects for being simple, user-friendly and not being too time consuming. When using the platform in the future, at least one of the changes considered necessary is to perform a pre-test to confirm that every subject is able to receive messages in a readable format.

ACKNOWLEDGMENT

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B.3 ICERI2014

Title

Psychometric study of a scale for academic self-efficacy assessment among Portuguese college students

Authors

Diana Oliveira *

Graça Esgalhado *

Daniel Oliveira **

Nuno Garcia **

Abstract

Background: Self-efficacy is considered a core aspect of Bandura's Social Cognitive Theory, in which the human being is seen as a self-regulated individual committed to its own development. Academic Self-efficacy increases the commitment to the educational process, so it is important to academic success as a source of increased motivation which positively influences the student's thoughts, feelings and actions**. Aim:** This research aimed at adapting and validating a scale of academic self-efficacy for the Portuguese college student population. **Method:** A total of 707 students who were also internet users participated in this study, 241 male and 466 female, aged between 18 and 40 years old (mean = 22,96, DS = 4,41). The inclusion criteria for participation in the study were: (1) being Portuguese and studying in a Portuguese university, and (2) willingness to participate in the study after knowing its objectives. Participants were recruited through two sampling methods: (1) Informal social networks. The eligible internet users who agreed to participate were asked to refer their friends to participate in the study; and (2) The Internet. **Material:** Together with the Academic General Self-efficacy Scale (ASES) (Torre-Puente, 2006), a socio-demographic questionnaire was applied, in order to characterize the study's participants and collected data on participant´s age, gender, grade/post-grade and University/college attendance. **Results:** The Cronbach's alpha for the total scale (Portuguese version) was 0.81, and a principal components factor analysis with varimax orthogonal rotation revealed only one factor structure, as found in the original study. With regard to sex, male and female has similar academic self-efficacy. Students with higher academic level showed better results (M=29; SD=9,98) than students with less academic level (M=26,09; SD=10,67). The average scores for academic sell-efficacy for the group of older students (22 to 40 years old) was 28,67 (SD=10,55), and 26,59 (SD=10,29) for the group of younger students (18 to 22 years old). **Conclusion**: This study provided evidence toward the reliability and validity of the instrument. The scale showed good psychometric characteristics. The reliability analysis demonstrated very good internal consistency and results indicate the ASES is an acceptable

measure of academic self-efficacy. As academic self-efficacy has been shown to be the strongest single predictor of college students' academic achievement and performance (Robbins et al, 2004), it is important to evaluate students' academic self-efficacy, to make possible an appropriated development and implementation of instructional strategies.

Keywords: Self-efficacy, Academic self-efficacy, Academic self-efficacy Scale

* University of Beira Interior, Department of Psychology and Education (Portugal)

** University of Beira Interior, Department of Computer Science Department (Portugal)

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