

**THE REPUBLIC OF TURKEY  
BAHÇEŞEHİR UNIVERSITY**

**THE ROLE OF IPAD IN DENTISTRY PATIENT  
EDUCATION AND CONSULTATIONS**

**M.S. Thesis**

**EROKAN CANBAZOĞLU**

**İSTANBUL, 2013**

**THE REPUBLIC OF TURKEY  
BAHÇEŞEHİR UNIVERSITY**

**THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES  
COMPUTER ENGINEERING**

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**Supervisor: Asst. Prof. Dr. Yücel Batu SALMAN**

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Name/Last Name of the Student: Erokan CANBAZOĞLU

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The thesis has been approved by the Graduate School of Natural and Applied Sciences.

Assoc. Prof. Dr., Tunç BOZBURA  
Graduate School Director  
Signature

I certify that this thesis meets all the requirements as a thesis for the degree of Master of Science.

Asst. Prof. Dr., Tarkan AYDIN  
Program Coordinator  
Signature

This is to certify that we have read this thesis and we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Arts.

Examining Comittee Members

Signature

Thesis Supervisor

Asst. Prof. Dr., Yücel Batu SALMAN

Member

Asst. Prof. Dr., M. Alper TUNGA

Member

Asst. Prof. Dr., Yalçın ÇEKİÇ

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May 2, 2013

Erokan CANBAZOĞLU

# ABSTRACT

## THE ROLE OF IPAD IN DENTISTRY PATIENT EDUCATION AND CONSULTATIONS

Canbazođlu, Erokan

Computer Engineering Master Program

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Smartphones and tablet devices are becoming increasingly popular day by day. With the world changing and technology evolving year by year, business world is constantly growing more dependent on technology at an ever-expanding rate. With iPad, the clear-cut winner in the tablet market, almost all the business fields are making use of the new devices from Apple in their own workflows. iPad is transforming the way businesses works with the power of mobile solutions.

In spite of advanced technology, there is not sufficient rich illustrative content for dentist in dental sector especially in implantology. According to user research results, most of the dentists struggle to build an image in their patients' minds just by the help of words. Therefore words are so inadequate. In addition to this, dentists desperately attempt to draw some sketching in an effort to explain the treatment plan to their patients but generally speaking, most of them are not good at pen and sketching. Real case photographs are sometimes of help in explaining cases. However, it has been witnessed that considerable numbers of patients get annoyed by "bloody" pictures, particularly in implant cases. To eliminate these drawbacks dental hard and soft tissues were modeled in 3D programs and most frequent implant cases on educative basis were prepared for both dentists and their patients.

The goal of this master thesis is to develop an application called "Implant Treatment Guide (ITG)" with an emphasis on user interface and usability of the ITG. The ITG application enhances the presentation of implants and implant-supported prosthetic treatments to the patients with rich 3D illustrative content. It makes expressing treatment plans easier for dentists needing to convey surgical operations to their patients. Finally, usability (ease of use and usefulness) of the ITG app will be determined by using the Technology Acceptance Model (TAM).

**Key Words:** dental apps, iPad implantology application, 3d dental illustration, implant procedures, patient education

# ÖZET

## DİŞ HEKİMLİĞİ HASTA EĞİTİMİ VE KONSÜLTASYONUNDA IPAD'İN ROLÜ

Canbazoğlu, Erokan

Bilgisayar Mühendisliği Yüksek Lisans Programı  
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Akıllı telefonlar ve tablet cihazlar günden güne daha popüler hale gelmektedir. Teknolojinin yıldan yıla gelişmesi ve dünyanın da değişmesi ile beraber iş dünyası daha önce hiç olmadığı kadar artan bir oranda teknolojiye bağımlı hale gelmeye başlamıştır. Tablet piyasasının lideri iPad ile beraber neredeyse tüm iş sahaları, kendi iş süreçlerinde Apple firmasının cihazlarını kullanır hale gelmektedir. iPad sunduğu mobil çözümler ile işlerin yapılış şekillerini dönüştürmeye başlamıştır.

İleri teknolojiye rağmen, dişçilik sektöründe ve bilhassa implantolojide diş hekimleri için yeterli düzeyde görsel içerik bulunmamaktadır. Araştırma sonuçlarına göre pek çok diş hekimi hastalarının zihinlerinde sadece sözcükleri kullanmak suretiyle bir algı oluşturmaktadırlar. Dolayısı ile sözcükler bazen çok yetersiz kalmaktadır. Ayrıca diş hekimleri, hastalarına tedavi planını açıklamaya çalışırken çaresiz bir şekilde taslak oluşturmaya çalışmaktadır. Fakat en genel tabiri ile ifade etmek gerekirse diş hekimlerin büyük bir kısmı kağıt ve çizim işlerinde iyi değillerdir. Gerçek vakalara dayalı fotoğraflar bazen durumu açıklamada faydalı olmaktadır. Bununla beraber çok sayıdaki hastanın, özellikle implant ile ilgili durumlarda “kanlı” fotoğrafları görmekten rahatsız olduğu gözlemlenmiştir. Bu olumsuzlukları ortadan kaldırmak için, diş ile ilgili bazı sert ve yumuşak dokular üç boyutlu programlarda modellenmekte ve hem diş hekimleri hem de hastaları için en sık implant vakaları eğitim için hazırlanmaktadır.

Bu yüksek lisans tezinin amacı Implant Tedavi Rehberi (ITR) olarak adlandırılan ve ITR'nin kullanılabilirliği ve kullanıcı arayüzüne vurguda bulunan bir uygulama geliştirmektir. ITR uygulaması, implantların ve implant destekli protezlerin hastalara sunum başarısını üç boyutlu görsel içeriklerle artırmaktadır. Bu uygulama, cerrahi operasyonları hastalarına açıklama ihtiyacı hisseden diş hekimlerinin, tedavi planlarını anlatmasını kolaylaştırmaktadır. Nihai olarak ITR uygulamasının diş hekimleri tarafından kullanılabilirliği (kolay kullanımı ve yararlılığı), Teknoloji Tasdik Modeli (TTM)'ne göre belirlenecektir.

**Anahtar Kelimeler:** diş hekimliği uygulamaları, ipad implantoloji uygulaması, üç boyutlu diş hekimliği illüstrasyonu, hasta eğitimi

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## LIST OF ABBREVIATIONS

3D	:	Three Dimensional
API	:	Application Programming Interface
App	:	Application
HE	:	Heuristic Evaluation
HIG	:	Human Interface Guideliness
IA	:	Information Architecture
IDE	:	Integrated Development Environment
IOS	:	IPad / iPhone Operating System
ITG	:	Implant Treatment Guide
MVC	:	Model View Controller
NUI	:	Natural User Interface
TAM	:	Technology Acceptance Model
UI	:	User Interface
UX	:	User Experience
XML	:	Extensible Markup Language

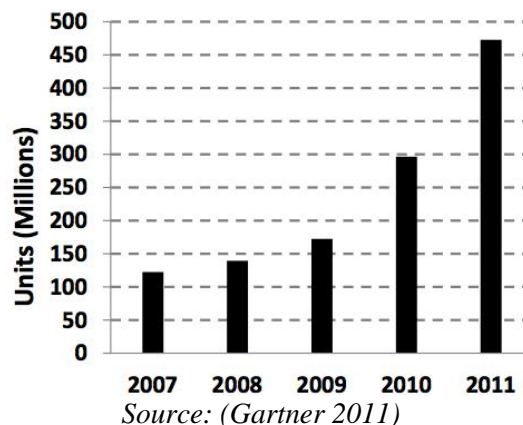
# 1. INTRODUCTION

## 1.1 THE RISE OF TABLET DEVICES

Each generation in the past century faced new challenges and frontiers. This generation will surely be defined by the constant and fast rise of the tablet computer and smart devices, the most popular of which are the iPhone and iPad. The reason why Keegan (2004) called “Smart devices” or Antewell (2005) called mobile multimedia machines is that they are able to do sophisticated computing processes and have a better connectivity to the information resources without time and location restrictions (Chen et al. 2006). In real world terms, a single iPad could serve the computer processing needs of almost 2,000 personal computer needs in 1980. The new iPad has 1.7 GHz A6X processor, 2048×1536 9.7" (264 ppi) retina touchscreen, light sensor, accelerometer, gyroscope, magnetometer, ten hours of power to run an application (app) and only 652g weight (Apple 2013).

Tablet devices are getting increasingly popular day by day. The past five years have seen the tremendous growth of smartphones and tablets. In 2007, the iPhone was introduced to the market as the first touchscreen smartphone. That year Gartner (2011) recorded smartphone sales of 122 million units. In 2011, worldwide smartphone sales reached 473 million units, and since iPad’s launch in 2010, it has sold 84.1 million units.

**Figure 1.1: Smartphone annual unit sales**





Meanwhile, the last three years have been marked by the rapid adoption of the tablet computer. In 2010, iPad was introduced, as seen in Figure 1.2. Apple was able to sell more iPads than any other individual PC maker did in the last quarter of 2011 (iCrossing 2012). In its debut quarter, iPad sold 3.27 million units, and by the first quarter of 2013, sales had reached 22.86 million units (Bare Figures 2013). In the U.S alone, researchers have expected that by 2014, twenty percent of the U.S. population will use touchscreens with natural user interfaces (NUI) as their primary computing device (Hinman 2012, p.24). Thirty seven percent of them will own them for business use, according to the survey (VentureBeat 2010).

**Figure 1.2: iPad quarterly unit sales**



*Source: (Bare Figures 2013)*

With the world changing and technology evolving year by year, business world is continually growing more dependent on technology at an ever-expanding rate. With iPad, the clear cut winner in the tablet market, almost all the business fields are making use of new devices from Apple in their own workflow. iPad is transforming the way business works with the power of mobile solutions, which include the manufacturing, retail services, medical and dental industries and so on. Using iPad makes it easy to deliver stunning presentations, collaborate with colleagues, and access important business information from anywhere required (Daniel 2012 p.Foreword).

## **1.2 NEED FOR THE ITG APPLICATION IN IMPLANTOLOGY**

According to user research results, most of the dentists struggle to build an image in their patients' minds just by the help of words. Therefore words are so inadequate. Moreover, dentists desperately attempt to draw some sketching in an effort to explain the treatment plan to their patients but generally speaking, they are not good at pen and paper work. Real case photographs are sometimes of help in explaining cases. However, it has been witnessed that "bloody" pictures, particularly in implant cases, annoy a great number of patients. In order to eliminate these drawbacks dental hard and soft tissues were modeled in 3D (three dimensional) computer aided design programs (3Ds Max, Modo and Zbrush) and most frequent implant cases on educative basis were prepared for both dentists and their patients.

The goal of this project is to develop an app called 'Implant Treatment Guide (ITG)' with an emphasis on user interface and usability. The ITG app makes it possible the presentation of implants and implant-supported prosthetic treatments to the patients with 3D rich illustrative content. It makes expressing treatment plans easier for dentists needing to convey surgical operations to their patients.

The user interface (UI) of the ITG has been carefully designed so that dentists can get familiar with the app easily and also feel comfortable with it. Throughout the process of the ITG, iterative designs and agile development methodology were used. Testing was done at regular intervals both on device and in simulator and finally the ITG app was submitted to Apple App Store. After inspection by Apple, the ITG app was published and available for download.

## **1.3 THESIS OVERVIEW**

In this thesis, first of all, different kinds of research techniques such as surveys, contextual inquiry, user interview, focus groups, card sorting and personas were conducted to identify mobile strategy, requirement specification, information architecture (IA) and feasibility of the ITG app. Following this, sketching, wireframing,

mock-up and prototyping stages of the ITG were completed. Once the initial sketches, wireframes and prototypes were created, presentation and critique were made at each stage and iteration of the project. The designs of the ITG concept were presented, discussed and evaluated for further improvements. Apple Human Interface Guidelines (HIG) was analyzed and implemented to the app for better interaction experience and universal acceptance. The way of displaying relatively huge content on a tablet device was the primary challenge in this project. The solutions were generated to organize the user interface elements and 3D illustrations for the benefits of dentists. Finally, paper, in-screen and platform-specific prototypes for the ITG app were developed and opened to discussion.

After the design stage of the ITG, the implementation stage started. Use cases, class and E-R diagrams were prepared for clearer structure before code implementation. Model View Controller (MVC) design pattern and agile development methodology were used throughout the project. Ease of use and usefulness of the ITG were inspected in usability evaluation stage. Early testing procedure was a useful way to see the interaction problems. Also, heuristic evaluation (HE) technique was used to improve the usability of the ITG app.

## 2. PREVIOUS STUDIES

The purpose of this section is discussing the current state of patient education and iPad healthcare app by introducing the previous conducted. Wingard (2005) described patient education as the process of informing the patients and their families about the disease, to improve some needed skills with treatment related tasks, and to aid in the development of remedying treatment. The general aim of patient education is to make sure that the patients are informed with their options of treatment, efficient use of medication, and the management of their needs of healthcare (Behar-Horenstein et al. 2005).

In addition to the complexities involved with developing education programs that meet the needs of a highly diverse population, healthcare provider resources have come under significant financial pressures. This difficult environment has made it essential that healthcare providers take a more systematic, coordinated, and strategically planned approach that will facilitate the effective deployment of the resources allocated to patient education (Green 1990). The use of tablet based education apps has appeared as an educational method that may assistance dentists in meeting these challenges. These apps may provide a highly cost effective modality for delivering patient education.

In order to gain a better understanding of the capabilities of interactive education apps, a systematic search of the literature was carried out by Fox (2009) to review empirical studies and knowledge gains, clinical, and economic results. The majority of the studies were noted as positive. Three of the studies measured the effect of interactive education app use on patients' perceptions of satisfaction with their healthcare encounter (Martin et al. 2005, Shaw et al 2001, Homer et al. 2000). The quality of patient education may also affect patients' health condition. Fox's (2009) study tried to determine the impact of interactive education apps on a number of clinical results and patient attitudes. There was no consistency in the reported outcomes for these evaluations. While five of the studies reported no benefits from using the application (Linne & Liedholm 2006, Stromberg et al. 2006, Gerber et al. 2005, Huss et al. 2003, Green et al. 1990), nine of

them reported a positive impact based on interactive education application use (Davis et al. 2006, Miller et al. 2005, Marsch & Bicket 2004, Reis et al. 2004, Krishna et al. 2003, Neafsey et al. 2002, Bartholomew et al. 2000, Evans et al. 2000, Homer et al. 2000).

Three studies reviewed supported the relationship between patient satisfaction and doctors' job satisfaction (Atkins et al. 1996, Garman and Corrigan 2002, Haas et al. 2000). The studies suggested that doctor's job satisfaction was a perception based reaction that resulted from a number of variables including the nature of relationships with patients.

The quality of doctor - patient interactions were consistently noted as important drivers of patient satisfaction and employee satisfaction. Garman & Corrigan (2002) noted that healthcare staff were motivated by their ability to effect improvements in their patients' lives and this same ability was the main reason many healthcare staff entered their professions. Haas et al. (2000) in explaining the relationship he found between physician job and patient satisfaction suggested a circular relationship where more satisfied physicians were better communicators and more empathetic. In turn, more satisfied patients prompted physicians to feel better about the care they provided which motivated physicians to spend more time meeting patient needs.

Although most of the studies founded as positive results in connection with the use of interactive programs, seven studies noted a negative or no impact concerning with app use (Linne & Liedholm 2006, Stromberg et al. 2006, Gerber et al. 2005, Campbell et al. 2004, Green et al. 2004, Huss et al. 2003, Jenny & Fai 2001). These inconsistent results continue to be a source of concern.

However, research results have been inconsistent and a number of questions remain unanswered regarding which forms of education or instructional techniques provide real value to patients and healthcare providers. Cooper et al. (2001) conducted a meta-analysis and the results of this analysis suggested that patients benefit from education interventions, but results varied significantly across studies. One of the conclusions drawn from this analysis was that there was a need for additional research that would

explore the specific educational processes that facilitate the transfer of required knowledge. More recent studies may have involved interactive education apps that have taken advantage of improved technology and access to programs. Rapidly advancing technological improvements have allowed for more powerful, graphically oriented apps to be created and utilized for patient education.

Although technological improvements and well-designed medical apps, there is still doubtful and negative thoughts about the use of tablet devices in medical operations and patient education. For instance, “ The cardiovascular apps are nice and fun to play with, but are mostly fairly basic and too simple to be of great use to the practicing cardiologist. As of now the iPad is still a toy.” (Mashman 2011). According to Edirisinghe & Crossette (2012):

*At the moment processing and software capabilities appear to be the limiting factor for advocating wide spread use of tablets for digital radiology. Even with current software its potential as an excellent radiology reference device is evident. With the natural assimilation of tablet technology to the practice of doctors further rapid enhancement of radiology software and processing capability is needed.*

Blanchet (2012) research paper has shown that it is believed by the doctors that there is a brilliant future where all of the clinical practices will be done on an iPad, even labs, CT images and labs. No longer will urologists be bound to their computers. Result of his study shown that doctors have a positive outcomes based on the use of iPad apps. For instance, according to Todd M. Morgan: “The iPad is no different. People are really embracing it. There are institutions where all of the residents are being supplied with iPads and tablets. It’s spreading like wildfire!”. Alexander Kutikov is also a strict believer of the usage of apps in medical area. He even sees older urologists who use apps as much as they can “I have a partner in his 60s and he uses his iPad every day.”

Blanchet (2012, pp 725-732):

*For Dr Morgan, the iPad makes the whole patient encounter so much more intimate compared with the use of a computer. “If you’ve ever been to a doctor who’s typing away on the computer in front of the patient, you know how it really interferes with the doctor–patient relationship. Being able to use professional images, manipulate and write on them, move them around, and do it all while you are sitting next to a patient is incredible. The iPad facilitates the relationship with the patient and helps them understand better.”*

*Using urology apps in his practice has been a huge benefit for Dr Kutikov, who is frequently called in to offer patients a third opinion. "A lot of these patients stay with me for their surgery, explaining how much better I was able to communicate with them and how they understand now what the risks and benefits are." For him, using the iPad over a computer means he doesn't lose the intimacy with the patient. "When you sit shoulder to shoulder with the patient with the iPad in front of you, it is really a conversation."*

*According to Drs Morgan and Kutikov, and Matthew Sterling, a number of trends are already emerging that will dictate how the future will shape up for medical apps and specifically for urology apps. For one thing, the Android platform will remain far behind Apple. "The iPad is unbelievably dominant in healthcare," says Dr Morgan. "Some say the iPad apps are friendlier to healthcare providers. Physicians are simply not using the Android platform." Dr Kutikov also sees another dimension to the problem. "Android controls only about 5% of the tablet market. It doesn't make any sense to build apps for a market so small."*

The expanding uses of portable tablet devices in the education of doctors and students is a well documented phenomenon (Kiser 2011, Kubben 2010). iPad is a useful tablet device for patient and dentist education that is increasingly seen in the clinical setting as a reference tool (Lacquiere & Courtman 2011, Savel & Munro 2011). There has been positive feedback from both patients and doctors regarding the addition of the tablet computer during treatments. In addition to showing patients pictures of operational procedures, iPad also has various multimedia capabilities such as CT images and drawing tools that are useful in increasing clinical efficacy, improving the patient experience, and optimizing patient satisfaction (Wang et al. 2012, Berger 2012).

### **3. APPLICATION DEVELOPMENT METHODOLOGY**

In this thesis, an application called “Implant Treatment Guide (ITG)”, compatible with iPad, was designed and developed to publish in Apple App Store. The first step in the project flow was the analysis phase. In the early stage of analysis, research techniques were used for determining the mobile strategy and the IA. Also requirement specification and feasibility study were completed. These processes mitigated the project’s major risks. Among the major challenges of such project were the mobile strategy and IA. The foundation of the ITG app was built on top of what it was created at that stage (Picchi 2011, p.9).

According to analysis phase result, iPad was preferred instead of any other tablet devices thanks to its common use by the dentists and its wider functionality. Other steps of the application development were designing, implementing and testing. User centered system design and agile development methodology were used throughout the project. User centered system design methodology focuses on the preferences and needs of the tablet users by involving them in the design and development phases (Norman & Draper, 1986). iPad Human Interface Guidelines (HIG) and principles were taken into consideration while designing the UI of the ITG. Therefore the superlative UI and user experience were achieved for the ITG app by working with iPad platform conventions.

#### **3.1 ANALYSIS**

In analysis stage, appropriate research techniques such as surveys, contextual inquiry, user interview, focus groups, card sorting and personas were chosen to identify mobile strategy, requirement specification, IA (user, content and context) and feasibility of the ITG app. The available platforms of the ITG (Android, Microsoft, BlackBerry, Apple), and smart device (iPhone, iPod, iPad or miniIpad), application type (native or web-based app), and style of the ITG app (utility, productivity or immersive) were defined after these research techniques were conducted (Ginsburg 2010, pp.3-17). Not only mobile strategy and IA, but also economic and technical feasibility, software and



hardware requirements of the ITG app were determined. Analysis was one of the most important stage of the ITG, because all of the ITG's important milestone was decided according to the outcome of the analysis.

### **3.1.1 Research Techniques**

There were many well-documented user research techniques for identifying the needs of the dentists. These techniques were applied to explore interactions between dentists and the ITG app throughout the project lifecycle (Kraft 2012, p.32). The techniques helped us to define dentists' business goals, put their needs in content, and assess the context of the ITG covering most common cases in dentistry (Unger & Chandler 2012, p.101). Moreover, research revealed opportunities for the ITG and inspired new solutions (Ginsburg 2010, pp.39-40). Some new information that positively affected the ITG app was received by visiting dentists prior to the preparation of the application and applying research techniques correctly (Moule 2012, p.142). Like any good yarn, our research outcomes should answer "the five W's": who, what, when, where, and why. "Who" identifies the audience for the ITG app, "what" identifies the actions they'll take, "when" and "where" zero in on context, and "why" describes their motivation and goals (Clark 2010, p.19).

#### **3.1.1.1 Survey**

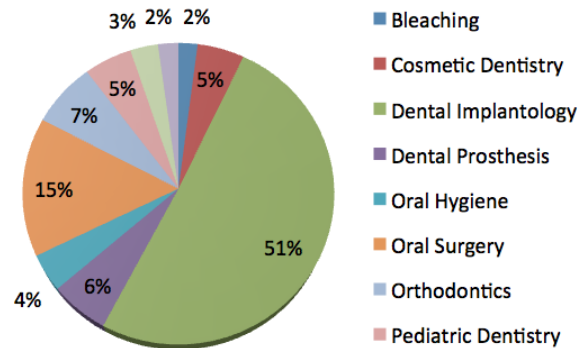
One way to get direct dentist feedback was by creating and collecting surveys. ITG surveys are powerful tools in reaching a broad spectrum of dentists in a short amount of time (Lowdermilk 2013, p.80). Instead of qualitative results, reliable numbers were needed for the ITG. That's why online survey was conducted initially. The questions of the survey were written clearly and the survey's target audience was chosen deliberately (Tidwell 2010, p.5). The survey was offered with a deadline (Unger & Chandler 2012, p.120). It had the clear undercover advantages of being quick, cheap, and easy to analyze. The questions were clear, direct and not deceiving. It consisted of close-ended and multiple-choice questions. Responses of dentists were collected easily (Bowles & Box 2010, p.29).

**Figure 3.1: Initial survey screen of dis-hekimi.org web portal**

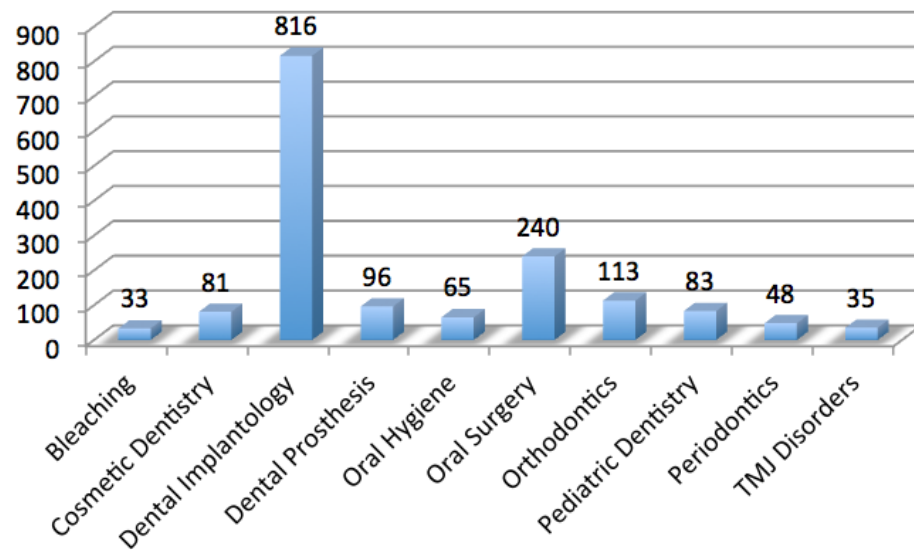


Sampling was used to cover as wide populations of dentists as possible at early stages in the lifecycle of the ITG to better understand the dentist. Language of the survey was clear and understood in the same way by all dentists (Rubin & Chisnell 2011, p.18). Survey was a broad and shallow research tool that provided an opportunity to gather input from a large number of dentists relatively quickly and inexpensively. One thousand six hundred and ten dentists participated to the survey via dentistry web portal. Result of the survey showed that dental implantology was found most valuable content for the ITG app. Among those surveyed, dental implantology was preferred a must-have topic by 51 percent of dentists and 32 percent of those had apple tablet devices.

**Figure 3.2: Percentage of demanded work areas of app according to dentists**



**Figure 3.3: The result of the initial survey**



Survey was the vital part of research of the ITG. Designing questions was as easy as writing a few sentences. Survey was great for getting a quick read on dentist preferences and creating new ideas for the ITG, which was more reliable (Tulathimutte & Bolt 2011, p.260).

### **3.1.1.2 Contextual inquiry**

A field study was an important part of the ITG's research program. Contextual inquiry was useful for the information architecture of the ITG app. For example, simply seeing the workspaces of dentists was very valuable in defining the spectrum of information resources they use on a daily basis. It was equally worthy to observe dentists make use of a tablet device during their daily practice providing insight into how the ITG app might help dentists be more productive (Morville & Rosenfeld 2008, pp.252-253). The primary job of contextual inquiry was to learn from potential user of the ITG app. Contextual inquiry was used to discover unmet needs or unexpressed requirements. It was also a good way to uncover the way dentists think and talk about a given topic. It revealed hidden issues and problems waiting to be resolved through good design (Moule 2012, p.58).

**Figure 3.4: The contextual inquiry of dentists**



A five-minute introduction was prepared before contextual inquiry started. The dentists were informed the purpose of the inquiry, a high-level description of what you'll be doing together and how the information will be used in the project (Unger & Chandler 2012, p.115). The only downside of contextual inquiry was very time-consuming and expensive research technique (Garrett 2010, p.47).

### **3.1.1.3 User interview**

While surveys can reach a large audience with little effort, they only give you a broad understanding of your users' needs. No matter how careful we are with our survey process, it can still feel like we're making assumptions based on the results. While interviews have time limitation and reach a smaller audience, they offer more detailed information. Conducting interviews ensures us to capture the intent of the dentist's remarks (Lowdermilk 2013, p.83).

The user interviews were conducted at the dentists' natural environment. The structure of interview was flexible. Dentists were asked about the moments when they experienced difficulty in completing tasks, as well as the moments when it all went well (Kraft 2012, p.34). Interviews were kept almost one hour, because of distraction and time issue. The goal of the interview was to find dentists' existing or latent needs (Moule 2012, pp.57-58). A list of questions was prepared for the user interview. Ideally,

questions were simple, neutral and open ended. Some examples of leading questions were listed below.

- i. What are your common goals and needs?
- ii. What do you like or dislike about dental apps?
- iii. Do dental apps meet your expectations?
- iv. Would you rather use iPad or other tablet devices?
- v. Tell me about your last dental app experience?

**Figure 3.5: Interview with dentists**



Richness of data was more important than consistency. Therefore, semi-structured interview was conducted. Questions were asked but the conversation was allowed to follow a natural path (Unger & Chandler 2012, pp.112-114). General attitudes, motivators, drivers, pain points, core tasks and dentists' workflow were explored by user interviews (Moule 2012, p.56).

#### **3.1.1.4 Focus groups**

In the focus group, a small group of knowledgeable dentists and a moderator were brought together to discuss about design ideas and proposed design tasks. Although the discussion was loosely structured and focused on specific topics, the range of topics was

determined beforehand. Session was limited to one hour and six participants. It was recorded for later detailed analysis. Each dentist was given a nametag and a place card at their seat so that every dentist could address each other by name easily. Important questions were put in the middle of the topics list, following a warm-up part but before any potential time crunch occurred before the end of the session (Unger & Chandler 2012, p.122).

The focus group was a useful method for obtaining initial thoughts and trying out ideas. It was easy to set up and run (Galitz 2007, pp.720-721). The focus group was good for qualitative information but not for learning about performance issues and real behaviors (Rubin & Chisnell 2011, p.17). One advantage of the focus group over the interviews was that more people were involved in a fixed amount of time (Spencer 2010, p.66). One of the classic problems in focus group was that more confident dentists overwhelmed those who were less confident about speaking up (Quesenbery & Brooks 2010, p.130).

#### **3.1.1.5 Card sorting**

Card sorting was one method to explore how dentists categorized and grouped content of the ITG and information elements. A stack of randomly shuffled index cards was given to the dentists. Each of them had the name, description, image and type of content on it (Tulathimutte & Bolt 2011, pp.250-251). The dentists sorted the cards into piles according to the groups and categories that felt most natural. Analyzing the result of cards helped us to understand how dentists thought about the content and design (Garrett 2010, p.49).

**Figure 3.6: Card sorting activity with dentists**



Card sorting was used in the very early stage of development to learn dentists' preferences and understanding of the IA, as well as their understanding of the terminology. These activities were done not only in person but also remotely, using an internet based application such as *optimalsort* web page (Barnum 2010, p.58). Card sorting was a very inexpensive method for getting dentist input on content organization, vocabulary, and labeling in the user interface of the ITG (Rubin & Chisnell 2011, p.18).

Briefly, the process was as follows: From previous analyses, almost one hundred content topics were identified and inscribed on index cards. The cards were numbered on the back. A facility with a large enough white board was arranged for spreading out cards. Participants were selected representing a range of dentists. One dentist was assessed at a time and six in total. The process was explained to the dentists. The dentists were asked to sort the cards and talked out loud while doing so. Participants were observed and notes were taken. Participants were asked to provide a name for each grouping on the colored blank cards. A record of the groupings was made using the numbers on the back of each card. The cards were reshuffled for the next session. The card sorting method was simple, but it required a lot of time to set up and conduct the tests and much concentration during analysis (Young 2008, pp.421-422).



### 3.1.1.6 Personas

Collecting the sort of data about dentists was incredibly valuable, but sometimes sight of the real people was lost behind all the statistics. Users of the ITG were made more real by turning them into personas (Garrett 2010, p.49). Persona was fictional characters (Anderson et al. 2010, p.196) that were created to represent the various user types of the ITG app (Moule 2012, p.71). Personas were the ideal tool to give everyone a shared view of ITG's user (Bowles & Box 2010, p.35). With personas, the tendency for making false assumptions were reduced (Barnum 2010, p.94). They helped us to stay focused on the dentists' needs during project life cycle of the ITG app (Tidwell 2010, p.5). A representative photo, name and surname, family status, application related and experience related goals, context of use and a quote were used in personas (Barnum 2010, p.95). Also, optional contents such as online activities, offline activities, technical comfort level, social comfort level, mobile comfort level were added to the persona (Unger & Chandler 2012, pp.137-138). Last but not least, detailed information on the computer and syncing setup, and experience in book versions of iPad application were added to personas (Ginsburg 2010, pp.80-81).

Some personas of the ITG were representative users, not real people (Spencer 2010, p.90) and they were evidence-based character sketches of hypothetical archetypes of actual users (Rubin & Chisnell 2011, p.332). Even though some of them were imaginary, they were determined with respectable hardship and sensitiveness (Mathis 2011, p.31). Photography of research participants was used rather than stock photography (Spencer 2010, p.90). Choosing photos for the persona should not take longer time. For this reason, their personal or clinic web sites were searched on to find their photos.

The intention of creating user persona was a good way to uncover dentists' goals and needs when designing the ITG application (Joseph Cartman & Ting 2008, pp.114-115). Personas helped us to put ourselves in the shoes of the dentist (Anderson et al. 2010, p.198). When a tricky point was encountered in design process of the ITG, audience segments and personas assisted us to create better design solutions, kept us focused on



real people (Walter & Spool 2011, p.34). The audience segments were used to write scenarios, use cases, usability test and card sort (Reiss 2012, p.73). Storyboards were drawn using personas (Young 2008, p.350). Information in the personas was used to model different types of scenarios related to the use of the ITG app (Wood 2011, p.40).

**Figure 3.7: Sample Personas**

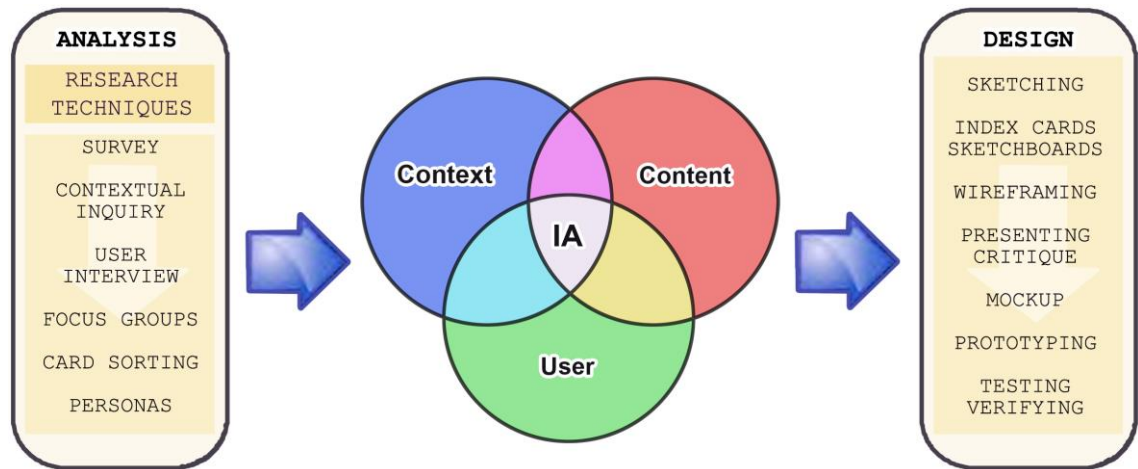


User research was first step of creating personas (Mathis 2011, p.30). Once user research was performed, target personas were created based on the user research, and then user goals were identified for each persona (Joseph Cartman & Ting 2008, p.113). Personas were developed from multiple research sources, including user research, focus groups and application analytics (Anderson et al. 2010, p.196). Numbers of personas were restricted to three due to limited time and resources (Barnum 2010, p.95).

### 3.1.2 Information Architecture

Good research means asking the right questions and the right questions require a conceptual framework of the broader environment. The three circle diagram shown in Figure 3.8 was invaluable in shaping a balanced approach to research. It helped us to decide where to shine the flashlight, and to better understand what we see. Consequently, we used this model to organize our exploration of the research process (Morville & Rosenfeld 2008, p.233). In order to understand the needs of the dentists, content of the ITG and the context of use helped us a deeper understanding of design function and empathy with the user (Katz 2012, p.125).

**Figure 3.8: Information architecture framework: content, context and user**



### 3.1.2.1 User

Collecting user requirements is the most important part of our user-centered strategy. The user requirements set the basics for the remaining steps in the user-centered design process. Without properly defined user requirements, it's impossible to move forward in the right direction (Lowdermilk 2013, p.32). At the most basic level, user research helped us to understand the user of the ITG and their needs. Research methods enabled us to explore how dentists do things today, what's important to them, and their requirements. Having this information helped us to make both high-level (overall the ITG app concept) and low-level (screen layout) design decisions (Ginsburg 2010, p.40).

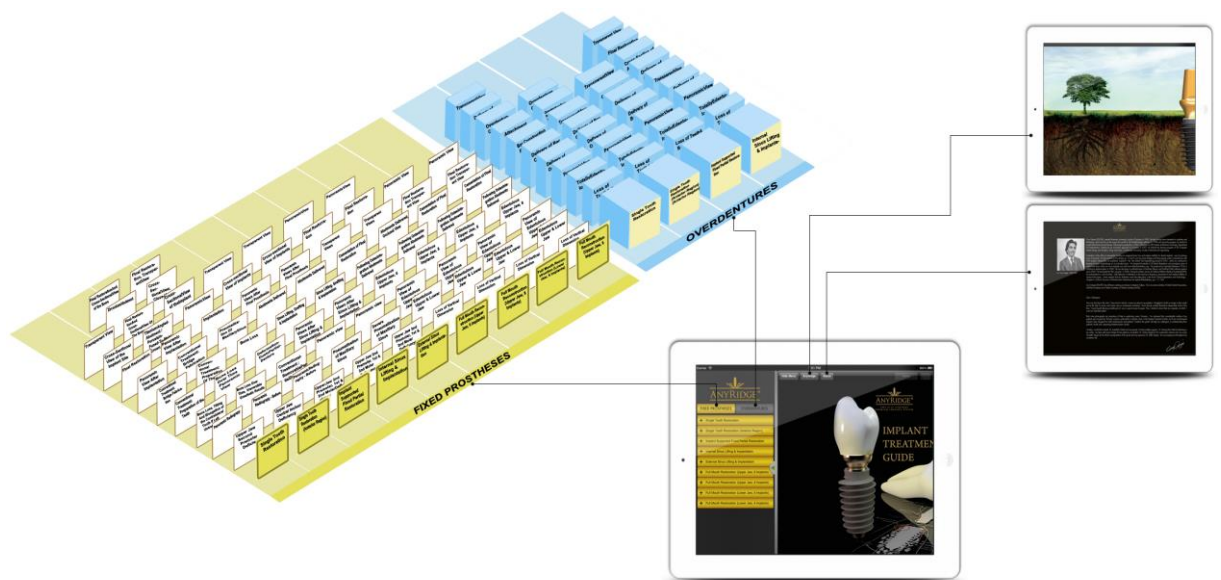
User needs were the keystones of all successful user experience innovation. If the ITG app had been unable to cover existing or latent needs of the dentists, then all efforts in creating a great user experience of such solution would have been wasted. Functionality without underlying dentists' needs added into the ITG, may not have been only wasting resources on developing this functionality but may have been compromising the overall user experience of the ITG. Therefore more functions may not necessarily mean to increase usability of the application or system (Kraft 2012, p.27).

Three characteristics that best describe the ITG target audience were decided: The dentist whose profession is implantology, who likes to have experiment with 3D illustrations and technology and who is willing to give information to their patients about the treatments using iPad (Apple iOS HIG 2012, p.23).

### 3.1.2.2 Content

Apart from the likelihood that the ITG users are dentists and mobile, they expect beautiful graphics, simple interactions, high performance and useful content. Content is king. It is absolutely true in mobile apps. Content is defined broadly as “the stuff in our application.” Content may include documents, data, images, audio and video files, and more. And it may include future stuff as well as present stuff (Morville & Rosenfeld 2008, p.239). 3D illustrations about implant-supported prosthetic treatments have been modeled in 3D programs over fifteen years. Content creation stages of the ITG can be seen in Figure A2 – A8. As it can be seen in Figure B.1, these illustrations published as the ITG book one year ago. The book edition of the ITG was redesigned and published as the ITG app. Content of the ITG consists of two main categories: “FIXED PROSTHESES” and “OVERDENTURES”. First main category has nine sub categories and second main category has four sub categories. Detailed sub categories and items can be found in Table B.1 - B.15. The contents were stored locally within the ITG app. The content of the ITG is be updated when the app is updated on the Apple App Store (McWherter & Gowell 2012, p.22).

**Figure 3.9: Content structure of the ITG app**



### **3.1.2.3 Context**

Coming from a background of creating websites and desktop software, designing an app for mobile devices is quite a change. The iPad is used in entirely different ways than desktop or laptop computers, so design of the ITG needs to keep that context in mind through the entire process (Barry 2013, p.8). Mobiles are contextual, meaning they are used alongside people's actual lives (Hooper & Berkman 2011 p.xxix). Specialists of mobile user experience (UX) design generally mention context as the significant difference between designing for mobile experiences and other design areas. Without understanding contextual information of dentists, our design and implementation would fail to make sense. In contrast, most mobile experiences are situated in highly dynamic and unpredictable environments. The mobile context can be anywhere (Hinman 2012, pp.40-41). Dentists are not stationary, nor focus entirely on the screen. They are everywhere, and they want to locate, identify, and manipulate information easily and quickly (Hooper & Berkman 2011, p.137). Context had a huge impact on the ways that dentists use mobile devices. User research helped us to understand where, why, and when surrounding app usage, such as the environment, time of day, constraints, motivations, and types of interruptions. Knowing contextual information helped us to make design decisions for the ITG app and revealed opportunities for innovation (Ginsburg 2010, p.40). According to contextual inquiry and user interview, dentists generally use medical and dental apps in clinic or hospital.

### **3.1.3 Requirement Specifications**

The human-computer interaction layer and the mobile apps are heavily influenced by project requirements. There are four primary types of requirements that can be important in designing the application: operational, performance, security, and cultural/political requirements (Dennis 2010, p.447). Operational requirements, such as choice of hardware and software platforms were inspected separately for the requirement specifications of the ITG application. Performance and security requirements were discussed in the non-functional requirements section.

### **3.1.3.1 Software requirements**

- i. For developing the ITG app, the following were the software requirements
  - a. Operating System: Leopard or Snow Leopard
  - b. Language: Objective-C for the ITG app, ActionScript 3.0 for platform specific prototypes of the ITG app, XML (Extensible Markup Language) for dynamic announcement.
  - c. Database: Database was not required for the ITG app. MySQL was required for the survey.
  - d. IDE and Tools: XCode 4.5 (4G182), Software Development Kit (SDK), Instruments, Altova XMLSpy 2011 for XML, iPad Operating System (iOS), Debugger: LLDB
  - e. Simulator: iPad 5.1 and iPad 6.0 Simulator
  - f. License: Apple Developer License
- ii. For running the ITG app, the following were the software requirements:
  - a. Operating System: iOS 5.0 or higher versions
  - b. Network: Wi-Fi, cellular Network might be required for announcement.

### **3.1.3.2 Hardware requirements**

- i. For developing the ITG app, the following were the hardware requirements
  - a. An Intel-based Macintosh: The iPad SDK runs only on Mac OS X. The only sanctioned hardware for iPad development is an Intel-based Macintosh (McWherter & Gowell 2012, p.187).
  - b. Processor: 2.0 GHz Intel Core or higher
  - c. RAM: 1 GB or higher
  - d. Space on disk: minimum 4 GB
  - e. Tablet Device: iPad
- ii. For running the ITG app, the following were the hardware requirements
  - a. Minimum space to execute: 170MB
  - b. Tablet Device: iPad / iPad2 / iPad3
  - c. Accessories: Smart Case or iPad case

### **3.1.3.3 Non-functional requirements**

Startup's loading time of the ITG app should be kept at a minimum time of no greater than three seconds. Corresponding events should take place in minimal time of no greater than one five hundred milliseconds when dentists click on a button. The application size should not exceed 200MB. This includes images, sounds and all other application data. Dentists should be able to download the ITG app from Apple App Store. Therefore, 200MB is a reasonable application size, as it would not take a person on broadband Internet a long time to download.

The ITG app should be easy to use by the dentists who have basic tablet skills. It is expected that users already possess the basic knowledge of taps and gestures using fingers and the general purpose of presentation. Buttons should be easy for dentists to press on with one finger. All the features should be easy to use and take no more than 3 steps or consist of no more than 3 screens deep for the usage of any feature (Apple iOS HIG 2012).

The ITG app is hosted on Apple App Store, so it is always available as long as Apple App Store is accessible. The ITG app will not require external hardware. The probability of an application failure is extremely low thanks to the extensive testing that will be implemented on the application before official release. The ITG app shall not disclose any personal information about dentists to the operators of the system. Statistical data will be transmitted to and stored on a secure online server that is only accessible through login authentication by the administrator.

### **3.1.4 Feasibility Study**

#### **3.1.4.1 Economic feasibility**

Development of the ITG app was economically feasible for iPad, but it was much more expensive than a tablet device with Android operating system. Although ITG app requirements for iOS were higher than Android platform, income of the ITG from

Apple App Store was quite reasonable (\$9.99 per download). The ITG app required intel-based Macintosh (min \$999), iPad (min \$499), iOS Developer account (\$99 per year). However dentists should have a internet connection to download the ITG app.

#### **3.1.4.2 Technical feasibility**

In order to develop the ITG app, an internet connection, a windows server for the dynamic xml announcement, a mySQL database server for the survey, action script 3.0 and objective-C programming language and MVC design pattern for prototyping and the ITG app, intel-based Macintosh for IDE, iPad for device testing, iOS Developer account for submitting an app to Apple App Store were required. The application was deployed and tested on iPad2, thereby making it technically feasible.

### **3.2 DESIGN**

iPad is an innovative device and calls for a thoughtful approach to solve the unique challenges of multitouch UI design. Apple has shown many of the more obvious challenges in their own apps, but just replication of Apple HIG isn't enough to create a usable and beautiful user interface. Existing development and design patterns have been studied carefully by iPad designers and developers carefully (Bondo et al. 2009, p.20). The design speaks to the overall quality of the application. Even though there are over 500,000 apps in the store, many are poorly designed. Often the low quality design tells you that the rest of the app is poorly made as well. Judging the code quality of an app is not possible, so users make decisions on design, the only thing they can see (Barry 2013, p.17). The large screen and different interaction style on the iPad present a new set of design challenges. For many applications the extra space is a welcome improvement from the small iPhone screen size. Applications sometimes have a hard time filling the extra screen real estate with useful information.

#### **3.2.1 Sketching**

Once the analysis phase is completed, the first step towards prototyping is sketching. It is cost-effective and easy to do, and helps to generate lots of ideas quickly (Moule 2012

p.xvii). Sketching is precious stage for idea generation because it enables ideas to be explored cheaply and quickly (Bernard & Summers 2010, p.2). Pen and paper sketches enable us to capture and revise ideas more quickly than any digital tool. They help us to set our ideas free, rather than getting bogged down in detail. Sketches are unresolved, and abstract. Sketches are expendable. Sketching is also good for fun (Bowles & Box 2010, p.43).

Sketching is all about testing ideas, not refining. The sketching process should be considered as an ideas generation stage, exploring a huge range of options and disposing of ideas that don't quite fit our design problem (Moule 2012, p.120). The key point of sketching is to generate several possible approaches to solve designing problem, as illustrated in Figure 3.10. This is helpful for considering which elements are truly essential to the overall experience, and what can be removed from your design (Moule 2012, p.129).

**Figure 3.10: Sketches of possible approaches**



Sketching was the generative part of ITG's design phase. As part of the generative nature of prototyping, our goal was to generate a number of concepts, and get them out



as quickly as possible. A time limit from ten to thirty minutes was put on for each sketching round. After that, the presentation and critique stage was completed. These short time limits forced us to focus more on producing ideas than getting caught up in the details (Warfel 2011, pp.31-32). Some sketches of the ITG were more refined than others. Sometimes actual words for field labels were put, and other times simple lines and shapes were drawn in Figure 3.10 (Warfel 2011, p.83). Because of its generative properties, sketching was the perfect activity during all the phases of ITG design project. Beautifully crafted drawing was not the goal. Initial ideas sketches were low fidelity and rough. These sketches should attempt to instantly communicate the idea (Bernard & Summers 2010, pp.44-45). The collaborative nature of sketching on paper was ultra portable and could be done anywhere (Warfel 2011, p.37). Although the sketching and prototyping are different stages activities and great prototypes always start with great sketches (Bernard & Summers 2010, p.3).

### **3.2.2 Wireframing**

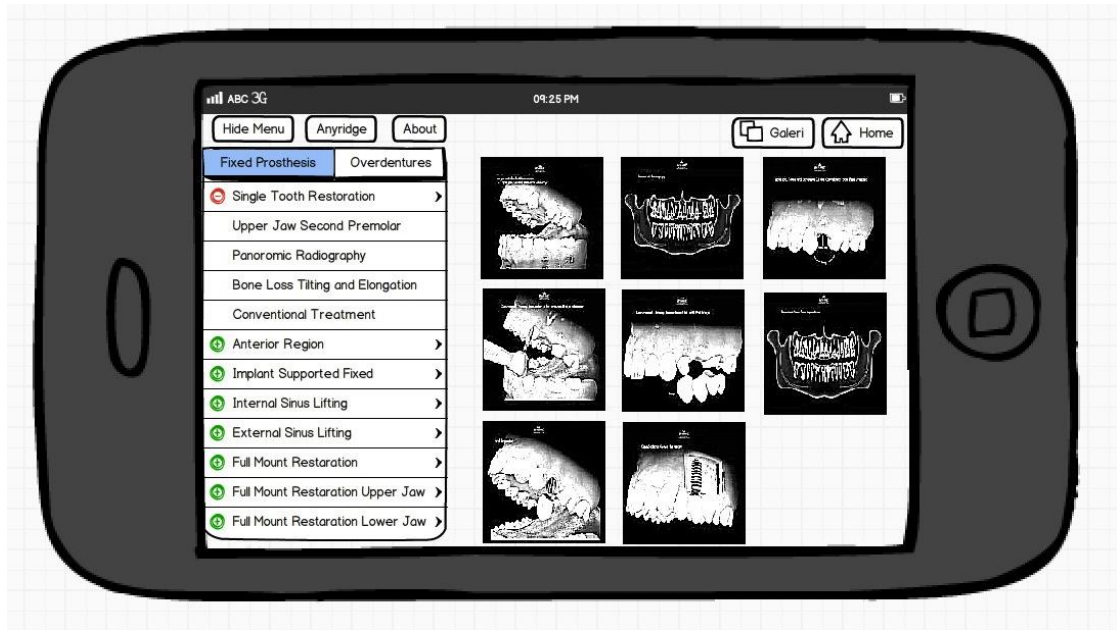
A wireframe is a low-fidelity and static representation of an interface. It neglects color, image detail, and other visual design specifics (Bowles & Box 2010, p.76). Wireframes are a visual representation of the functional page structure. They visually communicate what functional pieces are present on a page and their relationship to each other. Wireframes are typically in black and white or shades of gray (Warfel 2011, p.6).

The ITG's wireframe is a basic skeleton for the ITG. It is aimed to show structure, information hierarchy, functions, and content, while communicating through the lack of color and polish. Wireframes are still very much a work-in-progress. Its main purpose lies in helping us to better realize the functionality, behaviors, and content for different areas of the ITG.

Creating wireframes is the first step towards understanding the transitions between states in the ITG design, and they are a great way to progress problem solving beyond sketching (Moule 2012, p.164). With a focus on agility, Balsamiq is a great tool to communicate early mockups, layouts, and design. Balsamiq uses a hand-drawn effect for all of its widgets, which creates an experience that feels conceptual and iterative

(Lowdermilk 2013, p.110). Balsamiq Mockups was chosen for the ITG's wireframes. Balsamiq was easy to learn and fun to throw ideas onto the page and capture necessary design elements without becoming too hung up on the actual appearance (Faranello 2012, p.109).

**Figure 3.11: Wireframing of the ITG**

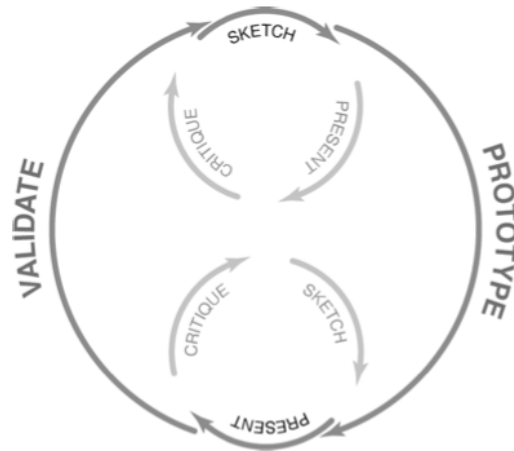


This early stage of design concepts should look incomplete and far from fully resolved, and Balsamiq Mockups helped us to accomplish this. This format enabled us to take what it was learned from the research stage and put it into a context, to be discussed before interactive prototype phase (Moule 2012, p.177).

### 3.2.3 Presenting and Critique

Presentation and critique were made at each progression and iteration of the project. It was arguably the most important part of design process. The goal of the presentation and critique stage was to find the best ideas. The designs of the ITG concept were presented, discussed and evaluated for further (Warfel 2011, pp.30-38).

**Figure 3.12: Diagram of the design and critique process**



*Source: Warfel, T.Z., 2011. Prototyping, Rosenfeld Media. p.30*

Duration of the presentation and critique was less than five minutes. Notes were taken directly on sketches, wireframes and sketchboards during critique of the ITG. The critiques were used to refine and strengthen the ITG design concept (Warfel 2011, pp.39-40).

**Figure 3.13: Presentation of sketches during a design studio critique session**



### 3.2.4 Mockup

Figure 3.14: Photoshop mockup screen 1 of the ITG

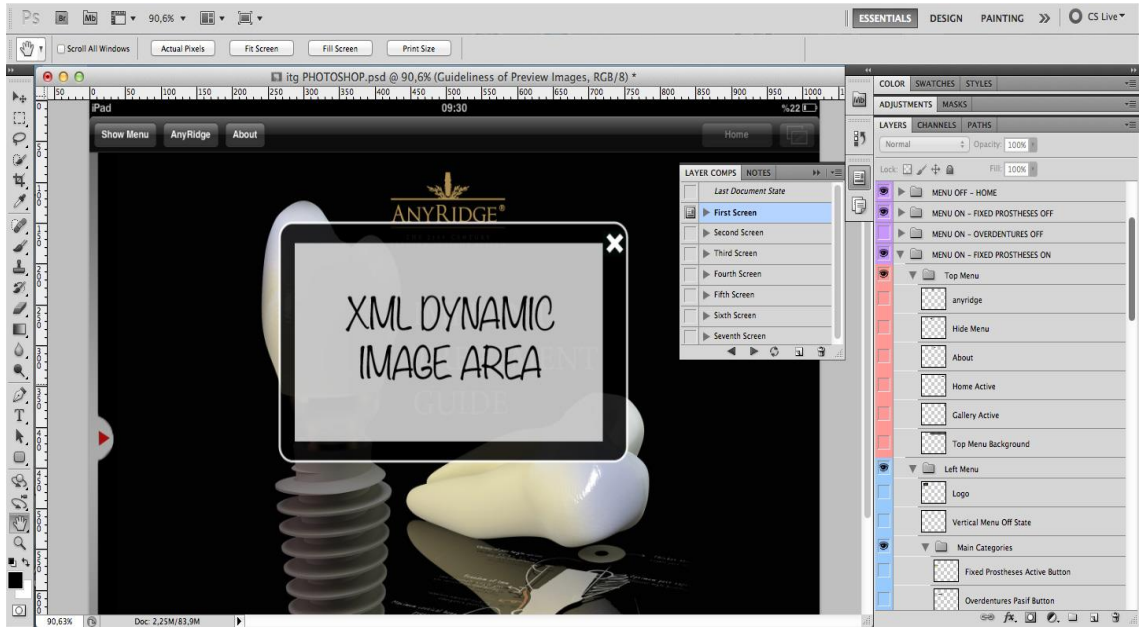
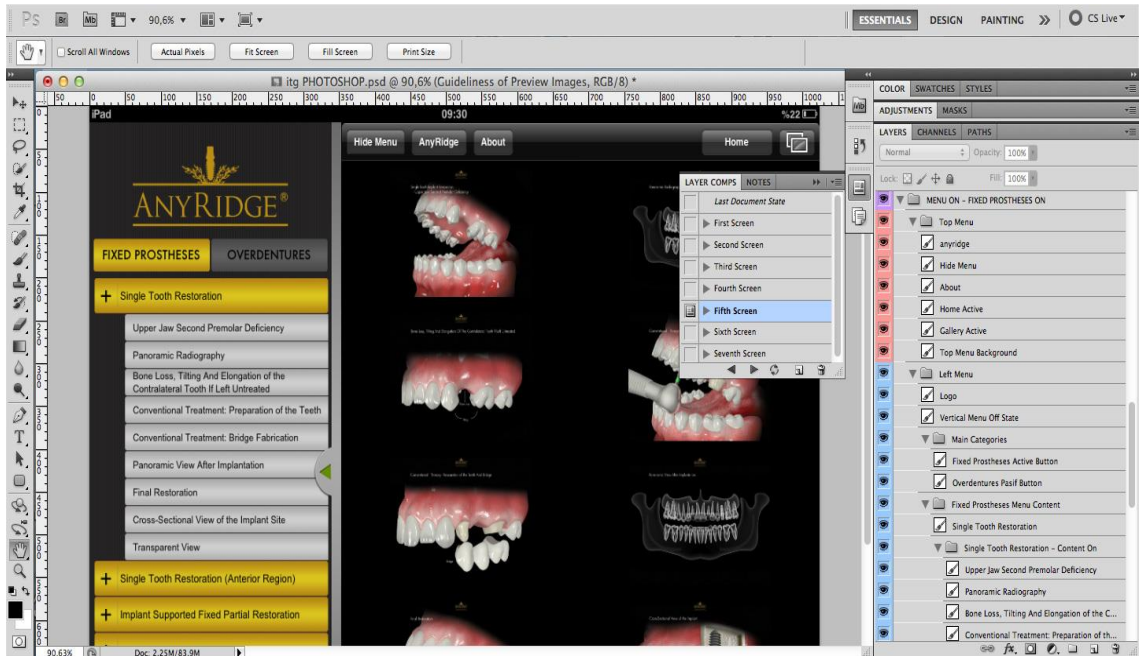


Figure 3.15: Photoshop mockup screen 2 of the ITG



### **3.2.5 Prototyping**

Static processes in projects ignore the transitions that must exist in application and interactive experiences (Bernard & Summers 2010, p.9). Sketches are not prototypes (Buxton 2007, p.139). Prototyping is the method for testing user flows, navigation, design, and overall usability for an application. Prototypes allow users to interact with designs and to provide valuable feedback in early stages (Faranello 2012, p.89).

The prototype of ITG was a simplified but functional model of an application. Dentists were able to move directly through a prototype. The most obvious disadvantage of a prototype was the effort required. The prototype of ITG called for more specialized skill than other deliverables (Bowles & Box 2010, pp.79-80). Prototyping reveals design problems of ITG at an early stage, and assisted us to understand constraints.

Prototypes are often referenced as either “low fidelity” or “high fidelity,” depending on the interactions and transitions in the context of designs. High fidelity conforms more closely or almost exactly to the end state; with low fidelity being less accurate in terms of closeness to the desired end result. High fidelity prototype was chosen for the ITG app (Moule 2012, pp.157-163).

Unlike sketches, sketchboards, index cards and wireframes; prototypes go further than show and tell, and actually let us to experience the design of ITG. The total amount of time and effort required to produce the prototype was less than that required to create a detailed specification document and annotated wireframes (Warfel 2011, pp.6-10). There are so many software tools such as Balsamiq, Axure, PowerPoint and iRise available nowadays that allow us to create functional digital prototypes. Adobe Flash Professional CS5.5 is chosen for platform specific prototype.

### 3.2.5.1 Paper prototype

Paper prototyping is the most versatile method around. Paper prototyping has been around for decades, gaining popularity primarily in academic institutions and large corporations. Paper is the most common method in use today. In fact, seventy-six percent of the survey respondents have stated that they use paper prototyping (Warfel 2011, pp.110-111).

**Figure 3.16: Sample iPad paper prototype of the ITG**



Paper prototyping was a great technique for working through the details of ITG's screen flows, sequencing, validating decisions about screen layout, button placements, and rough ideas for touch and gesture. They were a tangible way of testing our interaction ideas of the ITG with dentists and gathering feedback at an early stage in the design process (Hinman 2012, pp.156-157). Simple paper prototypes were very effective for testing interaction flows. They were completed NUI of the ITG's interface that were created in mockup (Kraft 2012, p.182). Paper prototypes were an easy way to test the ITG app without the time and expense of making a digital prototype (Bowles & Box 2010, p.82).



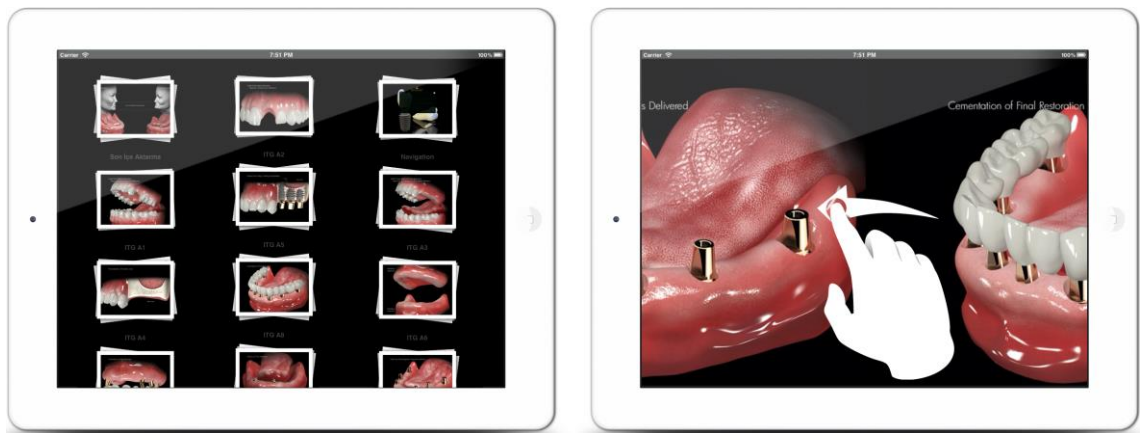
**Figure 3-17: The usability test of using the paper prototype of ITG**



### **3.2.5.2 In-Screen mobile prototype**

Screen layouts of ITG were designed in Photoshop and any necessary resizing to the design files were made. The resized images were saved with supported file format for the tablet devices. All the screen images were organized into the correct order for the scenario. The files were imported into the iPad's photo gallery. They were clicked and swiped away (Hinman 2012, pp.158-161).

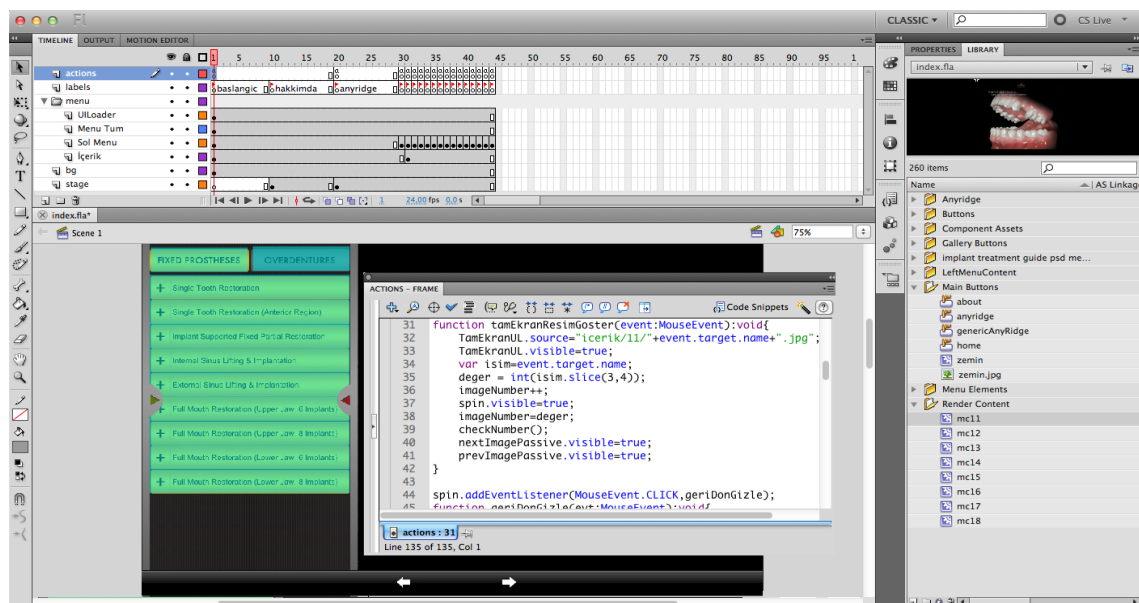
**Figure 3.18: In-screen prototype of the ITG**



### 3.2.5.3 Platform specific prototype

Adobe Flash CS5.5 is a great program for expressing detailed interactivity and transitions between screens. Using Flash is an easy way to deploy the interactive prototype on an iPad quickly, which provides a great user experience (Bernard & Summers 2010, p.3). Although the prototypes are coded in Flash, the final results are completely native iOS applications (Wagner 2011, pp.4-5). In order to compile native iOS apps, Flash Professional CS5 or above is needed (Caleb 2012, p.42). The new versions of Flash support panning an object, handling a swipe, pinch gesture on iOS devices (Caleb 2012, p.121). One of the many advantages of building iOS apps with Flash is the ability to use the authoring tools by dragging content from the library onto the stage allowing rapid development (Caleb 2012, pp.47-54).

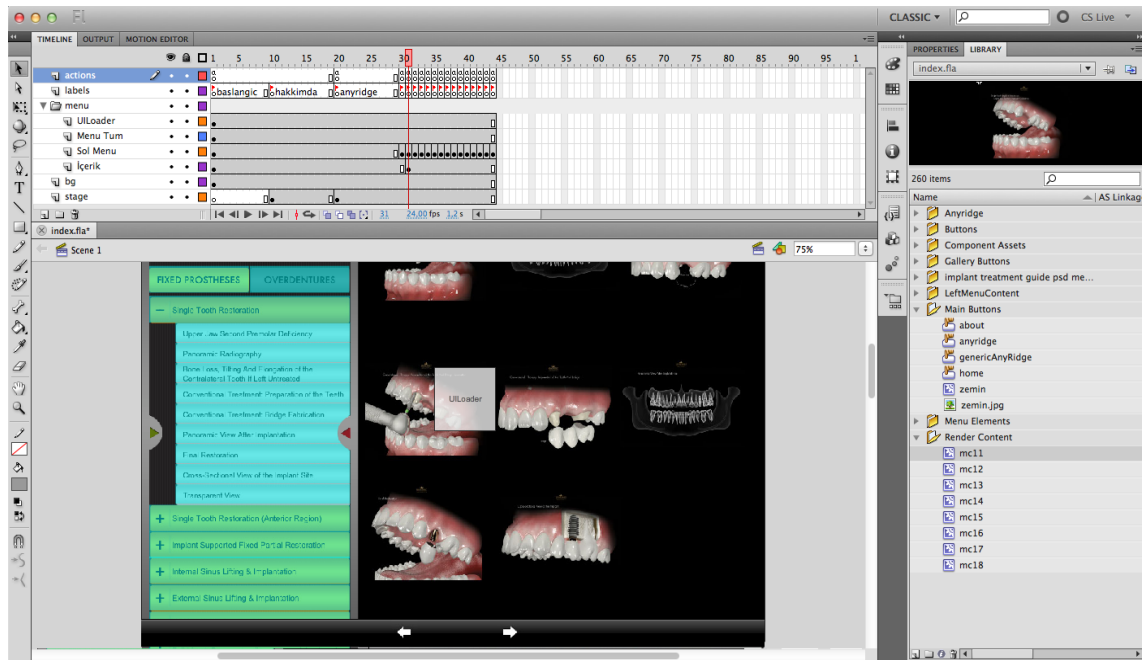
**Figure 3.19: Platform specific prototype screen 1 by using adobe flash**



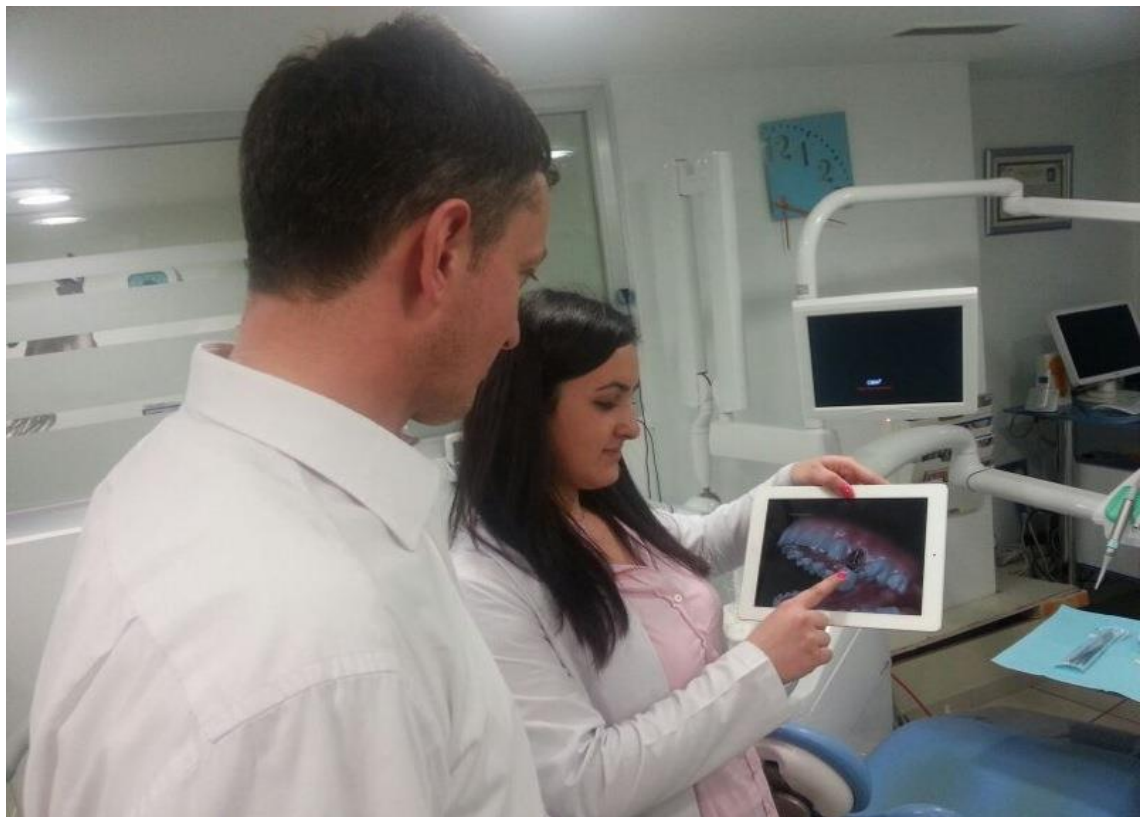
Flash CS5 allowed us to create native iOS apps, but some core mobile services were not supported such as library preferences and native UI controls (Wagner 2011, p.7). One of the largest bottlenecks was graphics rendering. Complex vector artworks, timeline animations, and alpha transparencies were all easy to create but they affected the performance of an app negatively (Caleb 2012, pp.151-152). For these reasons, native SDK of Apple was chosen for implementation the ITG in place of Flash platform (Wagner 2011, p.8).



**Figure 3.20: Platform specific prototype screen 2 by using adobe flash**



**Figure 3.21: The usability testing of platform specific prototype by dentists**



## **3.3 IMPLEMENTATION**

### **3.3.1 XCode Integrated Development Environment (IDE)**

XCode is a set of tools provided by Apple for developing applications to Mac OSX and iOS. XCode consists of XCode IDE, Interface Builder (IB), documentation and Application Programming Interface (API) reference.

#### **3.3.1.1 Interface builder**

Interface builder is a visual editor that is used for designing the user interface for your iOS application (McWherter & Gowell 2012, p.193). It provides interface elements like tables, buttons that the COCOA developers can easily drag and drop to create the user interfaces.

#### **3.3.1.2 Documentation and API reference**

Documentation and API Reference consists of Apple's Human Interface guidelines, how to's tutorials, sample codes etc. The main idea behind these documents is to ensure users have a consistent user experience and behavioral experience across applications.

#### **3.3.1.3 iOS simulator**

Developers use the iOS Simulator as their first way of finding issues with the code they just created. The iOS Simulator enables developers to run their iOS applications on their Macs without having to have a physical iOS device. The Simulator is a great tool for testing the ITG app quickly. The iOS Simulator is very quick to load, compared to other simulation tools for other mobile platforms. The iOS Simulator is not an emulator. An emulator tries to mimic the behavior of a real device. The iOS Simulator simulates real behavior of the iOS device, but relies on various libraries that are installed on the Mac (McWherter & Gowell 2012, pp.199-200).

#### **3.3.1.4 Instruments**

Instruments is a suite of tools that helps you analyze your iOS application and monitor for performance bottlenecks as well as memory leaks in real time while attached to an iOS device or iOS Simulator (McWherter & Gowell 2012, p.204).

#### **3.3.2 COCOA**

Cocoa is API used for building applications on iPhone, iPad and Mac OSX. The Cocoa Touch frameworks are extensive, and hundreds of classes are at our disposal. Cocoa Touch provides support for touch screen gesture recognitions and animations. The main features of Cocoa touch are multitasking, animation and touch screen gesture recognizers. Learning how to use this rich collection of components takes time. The best way to approach this task is to learn the common design patterns and functions implemented by the frameworks (Hockenberry 2010, p.65).

#### **3.3.3 Objective-C Programming Language**

Apple uses a specific programming language for developing applications for iOS called Objective-C. It is a superset of C, which extends the object-oriented capabilities. All of the syntax for non-object-oriented operations (primitive variables, expressions, function declarations and calls) is identical with C. The syntax of Objective-C is quite different from other programming languages.

#### **3.3.4 Agile Methodology**

Agile methodology is typically used when the requirements of the application is difficult to freeze and document initially. Hence it allows the developers to shift their primary focus on product itself, rather than designing and documenting at every stage. The tasks are divided into small increments so that developers do not focus on long term planning. Each iteration ends with the complete cycle of planning, designing, coding and testing. The biggest advantage of agile methodologies is that development time and

costs are cut down. Also developers are able to focus on launching the application to the market soon. Since the work is done in iterations it's easier to prioritize the requirements for the subsequent iterations. Agile methods are considered to be the opposite of sequential methodologies like Waterfall Model.

Agile methodology was used for the ITG app, because it was very difficult to freeze the application requirements in the beginning. Also the design of the individual screens had to be iterated based on feedback. The requirements were mainly gathered from analyzing what a dentist needs and also from a competitor analysis by checking out other applications categorized as similar genre. Since new applications or new versions were added to AppStore very frequently, it was decided to go with minimal set of requirements in the beginning and add requirements in subsequent iterations.

### **3.3.5 Use Case**

A use case is series of steps that can happen between the user and the software product. Use case help in determining the requirements and also prioritize them. It is useful in projects where the basic requirements should be listed in the beginning but new requirements will be added as the project grows. For the ITG application, the use cases are scenarios between the dentists and the ITG itself. The use case diagrams of the ITG apps were decided before the detailed design of the application.

### **3.3.6 MVC Design Pattern**

The designers of Cocoa Touch were guided by a concept called Model View Controller, which is a very logical way of dividing the code that makes up a NUI based application. The reason behind MVC design pattern is to break the complex application into smaller parts to simplify the process. Also, MVC helps ensure maximum reusability in our projects (Mark et al. 2013, pp.44-45).

### **3.3.6.1 Model object**

The Model object usually consists of the data encapsulating the instance variables needed for the object. It is highly reusable and it contains an initialization method to return instances to various other classes. The model object contains the data and logic of the ITG app. The model class inherits from superclass NSObject. It also consists of a set of instance variables to store the data. The class also contains a set of accessor methods for these instance variables and custom methods to modify the data.

### **3.3.6.2 View object**

The view is what the user sees, and it displays the model for the user. It allows the user to manipulate it and respond and generate events. In iPad applications, the view is normally built inside Interface Builder rather than programmatically (Allan 2013, p.65). Interface builder consists of a library of COCOA touch objects that can simply be dragged and dropped on to the screen to design the user interface.

### **3.3.6.3 Controller object**

Control object's function is to be a mediator between the model object and the view object. If any value change is made in a model, it is updated by the controller. Moreover, the controller is aware when a user input is made and can update the data as required (Hockenberry 2010, p.68).

### **3.3.7 Split View Controller**

For the ITG application, split view controller is the most common iPad View controller. When in landscape orientation it features a UITableView in a left column, with a detail view on the right. This is very effective for browsing through content and is a great starting point for content-heavy iPad apps. While it feels pretty basic, some more user interface elements were added to make it better match our application.

For the ITG app, a grid view was added in the details section, along with photos for each of the rows in the tableView. This makes the default element (the split view controller) feel unique inside of the ITG (Barry 2013, p.37).

### **3.4 TESTING**

Testing was done before the ITG app was submitted to AppStore. As mentioned in the previous section usability testing was done at regular intervals every sprint of implementation. However the ITG app had to be tested for memory leaks and application crashes at some point like failing to parse XML, update data set in table etc.

#### **3.4.1 Testing Application on Device**

In order to check if the ITG app crashes, the application had to be imported on to an iPad. Testing in the simulator is the first step, but is not sufficient. While running on the device, the ITG application had some issues such as orientation problem, empty announcement window, performance and appearance problem. These minor bugs were fixed and the final ITG app was satisfying and good for submission to AppStore.

XCode is Apple's IDE for creating Objective-C applications. XCode enables developers to manage, author, and debug their Objective-C projects (McWherter & Gowell 2012, p.193). XCode IDE consists of a compiler, a debugger, an iOS simulator and a powerful text editor. XCode is available for download for free, after registering in Apple's developer account. XCode 4.4 with Mac OS 10.7.5 was used for the ITG app.

#### **3.4.2 Testing for Memory Leaks**

Much of importance was given to testing for memory leaks and testing was done using Static Analyzer and another comprehensive tool called Instruments. It shows a time line displaying any event occurring in the application, such as CPU activity variation, memory allocation, network and file activity with statistics and graphs.

**Figure 3.22: Testing for memory leaks by using XCode instruments**



Source: McWherter, J. & Gowell, S., 2012. *Professional mobile application development*. P.204

### 3.5 RELEASE

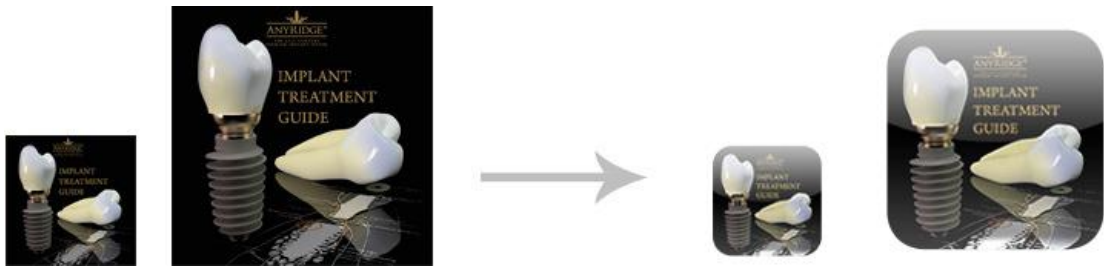
Every app needs an app icon and a launch image. It's recommended that apps also provide an icon for iOS to display in Spotlight search results (Apple iOS HIG 2012, p.181). For all images and icons, the PNG format is recommended. The standard bit depth for icons and images is 24 bits (8 bits each for red, green, and blue), plus an 8-bit alpha channel (Apple iOS HIG 2012, p.183).

#### 3.5.1 Adding the ITG App Icon

An icon is a visual representation of a function or action within a NUI. A successful icon focuses heavily on concept over aesthetic and must quickly and manifestly communicate its purpose. it's all about user experience. There are three things that make for a good icon:

- i. An icon must be universally recognized.
- ii. Icons must be clear and concise.
- iii. Icon design must adhere to platform guidelines (McInnes 2010, pp.40-42).

**Figure 3.23: Preparation of the ITG icon**



The standard iPad home screen icon (Icon.png) used for the ITG application was 72×72 pixel square in PNG format with no transparency or layers at 72 dpi. In addition to this, a 114×114 pixel high-resolution (Icon@2x.png) icon was provided in the same format that will be used when the application is running hardware with a Retina display (Allan 2013, p.385; Barry 2012, p.97). For the App Store, a large version of the ITG app icon was created in two sizes (512 x 512 pixels and 1024 x 1024 pixels for high resolution) so that it looks good on all devices (Apple iOS HIG 2012, p.189). Contrary to popular belief, the corners and shine of iOS icons are not applied to the design, instead they are dynamically added by the operating system (McInnes 2010, p.71).

### 3.5.2 Adding the ITG Launch Image

In order to enhance the user experience at app launch, one launch image must be provided at least. The launch image of the ITG looks very similar to the first screen of the ITG. iOS displays this image instantly when the dentist starts the ITG app and until the ITG app is fully ready to use. As soon as the ITG app is ready for use, the ITG displays its first screen, replacing the launch placeholder image. The launch image is not meant to provide an opportunity for artistic expression; it is solely intended to enhance the user's perception of the ITG app as quick to launch and immediately ready for use. 1024 x 748 pixels for standard resolution and 2048 x 1496 pixels for high resolution launch images were created for the ITG's landscape mode (Apple iOS HIG 2012, pp.189-190).



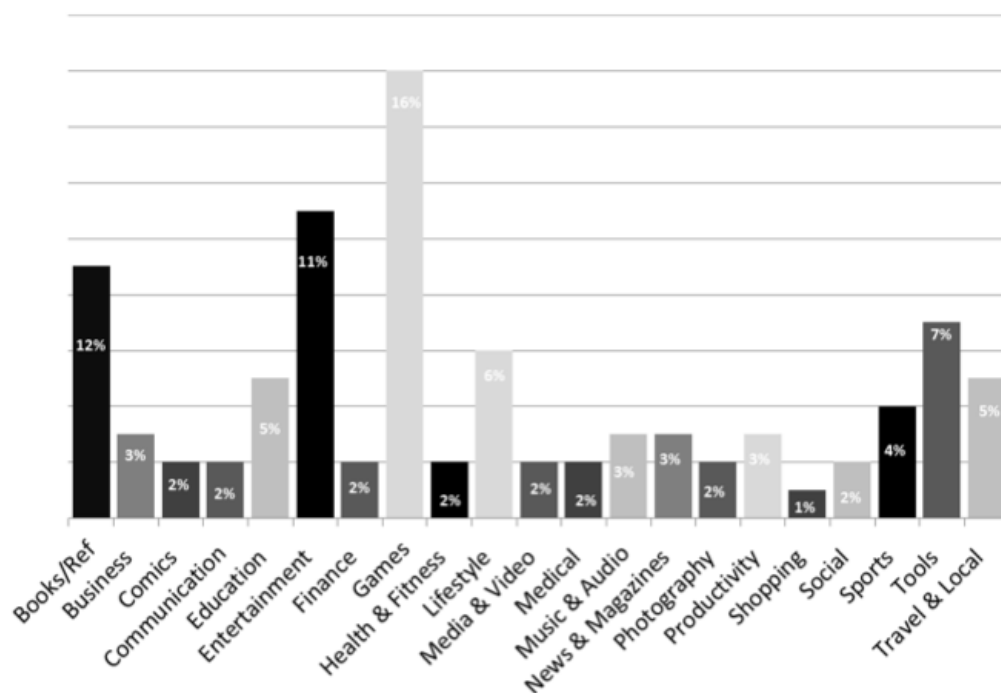
### 3.5.3 Small Icon of the ITG Application

Every app should supply a small icon that iOS can display when the app name matches a term in a spotlight search. The final visual size of a spotlight search results icon of the ITG is 48 x 48 pixels (96 x 96 pixels in high resolution). iOS trims 1 pixel (or 2 pixels, for high resolution) from each side of the ITG's artwork and adds a drop shadow (Apple iOS HIG 2012, p.192).

### 3.5.4 Category Selection of the ITG App

When development of the ITG app was finished and it was being deployed to the AppStore, it was required to put it into a category within the market to allow users to discover the ITG more easily. Within all markets, apps are divided into categories, and some categories are more popular than others. Most users are not using a search engine to find apps for their mobile devices; they are using the built-in search tools within the installed market tool (McWherter & Gowell 2012, p.23). The ITG app was put into medical category in order to improve discoverability of the ITG.

**Figure 3.24: Types of apps in the markets**



Source: McWherter, J. & Gowell, S., 2012. *Professional Mobile Application Development* p.20

### 3.5.5 Availability Date and Price Tier

iTunes's default behavior is to make our new release available immediately. An availability date was selected to control the date that our app will be released. Enough time was given for the availability date to control our marketing efforts around it. After selecting the availability date, price was picked for our app. Again, since iTunes works worldwide, the price can't be set in dollars and cents. Instead, Apple uses Price Tiers groups of equivalent prices (Hockenberry 2010, pp.248-249). Price tier 10 was chosen for the ITG app. Lite version of the ITG can be downloaded free of charge for trial usage. The first option is free that was selected for free version of the ITG.

**Figure 3.25: Availability date and price tier of the ITG**

The screenshot shows the 'Implant Treatment Guide' app configuration interface. It prompts the user to 'Select the availability date and price tier for your app.' The 'Availability Date' is set to 06/Jun, 4, 2012. The 'Price Tier' is set to Tier 10. A 'View Pricing Matrix' link is visible below the price tier selection. The pricing matrix table is as follows:

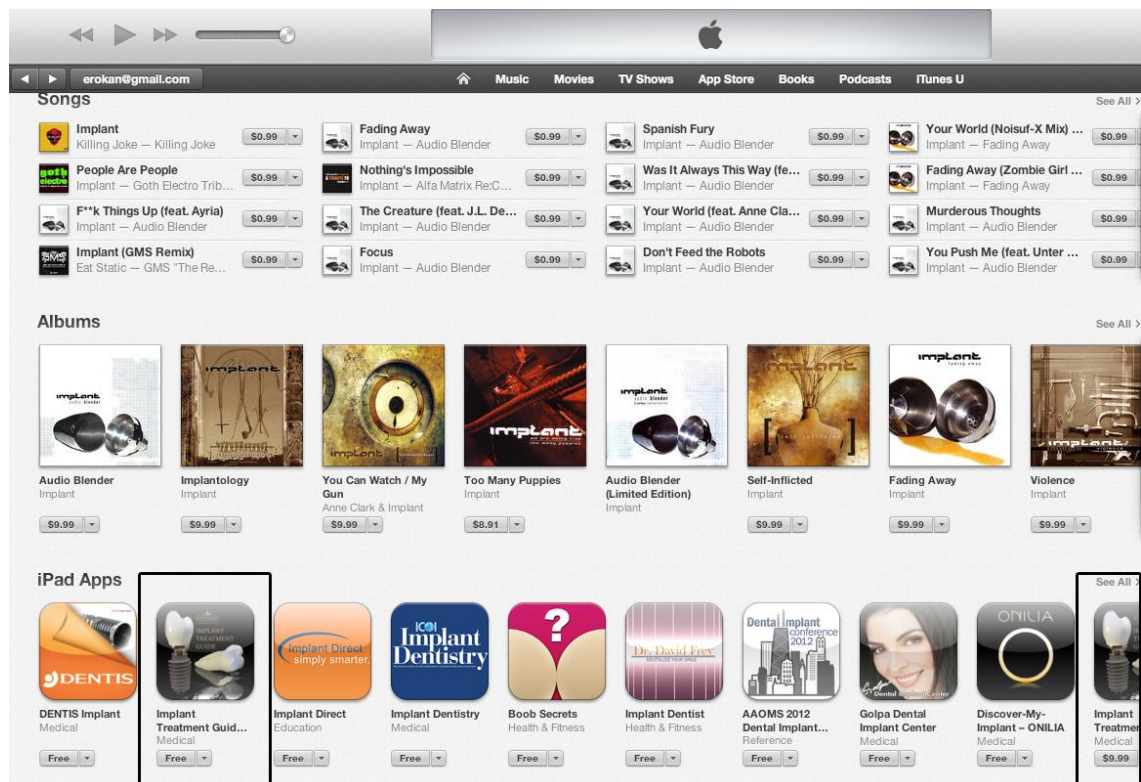
Price Tier 10		
App Store	Customer Price	Your Proceeds
U.S.*	US \$9.99	US \$7.00
Mexico	MX \$120.00	MX \$84.00
Canada	CA \$9.99	CA \$7.00
U.K.	£6.99	£4.25
European Union*	7,99 €	4,86 €
Sweden	SE 75,00kr	SE 45,65kr
Denmark	DK 59,00kr	DK 35,91kr
	NO	NO

### 3.5.6 Marketing of the ITG

iOS users tend to install apps from within iTunes or the App Store directly on their devices. The App Store gives apps discoverability, and a place where users can search for keywords, or possibly bump into while browsing through categories. After the ITG is created, it can't be thrown up on AppStore and expect dentist to find it. The success

of the ITG app depends on our marketing strategy. Rushing the ITG app to the market without a marketing plan could take away from it performing to its full potential. Using advertisements on websites (dental-animation.com), press releases, and mailings to existing customers are all ways to drive interest in your app for potential users (McWherter & Gowell 2012, p.24).

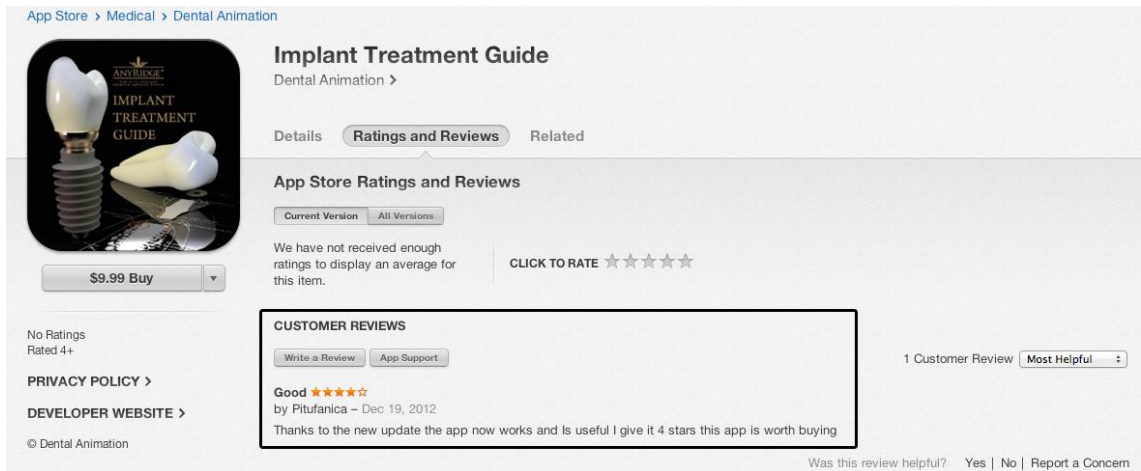
**Figure 3.26: The ITG apps in the app store**



### 3.5.7 Customer Reviews

Customer reviews can make or break an app; in the mobile world, users are very harsh over all platforms. Having a good rating with positive feedback is what a potential user needs to see to download an app. If an app is put into the app store without thoroughly testing, users will give it poor feedback, and that is a permanent record. Figure 3.27 shows a set of user reviews for the ITG application within the iOS App Store (McWherter & Gowell 2012, p.29).

**Figure 3.27: The customer reviews of the ITG app**



### 3.5.8 Tracking Information of the ITG according to iTunesConnect

Tracking app sales helped us to provide insight into the ITG's price. The price of the ITG was adjusted according to tracking information. Tracking information, such as the type of OS version, helped us to focus on future development efforts. Being able to track sales down to the day will also help with marketing and advertising efforts, comparing sales trends to campaigns. Knowing where in the world the ITG app is in use was helped advertising and product decisions (McWherter & Gowell 2012, p.31).

**Figure 3.28: Download statistics of the ITG**



## **4. DISCUSSION AND RESULTS**

In this study, an iPad application called “ITG” was designed and developed by implementing the user centered development methodology. The potential users of the application participated the design and evaluation phase. They provided several benefits to catch the usability problems in the early design phase and improve the user interfaces based on the needs and preferences by the dentists. The heuristic evaluation techniques were used to improve the usability of the application by the help of usability experts.

### **4.1 HEURISTIC EVALUATION**

Heuristic Evaluation is a usability engineering method, which is used to identify interaction problems with the computerized applications at the early assessment stage (Nielsen 1995). A heuristic evaluation makes the examination of the interface by making a comparison between it and a set of heuristics or principles for interface design (Dennis 2010, p.429). HE is a usability inspection method, which includes usability experts’ work with a system to anticipate possible usability problems. A small group of evaluators test the NUIs of the ITG and decide whether the interface satisfies the end-users’ needs according to fairly strict user interface guidelines of Apple.

Ji et al. (2006) develop a usability checklist for the usability evaluation of mobile device user interface, which based on heuristic evaluations in views of mobile user interface users. Simeral & Branaghan (1997) analysis of heuristic evaluation and found some restrictions: it doesn’t provide the conditions under which real users would use the mobile application and it provides little information about the measure of the usability problems that are detected. Ji et al. (2006) had opportunity to improve the traditional heuristic evaluation and collected some usability principles from previous studies. For instance, for Constantine (1994) structure principle the layout makes sense to actual users in terms of their tasks and intentions. In the case of simplicity principle when the application is designed simply and clearly, users can use this application easily. Feedback principle provides users are kept informed of what is happening in each

action. Visibility principle provides the content is more understandable for the users. Tolerance principle provides flexible user interaction. In addition to these, the application must be efficient and easy to remember for the actual user. Also, the application must be easy to learn for all of the user groups from novice users to expert users. When user is using the application, the user must feel satisfied and must understand what the application does. Researchers have identified design guidelines for mobile usability (Buchanan et al. 2001). These guidelines minimize the navigation level, have simple access to main content, simplify the displayed text, and have convenient input methods like a list of selection. The use of usability evaluation in development lifecycle is significant to ensure the development of an efficient, effective and useful application.

## **4.2 SURVEY**

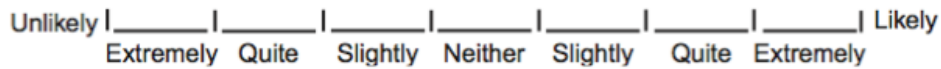
### **4.2.1 Methods**

At roughly the same time that usability researchers were producing the first standardized usability questionnaires, market researchers were tackling similar issues (Sauro & Lewis 2012, p.231). Of these, one of the most influential has been the Technology Acceptance Model (TAM) (Davis 1989, p324). According to the TAM, the primary factors that affect a user's intention to use a technology are its perceived usefulness and perceived ease of use. In the TAM, perceived usefulness is the extent to which a person believes a technology will enhance job performance, and perceived ease of use is the extent to which a person believes that using the technology will be effortless. A number of studies support the validity of the TAM and its satisfactory explanation of end-user application usage (Wu et al. 2007, pp162-174).

There are two six-item questionnaires used in the TAM, one for Perceived Usefulness and one for Perceived Ease of Use (starting from initial pools of 14 items for each construct mixed positive and negative tone). As shown in Figure 4.1, the items for these questionnaires have seven steps from “unlikely” to “likely,” each with a verbal rather than numeric label.

**Figure 4.1: Sample item from the TAM survey.**

Using the ITG app in my job would enable me to accomplish tasks more quickly.



An initial study with 112 participants provided the data needed to refine the scales (Davis, 1989). The results of this initial study indicated that mixing the tone of the items was causing problems in the factor structure for the intended constructs. “These ‘reversed’ items tended to correlate more with the same item used to measure a different trait than they did with other items of the same trait, suggesting the presence of common method variance. This is ironic, since reversed scales are typically used in an effort to reduce common method variance.” (Davis 1989, p.327). Consequently, Davis eliminated the items with negative tone, converting a few of them to positive tone to ensure enough items in the scales for high reliability, and ending with six items per construct (Sauro & Lewis 2012, p.231). The final versions of the Perceived Usefulness and Perceived Ease of Use items appear in Table 4.1 and Table 4.2.

Davis (1989) conducted a lab study in which 40 participants evaluated (in counterbalanced order) two graphics applications with different user interfaces. Coefficient alpha was 0.98 for Perceived Usefulness and 0.94 for Perceived Ease of Use, and multitrait–multimethod analyses indicated appropriate convergent and divergent validity. A factor analysis of the data had the expected pattern of association of items with factors. Both Perceived Usefulness and Perceived Ease of Use (pooled data) correlated significantly with self-predictions of likelihood of use if the product was available at the participants’ place of work (respectively,  $r = 0.85$  and  $0.59$ , both  $p < 0.001$ ).

**Figure 4.2: Sample screen from the survey.**



The survey was conducted with the participants for the subjective evaluation of the ITG. Our personal preference for the style of survey questions was to use the Likert scale. Likert scale was used to evaluate each item in the survey from 1 as “extremely unlikely” and up to 7 as “extremely likely”. These questionnaires most commonly 7-point scale format and studies were proposed. By providing a range of responses, Likert scales helped us to gain greater insight into how much a dentist agrees with a particular statement. On the other hand, one downside to Likert scales was the potential for acquiescence bias, which was the tendency for dentists to agree with statements (Lowdermilk 2013, p.81). One hundred dentists who downloaded ITG app from Apple App Store attended this survey voluntarily. The overall usability of the ITG was evaluated by the final version (2.0) of the ITG.



Davis (1989) validated new usability scales for two specific variables, perceived usefulness and perceived ease of use. He tested two variables were used to develop scale items for content validity and reliability. For the evaluation part, two studies were discussed and these scales were performed 152 users and four application programs. As a result of these two studies, usefulness had directly relationship with ease of use. In order to the evaluation of the ITG app, these perceived usefulness and perceived ease of use usability scales were implemented for this project.

#### 4.2.2 Ease of Use

**Table 4.1: Survey questions for perceived ease of use**

<b>Survey items for perceived ease of use.</b>	
<b>Question No</b>	<b>Questions</b>
1	Learning to operate the ITG app would be easy for me.
2	I would find it easy to get the ITG app to do what I want it to do.
3	My interaction with the ITG app would be clear and understandable.
4	I would find the ITG app to be flexible to interact with.
5	It would be easy for me to become skillful at using the ITG app.
6	I would find the ITG app easy to use.

#### 4.2.3 Usefulness

**Table 4.2: Survey questions for perceived usefulness**

<b>Survey items for perceived usefulness.</b>	
<b>Question No</b>	<b>Questions</b>
1	Using ITG in my job would enable me to accomplish tasks more quickly.
2	Using the ITG app would improve my job performance.
3	Using the ITG in my job would increase my productivity.
4	Using the ITG app would enhance my effectiveness on the job.
5	Using the ITG app would make it easier to do my job.
6	I would find the ITG app useful in my job.

### 4.3 RESULTS

The survey was conducted with the participants for the subjective evaluation of the ITG. The survey consisted of three parts. Part I was about dentists' demographic information, part II was about ease of use and part III was about perceived usefulness. Seven points Likert scales were used to evaluate each item in the survey from 1 as “extremely unlikely” and up to 7 as “extremely likely” and calculated each item mean values. One hundred participants attended to the survey voluntarily.

#### 4.3.1 The Findings on the General Information of the Survey Participants

In this section shows us some demographic information about dentists such as gender, country, age, work experience, experience with iPad usage, iPad model, the situation of whether iPad has 3G/4G or not. These demographic information will constitute the survey data source. In the survey, the participants are all around the world, especially in USA and %76 of them are male and %24 of them are female. Generally, they are young dentists and not experienced in dentistry and implantology. They are familiar with iPad tablet device and iOS applications. Most of them have new iPad with cellular.

**Table 4.3: The frequency of participants in terms of gender**

<b>Gender</b>	<b>Frequency</b>	<b>Percent</b>
Female	24	24,0
Male	76	76,0
Total	100	100,0

**Table 4.4: The frequency of participants in terms of age**

		<b>Frequency</b>	<b>Percent</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
Valid	-24	18	18,0	18,0	18,0
	25-34	31	31,0	31,0	49,0
	35-44	24	24,0	24,0	73,0
	45-54	20	20,0	20,0	93,0
	55+	7	7,0	7,0	100,0
	Total	100	100,0	100,0	

**Table 4.5: The frequency of participants in terms of country**

		Frequency	Percent	Valid Per.	Cumulative P.
Valid	USA	26	26,0	26,0	26,0
	Brazil	14	14,0	14,0	40,0
	Italy	11	11,0	11,0	51,0
	Mexico	8	8,0	8,0	59,0
	Russia	8	8,0	8,0	67,0
	UK	9	9,0	9,0	76,0
	Spain	8	8,0	8,0	84,0
	Turkey	3	3,0	3,0	87,0
	China	2	2,0	2,0	89,0
	France	4	4,0	4,0	93,0
	Others	7	7,0	7,0	100,0
Total		100	100,0	100,0	

**Table 4.6: The frequency of participants in terms of work experience**

		Frequency	Percent	Valid Per.	Cumulative P.
Valid	0-4	32	32,0	32,0	32,0
	5-9	18	18,0	18,0	50,0
	10-14	16	16,0	16,0	66,0
	15-19	16	16,0	16,0	82,0
	20+	18	18,0	18,0	100,0
	Total		100	100,0	100,0

**Table 4.7: The frequency of participants in terms of experience with iPad**

		Frequency	Percent	Valid Per.	Cumulative P.
Valid	0-5	33	33,0	33,0	33,0
	6-11	11	11,0	11,0	44,0
	12-17	13	13,0	13,0	57,0
	18-25	14	14,0	14,0	71,0
	26+	29	29,0	29,0	100,0
	Total		100	100,0	100,0

**Table 4.8: The frequency of participants in terms of iPad model**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	iPad	28	28,0	28,0	28,0
	iPad2	28	28,0	28,0	56,0
	iPad3	44	44,0	44,0	100,0
	Total	100	100,0	100,0	

**Table 4.9: The frequency of participants in terms of ipad with cellular**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Without 3G	33	33,0	33,0	33,0
	3G-4G	67	67,0	67,0	100,0
	Total	100	100,0	100,0	

#### **4.3.2 The Findings on Perceived of the Ease of Use**

The average of the score that obtained from the measurement of the ease of use of the dentists resulted as 4.93. As it was stated in the heading which called “the survey”, minimum score is 1.00 and maximum score is 7.00. These scores can be obtained by the data collecting means. When this information is taken into consideration, the average of the survey result, which is 4.93, means “slightly likely” according to Table 4.10.

**Table 4.10: The reference table of the survey according to likert scale**

1.000-1.857	Extremely Unlikely
1.857-2.714	Quite Unlikely
2.714-3.571	Slightly Unlikely
3.571-4.428	Neither
4.428-5.285	Slightly likely
5.285-6.142	Quite likely
6.142-7.000	Extremely likely

Table 4.11 shows us some information such as frequency, mean value and standart deviation about the questions concerning the “ease of use” part of the survey.

**Table 4.11: Frequency and mean values for each perceived ease of use items.**

		<i>Unlikely</i>	1	2	3	4	5	6	7	<i>Likely</i>	Mean	Std. Dev.
			Extremely	Quite	Sightly	Neither	Sightly	Quite	Extremely			
<b>1</b>	Learning to operate the ITG app would be easy for me.		1	3	11	31	15	25	14		4,87	1,41
<b>2</b>	I would find it easy to get the ITG app to do what I want it to do.		1	1	7	38	14	28	11		4,91	1,28
<b>3</b>	My interaction with the ITG app would be clear and understandable.		1	3	7	38	16	21	14		4,84	1,36
<b>4</b>	I would find the ITG app to be flexible to interact with.		1	3	4	38	20	24	10		4,85	1,27
<b>5</b>	It would be easy for me to become skillful at using the ITG app.		1	2	5	34	15	16	27		5,16	1,45
<b>6</b>	I would find the ITG app easy to use.		1	2	7	32	19	27	12		4,95	1,31

#### 4.3.2.1 The findings on perceived ease of use in terms of gender

In order to find out whether the score obtained from the answers to the ease of use survey questions shows a significant difference in terms of gender, Independent - T test was applied and the findings were stated in the Table 4.13.

**Table 4.12: Descriptive statistics for perceived ease of use in terms of gender**

Gender	N	Mean	Std. Deviation	Std. Error Mean
Male	76	4,662281	1,271037	0,145798
Female	24	5,7778	0,968921	0,197780

**Table 4.13: Independent - samples t test result for perceived ease of use in terms of gender**

	Levene's test for equality of variances					T-Test for equality of Means			
	F.	Sig.	t	df	Sig (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence interval of the Difference	
								Lower	Upper
<b>Equal Variances assumed</b>	3,386	,069	-3,947	98	,000	-1,115	,28260	-1,67631	-,55468
<b>Equal Variances not assumed</b>			-4,540	50,240	,000	-1,115	,24571	-1,60896	-,62203

In Table 4.13 shows us the independent samples t test result for perceived ease of use in terms of gender. Independent - T test determines if the two conditions have about the same or different amounts of variability between scores. Based on the data gathered from the analysis, in Table 4.13, we see that the significance is .069, which is greater than .05. So that we can assume the variances are approximately equal.  $T(98) = -3.947$ . Also, Sig (2-Tailed) provides us to condition means are statistically different for  $p = .000$  which  $p < .05$ . In terms of ease of use criteria, it shows significant difference according to gender variable. Female dentists have found the ITG application easier to use than male dentist have. Mean score for perceived ease of use by female dentists is 5.7778. Mean score for perceived ease of use by male dentists is 4.6623.

#### **4.3.2.2 The findings on perceived ease of use in terms of age**

In order to find out whether the score obtained from the answers to the ease of use survey questions shows a significant difference in terms of age, ANOVA test was applied and the findings were stated in the Table 4.15.

**Table 4.14: Descriptive statistics for perceived ease of use in terms of age**

Age	N	Mean	Std. Deviation	Std. Error
-24	18	4,56	1,00	0,24
25-34	31	5,69	1,18	0,21
35-44	24	4,69	1,39	0,28
45-54	20	4,76	1,22	0,27
55+	7	3,81	0,64	0,24
<b>Total</b>	100	4,93	1,29	0,13

**Table 4.15: ANOVA test result for perceived ease of use in terms of age**

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
<b>Between Groups</b>	31,30628	4	7,826569	5,542559	0,000
<b>Within Groups</b>	134,1482	95	1,412086		
<b>Total</b>	165,4544	99			

As it can be seen in Table 4.15, it was found out that the age variable that was measured in the ease of use criteria showed a significant difference. ( $F=5.54$ ;  $p<0.05$ ). Tukey test was applied in order to find out the differentiation among dentists' age range variable.

**Table 4.16: TUKEY test result for perceived ease of use in terms of age**

	-24	25-34	35-44	45-54	55+
-24		* 0,014			
25-34	* 0,014		*0,021		* 0,002
35-44		*0,021			
45-54					
55+		* 0,002			

As it can be seen in Table 4.16, the differentiation among the scores that were obtained from dentists' age range variable in the "ease of use" criteria, appeared between the dentists which marked the option of "under 24 years and 25-34 years old", "25-34 years old and 35-44 years old" and "25-34 years old and over 55 years" ( $p<0.05$ ).

#### 4.3.2.3 The findings on perceived ease of use in terms of work experience

In order to find out whether the score obtained from the answers to the ease of use survey questions shows a significant difference in terms of work experience, ANOVA test was applied and the findings were stated in the Table 4.18.

**Table 4.17: Descriptive statistics for perceived ease of use in terms of work experience**

<b>Exp.InDent</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>	<b>Std. Error</b>
0-4	32	5,00	1,26	0,22
5-9	18	6,02	0,78	0,18
10-14	16	4,63	1,17	0,29
15-19	16	4,80	1,55	0,39
20+	18	4,10	0,91	0,21
<b>Total</b>	<b>100</b>	<b>4,93</b>	<b>1,29</b>	<b>0,13</b>

**Table 4.18: ANOVA test result for perceived ease of use in terms of work experience**

<b>ANOVA</b>					
	<b>Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>
<b>Between Groups</b>	35,57964	4	8,894909	6,506392	0,000
<b>Within Groups</b>	129,8748	95	1,367103		
<b>Total</b>	165,4544	99			

As it can be seen in Table 4.18, it was found out that the work experience variable that was measured in the ease of use criteria showed a significant difference ( $F=6.51$ ;  $p<0.05$ ). Tukey test was applied in order to find out the differentiation among dentists' work experience variable.

**Table 4.19: TUKEY test result for perceived ease of use in terms of work experience**

	0-4	5-9	10-14	15-19	20+
0-4		* 0,031			
5-9	* 0,031		* 0,007	* 0,026	* 0,000
10-14		* 0,007			
15-19		* 0,026			
20+		* 0,000			



As it can be seen in Table 4.19, the differentiation among the scores that were obtained from dentists' work experience variable in the "ease of use" criteria, appeared between the dentists who marked the option of "from 5 to 9 years and the other work experience options". ( $p < 0,05$ ).

#### 4.3.2.4 The findings on perceived ease of use in terms of experience with iPad

In order to find out whether the score obtained from the answers to the ease of use survey questions shows a significant difference in terms of experience with iPad, ANOVA test was applied and the findings were stated in the Table 4.21.

**Table 4.20: Descriptive statistics for perceived ease of use in terms of experience with iPad**

<b>Exp.InTech</b>	<b>N</b>	<b>Mean</b>	<b>Std. Dev</b>	<b>Std. Err.</b>
0-5	33	4,35	0,90	0,16
6-11	11	4,94	1,33	0,40
12-17	13	4,92	0,91	0,25
18-25	14	5,39	1,69	0,45
26+	29	5,37	1,40	0,26
<b>Total</b>	<b>100</b>	<b>4,93</b>	<b>1,29</b>	<b>0,13</b>

**Table 4.21: ANOVA test result for perceived ease of use in terms of experience with iPad**

<b>ANOVA</b>					
	<b>Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>
<b>Between Groups</b>	19,71899	4	4,929747	3,213535	0,016
<b>Within Groups</b>	145,7355	95	1,534057		
<b>Total</b>	165,4544	99			

As it can be seen in Table 4.21, it was found out that the experience with iPad variable that was measured in the ease of use criteria showed a significant difference ( $F=3,21$ ;  $p < 0,05$ ). TUKEY test was applied in order to find out the differentiation among dentists' experience with iPad variable.

**Table 4.22: TUKEY test result for perceived ease of use in terms of experience with iPad**

	0-5	6-11	12-17	18-25	26+
0-5					* 0,014
6-11					
12-17					
18-25					
26+	* 0,014				

As it can be seen in Table 4.22, the differentiation among the scores that were obtained from dentists' experience with iPad variable in the "ease of use" criteria, appeared between the dentists which marked the option of "under 5 months and over 26 months" ( $p < 0.05$ ).

#### **4.3.2.5 The findings on perceived ease of use in terms of iPad model**

In order to find out whether the score obtained from the answers to the ease of use survey questions shows a significant difference in terms of iPad model, ANOVA test was applied and the findings were stated in the Table 4.24.

**Table 4.23: Descriptive statistics for perceived ease of use in terms of iPad model**

<b>iPad</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>	<b>Std. Error</b>
iPad	28	4,51	1,24	0,23
iPad2	28	4,83	1,43	0,27
iPad3	44	5,26	1,17	0,18
Total	100	4,93	1,29	0,13

**Table 4.24: ANOVA test result for perceived ease of use in terms of iPad model**

<b>ANOVA</b>					
	<b>Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>
<b>Between Groups</b>	9,877605	2	4,938802	3,079275	0,051
<b>Within Groups</b>	155,5768	97	1,603885		
<b>Total</b>	165,4544	99			

As it can be seen in Table 4.24, it was find out that there was nonsignificant difference between iPad model and perceived ease of use. ( $F=3,07$ ;  $p>0,05$ ).

#### 4.3.2.6 The findings on perceived ease of use in terms of iPad celular

In order to find out whether the score obtained from the answers to the ease of use survey questions shows a significant difference in terms of iPad celular option, Independent - T test was applied and the findings were stated in the Table 4.26.

**Table 4.25: iPad celular option group statistics for perceived ease of use**

	3G/4G	N	Mean	Std. Deviation	Std. Error Mean
avgEOU	Without 3G	33	4,8586	1,58011	,27506
	3G-4G	67	4,9652	1,13690	,13889

**Table 4.26: Independent samples t test result for perceived ease of use in terms of celular**

	Levene's test for equality of variances					T-Test for equality of Means			
	F.	Sig.	t	df	Sig (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence internal of the Difference	
								Lower	Upper
<b>Equal Variances assumed</b>	7,849	,006	-,386	98	,700	-,1065	,27612	-,65454	,44137
<b>Equal Variances not assumed</b>			-,346	48,859	,731	-,1065	,30814	-,72586	,51269

As it can be seen in Table 4.26, it was find out that there was no significance between 3G/4G specification and perceived ease of use. ( $F=0,70$ ;  $p>0,05$ ).

### 4.3.3 The Findings On Perceived Usefulness

The average of the score that obtained from the measurement of the usefulness of the dentists resulted as 5.22. As it was stated in the heading which called “the survey”, minimum score is 1.00 and maximum score is 7.00. These scores can be obtained by the data collecting means. When this information is taken into consideration, the average of the survey result, which is 4.93, means “slightly likely” according to Table 4.10.

Table 4.27 shows us some information such as frequency, mean value and standard deviation about the questions concerning the “usefulness” part of the survey.

**Table 4.27: Frequency and mean values for each perceived usefulness item**

		<i>Unlikely</i>	1	2	3	4	5	6	7	<i>Likely</i>	Mean	Std. Deviation
			Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely			
<b>1</b>	Using ITG in my job would enable me to accomplish tasks more quickly.		0	2	2	36	14	33	13		5,13	1,212
<b>2</b>	Using the ITG app would improve my job performance.		0	1	3	33	14	34	15		5,22	1,203
<b>3</b>	Using the ITG in my job would increase my productivity.		0	1	2	37	22	24	14		5,08	1,161
<b>4</b>	Using the ITG app would enhance my effectiveness on the job.		0	1	4	31	17	28	19		5,24	1,248
<b>5</b>	Using the ITG app would make it easier to do my job.		0	1	2	31	14	31	21		5,35	1,234
<b>6</b>	I would find the ITG app useful in my job.		0	1	3	30	15	34	17		5,29	1,209

#### 4.3.3.1 The findings on perceived usefulness in terms of gender

In order to find out whether the score obtained from the answers to the usefulness survey questions shows a significant difference in terms of gender, Independent - T test was applied and the findings were stated in the Table 4.29.

**Table 4.28: Descriptive statistics for perceived usefulness in terms of gender**

Gender	N	Mean	Std. Deviation	Std. Error Mean
Male	76	5,0044	1,12611	,12917
Female	24	5,8958	,96285	,19654

**Table 4.29: Independent - samples t test result for perceived usefulness in terms of gender**

	Levene's test for equality of variances					T-Test for equality of Means			
	F.	Sig.	t	df	Sig (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence internal of the Difference	
								Lower	Upper
<b>Equal Variances assumed</b>	3,33	,071	-3,493	98	,001	-,8914	,2552	-1,3979	-,3849
<b>Equal Variances not assumed</b>			-3,790	44,609	,000	-,8914	,2351	-1,3652	-,4176

In Table 4.29 shows us the independent samples t test result for perceived usefulness in terms of gender. Independent - T test determines if the two conditions have about the same or different amounts of variability between scores. Based on the data gathered from the analysis, in Table 4.29, we see that the significance is .071, which is greater than .05. So that we can assume the variances are approximately equal.  $T(98) = -3.493$  Also, Sig (2-Tailed) provides us to condition means are statistically different for  $p = .001$  which  $p < .05$ . In terms of usefulness criteria, it shows significance according to gender variable. Female dentists have found the ITG application more useful than male dentist have. Mean score for perceived usefulness by female dentists is 5.7778. Mean score for perceived usefulness by male dentists is 4.6623.

#### **4.3.3.2 The findings on perceived usefulness in terms of age**

In order to find out whether the score obtained from the answers to the usefulness survey questions shows a significant difference in terms of age, ANOVA test was applied and the findings were stated in the Table 4.31.

**Table 4.30: Descriptive statistics for perceived usefulness in terms of age**

Age	N	Mean	Std. Deviation	Std. Error
-24	18	4,58	1,03	0,24
25-34	31	5,72	1,13	0,20
35-44	24	5,26	1,19	0,24
45-54	20	5,07	1,07	0,24
55+	7	4,95	0,77	0,29
<b>Total</b>	100	5,22	1,15	0,12

**Table 4.31: ANOVA test result for perceived usefulness in terms of age**

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
<b>Between Groups</b>	15,89767	4	3,974417	3,282362	0,014
<b>Within Groups</b>	115,0298	95	1,21084		
<b>Total</b>	130,9275	99			

As it can be seen in Table 4.31, it was found out that the age variable that was measured in the usefulness criteria showed a significant difference. ( $F=3.28$ ;  $p<0.05$ ). TUKEY test was applied in order to find out the differentiation among dentists' age range variable.

**Table 4.32: TUKEY test result for perceived usefulness in terms of age**

	-24	25-34	35-44	45-54	55+
-24		* 0,007			
25-34	* 0,007				
35-44					
45-54					
55+					

As it can be seen in Table 4.32, the differentiation among the scores that were obtained from dentists' age range variable in the "usefulness" criteria, appeared between the dentists which marked the option of "under 24 years and 25-34 years old" ( $p<0.05$ ).

### 4.3.3.3 The findings on perceived usefulness in terms of work experience

In order to find out whether the score obtained from the answers to the usefulness survey questions shows a significant difference in terms of work experience, ANOVA test was applied and the findings were stated in the Table 4.34.

**Table 4.33: Descriptive statistics for perceived usefulness in terms of work experience**

<b>Exp.InDent</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>	<b>Std. Error</b>
0-4	32	5,09	1,34	0,24
5-9	18	5,97	0,82	0,19
10-14	16	5,13	1,07	0,27
15-19	16	5,25	1,11	0,28
20+	18	4,75	0,90	0,21
<b>Total</b>	<b>100</b>	<b>5,22</b>	<b>1,15</b>	<b>0,12</b>

**Table 4.34: ANOVA test result for perceived usefulness in terms of work experience**

<b>ANOVA</b>					
	<b>Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>
<b>Between Groups</b>	14,87281	4	3,718203	3,043645	0,021
<b>Within Groups</b>	116,0547	95	1,221628		
<b>Total</b>	<b>130,9275</b>	<b>99</b>			

As it can be seen in Table 4.34, it was found out that the work experience variable that was measured in the usefulness criteria showed a significant difference ( $F=3,04$ ;  $p<0,05$ ). TUKEY test was applied in order to find out the differentiation among dentists' work experience variable.

**Table 4.35: TUKEY test result for perceived usefulness in terms of work experience**

	0-4	5-9	10-14	15-19	20+
0-4					
5-9					* 0,011
10-14					
15-19					
20+		* 0,011			

As it can be seen in Table 4.35, the differentiation among the scores that were obtained from dentists' work experience variable in the "usefulness" criteria, appeared between the dentists who marked the option of "from 5 to 9 years and over 20 years". ( $p < 0,05$ ).

#### 4.3.3.4 The findings on perceived usefulness in terms of experience with iPad

In order to find out whether the score obtained from the answers to the usefulness survey questions shows a significant difference in terms of experience with iPad, ANOVA test was applied and the findings were stated in the Table 4.37.

**Table 4.36: Descriptive statistics for perceived usefulness in terms of experience with iPad**

<b>Exp.InTech</b>	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>	<b>Std. Error</b>
0-5	33	4,62	0,96	0,17
6-11	11	5,15	0,89	0,27
12-17	13	5,33	1,08	0,30
18-25	14	5,80	1,39	0,37
26+	29	5,59	1,10	0,20
<b>Total</b>	<b>100</b>	<b>5,22</b>	<b>1,15</b>	<b>0,12</b>

**Table 4.37: ANOVA test result for perceived usefulness in terms of experience with iPad**

<b>ANOVA</b>					
	<b>Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>
<b>Between Groups</b>	20,7335	4	5,183374	4,468669	0,002
<b>Within Groups</b>	110,194	95	1,159937		
<b>Total</b>	130,9275	99			

As it can be seen in Table 4.37, it was found out that the experience with iPad variable that was measured in the usefulness criteria showed a significant difference ( $F=4,46$ ;  $p < 0,05$ ). TUKEY test was applied in order to find out the differentiation among dentists' experience with iPad variable.



**Table 4.38: TUKEY test result for perceived usefulness in terms of experience with iPad**

	0-5	6-11	12-17	18-25	26+
0-5				* 0,008	* 0,005
6-11					
12-17					
18-25	* 0,008				
26+	* 0,005				

As it can be seen in Table 4.38, the differentiation among the scores that were obtained from dentists' experience with iPad variable in the "usefulness" criteria, appeared between the dentists which marked the option of "under 5 months and 18-25 months" and "under 5 months and over 26 months" ( $p < 0.05$ ).

#### 4.3.3.5 The findings on perceived usefulness in terms of iPad model

In order to find out whether the score obtained from the answers to the usefulness survey questions shows a significant difference in terms of iPad model, ANOVA test was applied and the findings were stated in the Table 4.40.

**Table 4.39: Descriptive statistics for perceived usefulness in terms of iPad model**

iPad	N	Mean	Std. Deviation	Std. Error
iPad	28	4,58	1,18	0,22
iPad2	28	5,40	1,13	0,21
iPad3	44	5,51	1,00	0,15
Total	100	5,22	1,15	0,12

**Table 4.40: ANOVA test result for perceived usefulness in terms of iPad generation**

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
<b>Between Groups</b>	15,8834	2	7,941699	6,696083	0,002
<b>Within Groups</b>	115,0441	97	1,186022		
<b>Total</b>	130,9275	99			

As it can be seen in Table 4.40, it was found out that the iPad model variable that was measured in the usefulness criteria showed a significant difference ( $F=6,69$ ;  $p<0,05$ ). TUKEY test was applied in order to find out the differentiation among dentists' iPad model variable.

**Table 4.41: TUKEY test result for perceived usefulness in terms of iPad cellular option**

	iPad	iPad2	iPad3
iPad		* 0,017	* 0,002
iPad2	* 0,017		
iPad3	* 0,002		

As it can be seen in Table 4.41, the differentiation among the scores that were obtained from dentists' iPad model variable in the "usefulness" criteria, appeared between the dentists which marked the option of "iPad and iPad2" and "iPad and iPad3" ( $p<0.05$ ).

#### 4.3.3.6 The findings on perceived usefulness in terms of iPad celular

In order to find out whether the score obtained from the answers to the usefulness survey questions shows a significant difference in terms of iPad cellular option, Independent - T test was applied and the findings were stated in the Table 4.43.

**Table 4.42: Descriptive statistics for perceived usefulness in terms of iPad celular**

	3G/4G	N	Mean	Std. Deviation	Std. Error Mean
avgUse	Without 3G	33	5,3485	1,16321	,20249
	3G-4G	67	5,1542	1,14677	,14010

**Table 4.43: Independent samples t test result for perceived usefulness in terms of cellular**

	Levene's test for equality of variances					T-Test for equality of Means			
	F.	Sig.	t	df	Sig (2-tailed)	Mean Diff.	Std. Error Diff.	95% Confidence interval of the Difference	
								Lower	Upper
<b>Equal Variances assumed</b>	1,320	,253	,793	98	,430	-1,942	,24503	-,29200	,68051
<b>Equal Variances not assumed</b>			,789	62,974	,433	-1,942	,24623	-,29780	,68631

As it can be seen in Table 4.43, it was found out that there was nonsignificant difference between iPad cellular option and perceived usefulness. ( $F=0,430$ ;  $p>0,05$ ).

According to the survey results, using the ITG app gives dentists greater control of their work. Dentists expressed the ITG application saves their time and effort. Overall, dentists found the ITG application easy to use and useful.

## 5. CONCLUSION

Mobile and tablet devices are widely used in the daily life for several purposes. There has been substantial growth in tablet device sales in recent years. As mobile technology becomes a part of everyday life, supportive learning is important for people who are interested in patient education. Previous studies show that tablet applications, as supportive learning tools to patient education, are a great way to educate patients and provide a visual guide when dentists are explaining their treatment procedures. The portability of iPad provides dentists flexibility in communicating with the patients as well as in their continuing education courses to communicate with the dentists anywhere and anytime. Explaining the benefits of treatment, the consequences of untreated cases, and demonstrating dental concepts from simple fillings to complex surgical and implant procedures are one of the most difficult daily tasks for the dental professional. Using 3D illustrations in the ITG application is a very nice way to explain these concepts to patients. The ITG app is an invaluable tool for implant case presentations.

User centered system design process provides a framework for developing products that dentists will use this application, if the ITG app meets the dentists' needs. In this thesis, the processes for designing and evaluating the ITG app for dentists were introduced, and the initial design sketches, wireframes, mockups and prototypes were created. Current medical, dental and interactive education programs were inspected first for determining the contents and required functionality. The needs and preferences of the dentists were identified by their direct participation. Apple human interface guidelines were analyzed and implemented to the application for better interaction and universal acceptance. The way of displaying relatively huge content on a tablet screen was the primary challenge in this project, which was also solved with the actual users' participation to the design phase. The solutions were generated to organize the user interface objects for the benefits of dentists.

Finally, Implant Treatment Guide application was developed and suggested. The usability of the ITG completed as the second part of the thesis. Early testing procedure was a useful way to see the interaction problems. Therefore, heuristic evaluation, perceived usefulness and perceived ease of use techniques were used to improve the usability of the ITG application. The usability experts evaluated the initial prototype. The user interfaces were reviewed and modified based on the suggestions done by the experts.

In the final evaluation phase, an online survey was conducted with the dentists to test ease of use and usefulness of the ITG app. One hundred dentists from all over the world filled the online survey on their tablet devices. The survey was designed including three pages with nineteen items by considering Technology Acceptance Model in the Human-Computer Interaction research field. First page had seven questions about demographic information. Second page of the survey was related to the ITG's ease of use. The last page of the survey contained usefulness questions of the ITG. According to this research, tablet devices of Apple are effective and convenient platform for many educational tasks, especially in medical field.

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## **APPENDICES**

## APPENDIX A. FIGURES

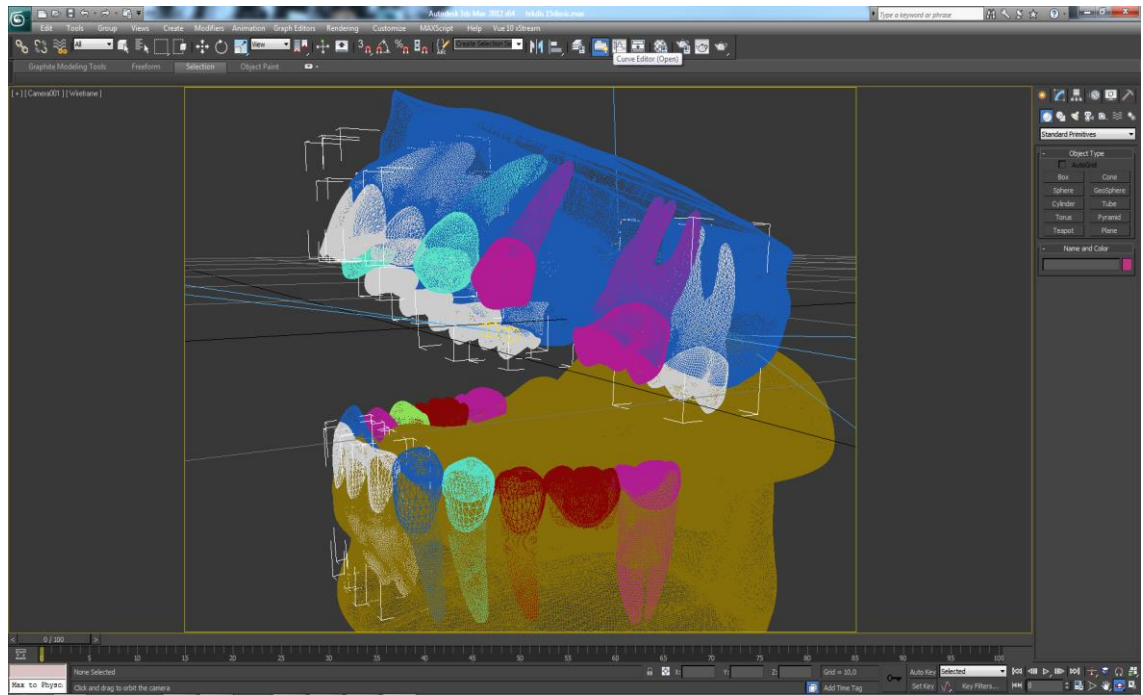
Figure A.1: The book version of the ITG



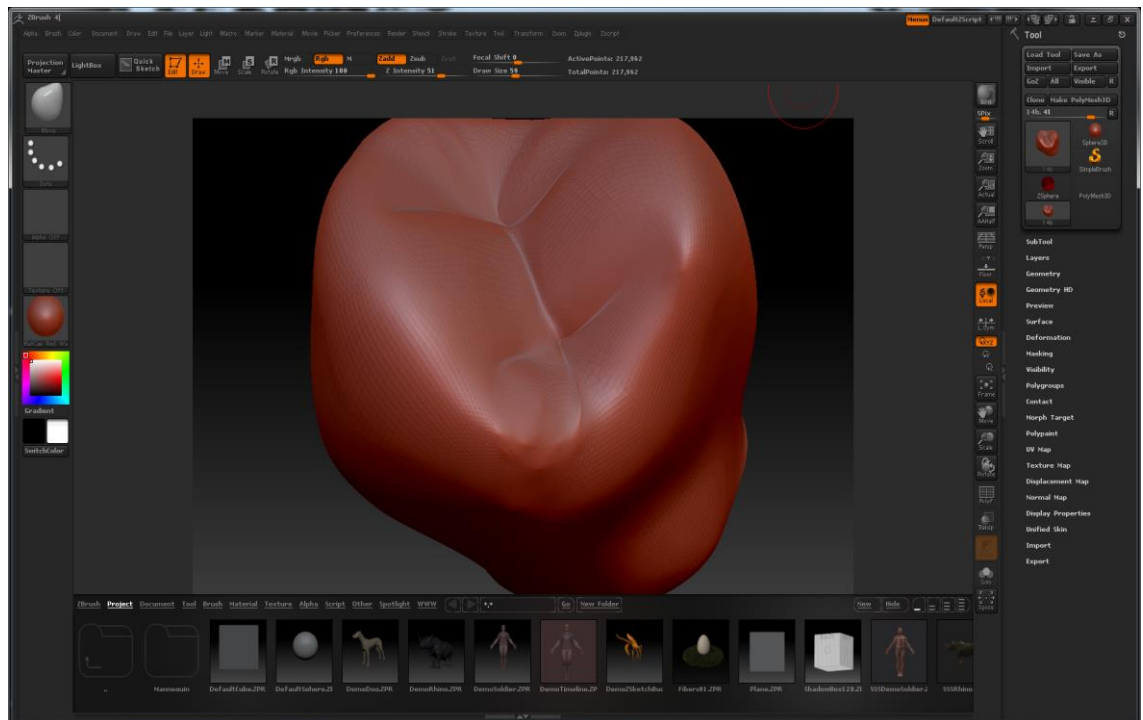
Figure A.2: Real case photography



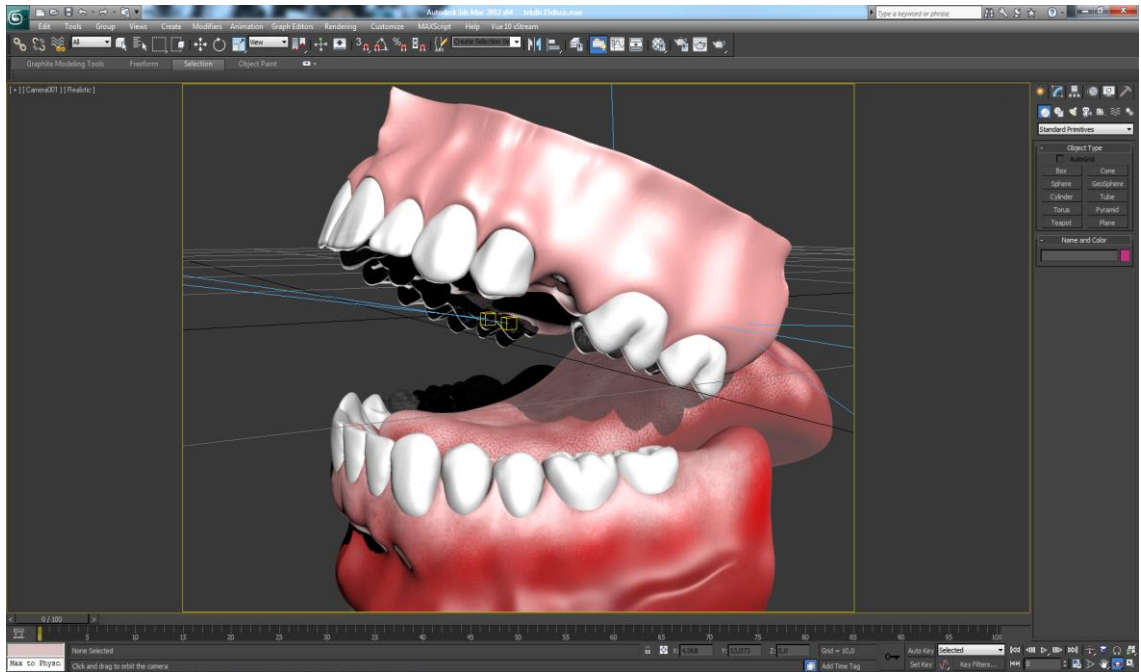
**Figure A.3: Content creation stage 1 - Autodesk 3DsMax wireframe**



**Figure A.4: Content creation stage 2 - Pixologic Zbrush**



**Figure A.5: Content creation stage 3 - Autodesk 3DsMax first render**



**Figure A.6: Content creation stage 4 - Autodesk Mudbox**

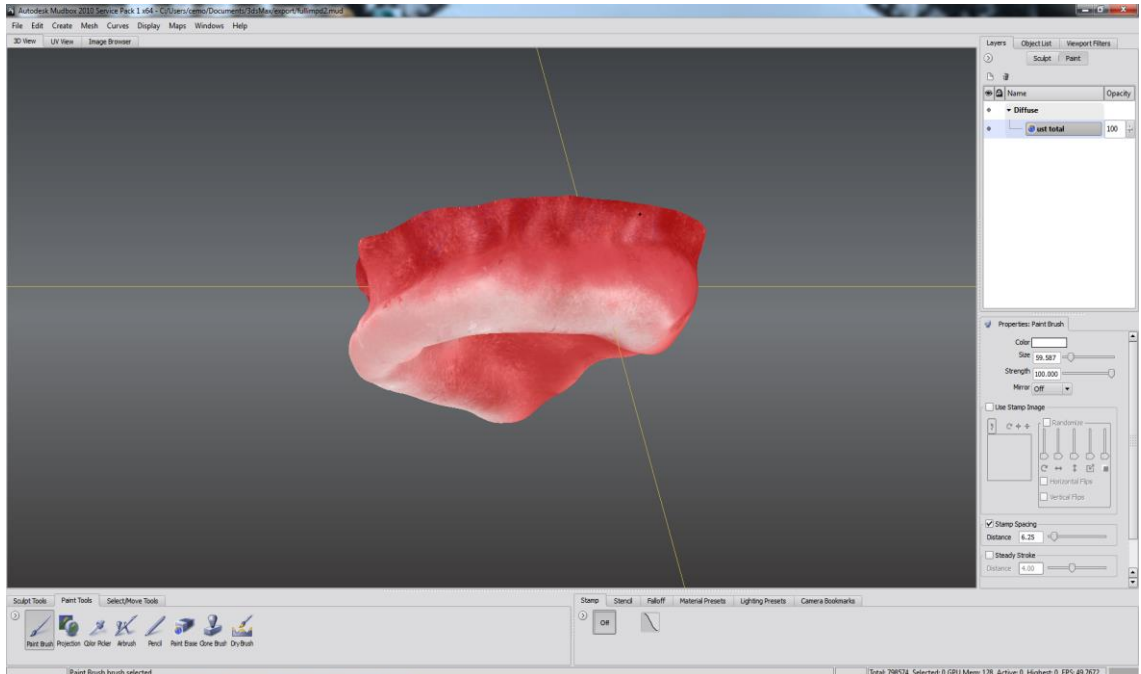




Figure A.7: Content creation stage 5 – Autodesk Material Editor

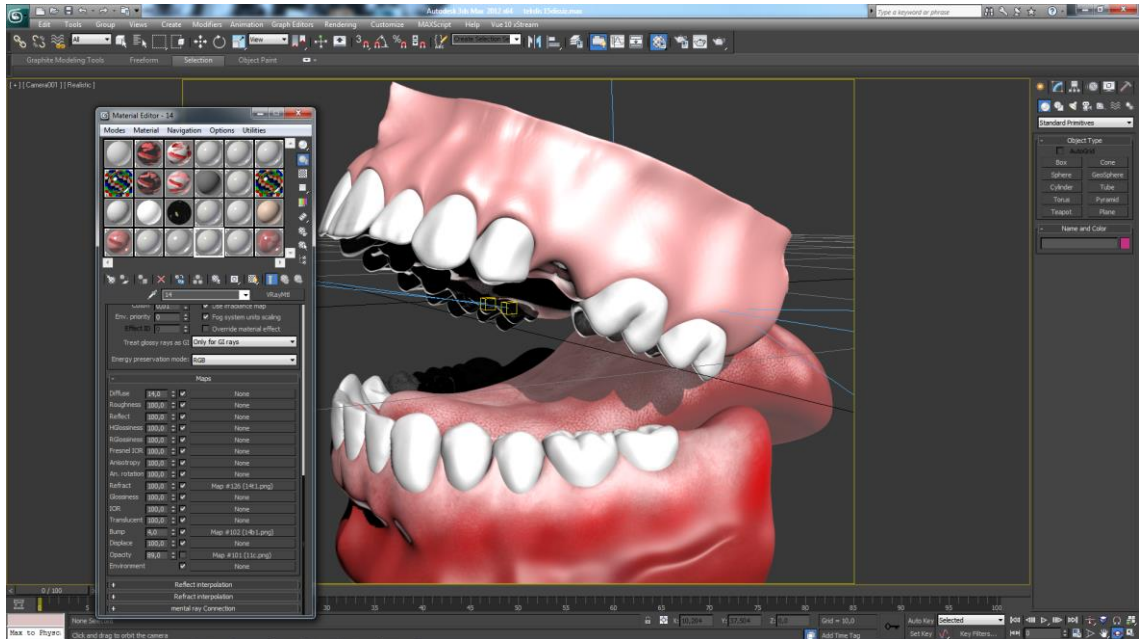
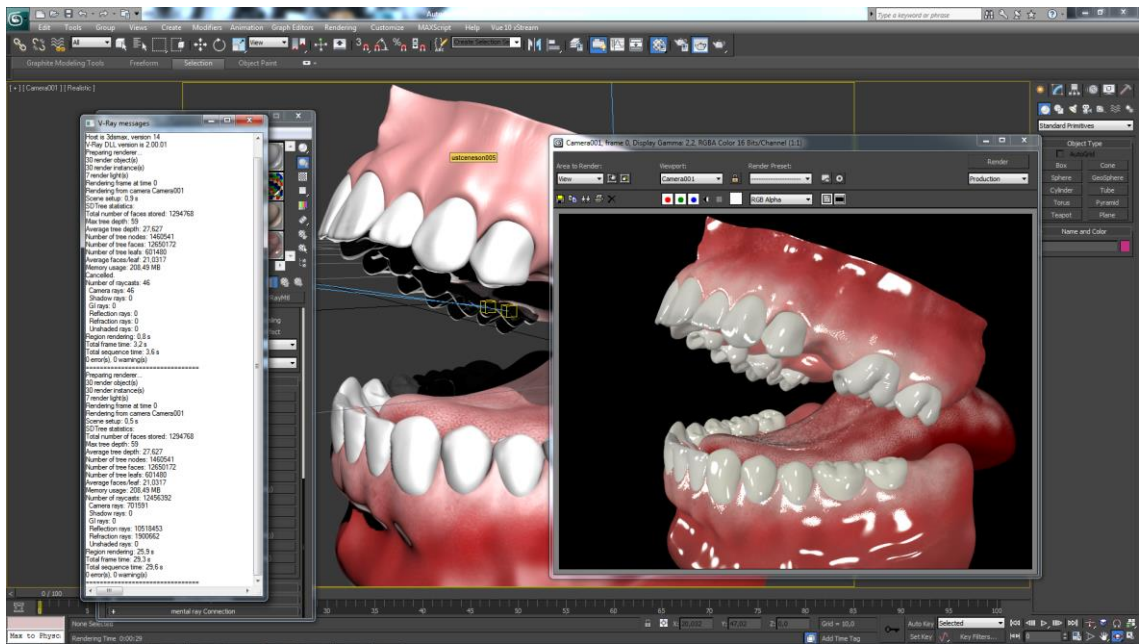
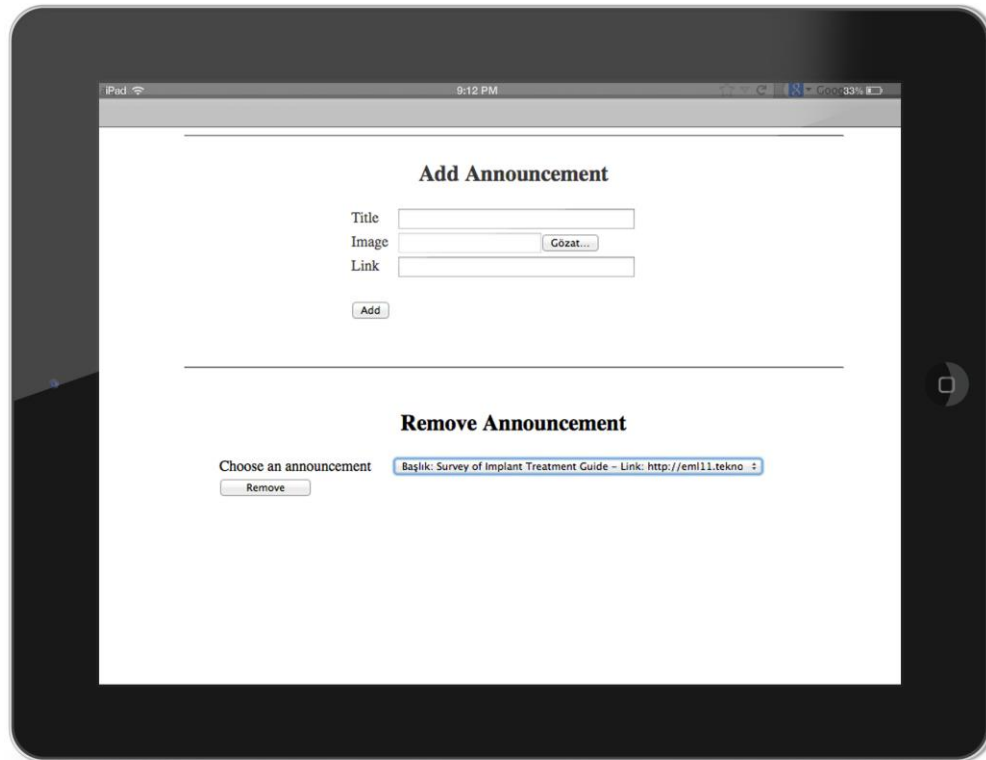


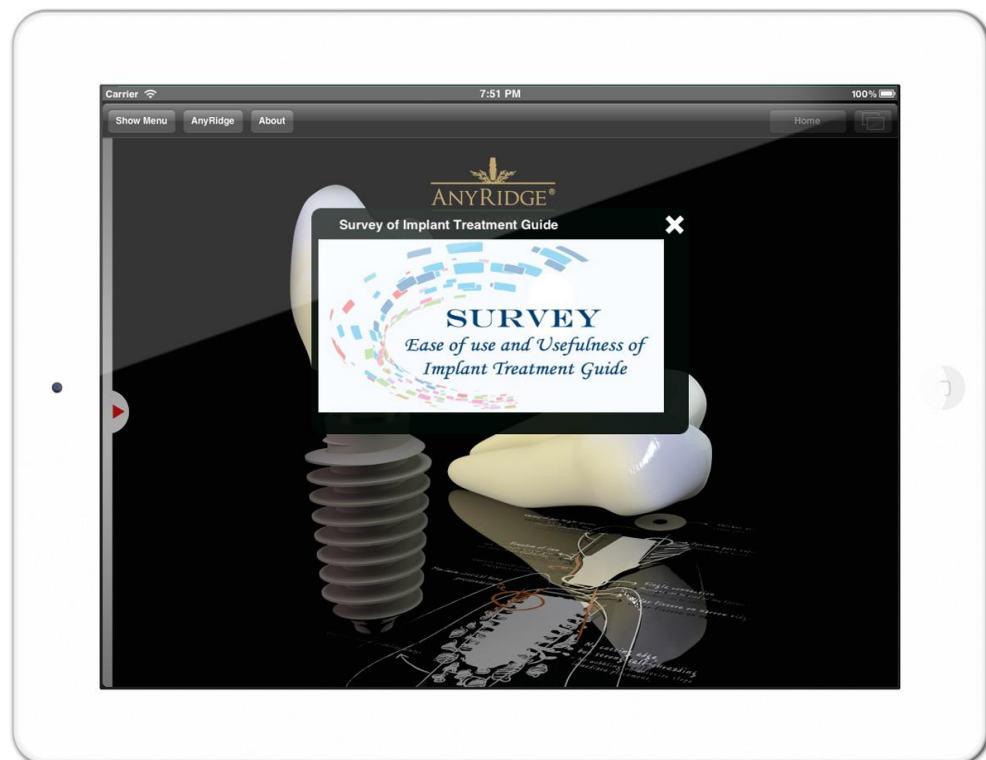
Figure A.8: Content creation stage 5 – Autodesk Render with Vray



**Figure A.9: Admin page of the ITG app**



**Figure A.10: Announcement screen of the ITG app**



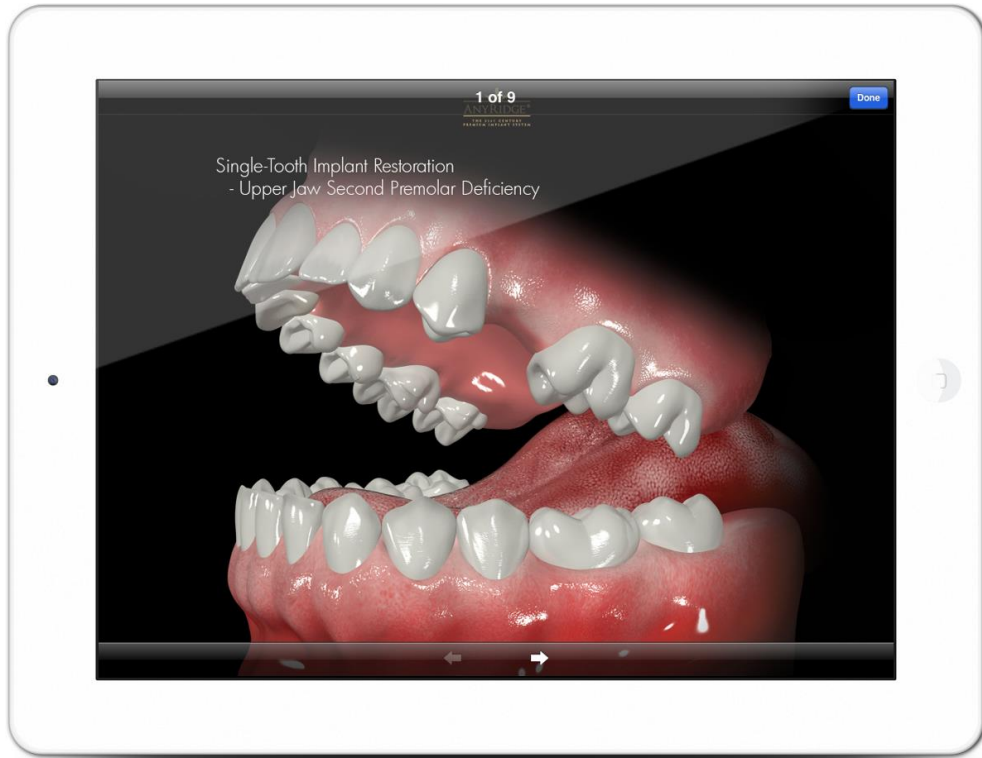
**Figure A.11: Home page screen of the ITG app**



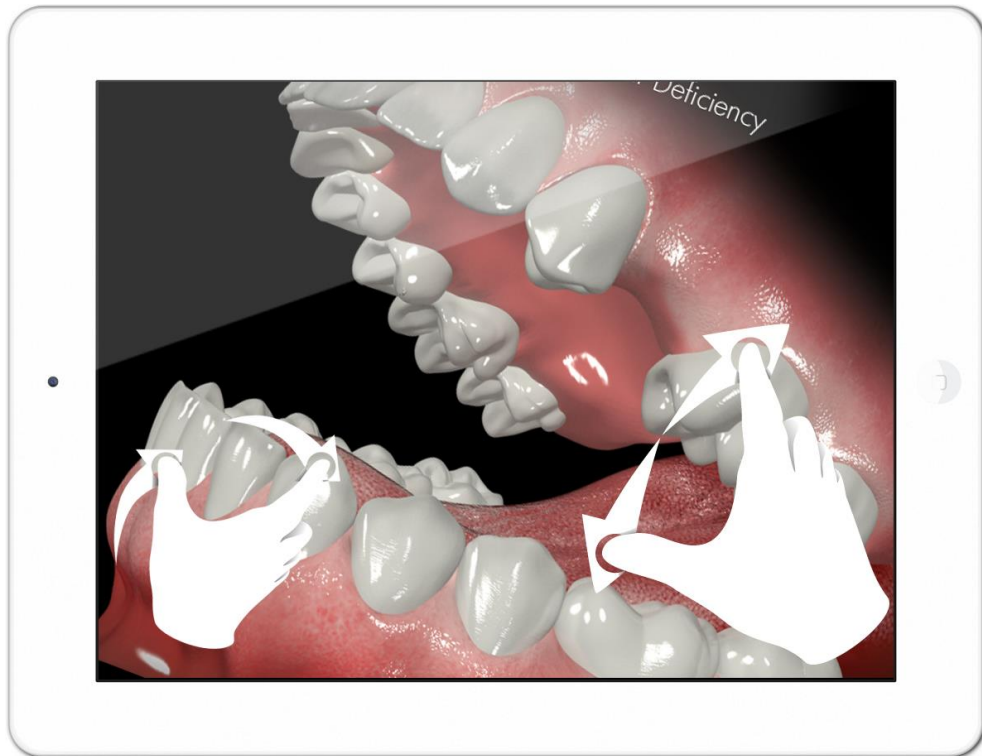
**Figure A.12: Main category and sub category screen of the ITG app**



**Figure A.13: Content screen of the ITG app**



**Figure A.14: Content screen of the ITG app while pinching and rotating**



## APPENDIX B. TABLES

**Table B.1: Fixed prostheses main category items**

<b>1- FIXED PROSTHESES</b>
1.1- Single Tooth Restoration
1.2- Single Tooth Restoration (Anterior Region)
1.3- Implant Supported Fixed Partial Restoration
1.4- Internal Sinus Lifting & Implantation
1.5- External Sinus Lifting & Implantation
1.6- Full Mouth Reconstruction (Upper Jaw, 6 Implants)
1.7- Full Mouth Reconstruction (Upper Jaw, 8 Implants)
1.8- Full Mouth Reconstruction (Lower Jaw, 6 Implants)
1.9- Full Mouth Reconstruction (Upper Jaw, 8 Implants)

**Table B.2: Single tooth restoration**

<b>1.1 Single Tooth Restoration</b>
1.1.1 Upper Jaw Second Premolar Deficiency
1.1.2 Panoramic Radiography
1.1.3 Bone Loss, Tilting And Elongation of the Contralateral Tooth If Left Untreated
1.1.4 Conventional Treatment: Preparation of the Teeth
1.1.5 Conventional Treatment: Bridge Fabrication
1.1.6 Panoramic View After Implantation
1.1.7 Final Restoration
1.1.8 Cross-Sectional View of the Implant Site
1.1.9 Transparent View

**Table B.3: Single tooth restoration (anterior region)**

<b>1.2 Single Tooth Restoration (Anterior Region)</b>
1.2.1 Upper Jaw Central Incisor Deficiency
1.2.2 Panoramic Radiography - Before
1.2.3 Bone Loss Over Time, Irreversible Unesthetic Results
1.2.4 Bone Loss Over Time Panoramic View
1.2.5 Conventional Treatment: Preparation Of The Teeth
1.2.6 Conventional Treatment: Bridge Fabrication
1.2.7 Panoramic View After Implantation
1.2.8 Titanium Angled Abutment / Porcelain-Fused-To-Metal Crown
1.2.9 Final Restoration And Cross-Sectional View Of The Bone
1.2.10 Zirconium Abutment
1.2.11 Final Restoration And Cross-Sectional View of the Bone

**Table B.4: Implant supported fixed partial restoration**

<b>1.3 Implant Supported Fixed Partial Restoration</b>
1.3.1 Upper Jaw 2nd Premolar, 1st & 2nd Molar Deficiency
1.3.2 Panoramic Radiography - Before
1.3.3 Conventional Treatment : Removable Partial Denture
1.3.4 Deformation Due to Partial Denture
1.3.5 Bone Loss
1.3.6 Pneumatization Of Maxillary Sinus
1.3.7 Implantation
1.3.8 Panoramic View
1.3.9 Cross-Sectional View of the Implant
1.3.10 Cross-Sectional View, Close-Up
1.3.11 Final Restoration, Transparent View

**Table B.5: Internal sinus lifting and implantation**

<b>1.4 Internal Sinus Lifting &amp; Implantation</b>
1.4.1 Upper Jaw 2nd Premolar, 1st & 2nd Molar Deficiency
1.4.2 Pneumatization of Maxillary Sinus
1.4.3 Panoramic view
1.4.4 Panoramic Views After Sinus Lifting & Implantation
1.4.5 Sinus Lifting, Grafting & Implantation
1.4.6 Abutments Delivered
1.4.7 Panoramic Views After Final Prosthesis
1.4.8 Cross-sectional View of Implants
1.4.9 Transparent View

**Table B.6: External sinus lifting and implantation**

<b>1.5 External Sinus Lifting &amp; Implantation</b>
1.5.1 Upper Jaw 2nd Premolar, 1st & 2nd Molar Deficiency
1.5.2 Severe Pneumatization of Maxillary Sinus
1.5.3 Panoramic View
1.5.4 Panoramic Views After Sinus Lifting & Implantation
1.5.5 Sinus Lifting, Grafting & Implantation
1.5.6 Abutments Delivered
1.5.7 Panoramic Views After Final Prosthesis
1.5.8 Cross-sectional View of Implants
1.5.9 Transparent View

**Table B.7: Full mouth restoration (upper jaw, 6 implants)**

<b>1.6 Full Mouth Restoration (Upper Jaw, 6 Implants)</b>
1.6.1 Loss of Vertical Dimension
1.6.2 Edentulous Upper & Lower Jaw
1.6.3 Panoramic View of Edentulous Upper & Lower Jaw
1.6.4 Edentulous Upper Jaw, 6 implants
1.6.5 Following Osteointegration Abutments Delivered
1.6.6 Cementation of Final Restoration
1.6.7 Transparent View
1.6.8 Final Restoration
1.6.9 Panoramic View

**Table B.8: Full mouth restoration (upper jaw, 8 implants)**

<b>1.7 Full Mouth Restoration (Upper Jaw, 8 Implants)</b>
1.7.1 Loss of Vertical Dimension
1.7.2 Edentulous Upper & Lower Jaw
1.7.3 Panoramic View of Edentulous Upper & Lower Jaw
1.7.4 Edentulous Upper Jaw, 8 implants
1.7.5 Following Osteointegration Abutments Delivered
1.7.6 Abutments Delivered, Occlusal View
1.7.7 Transparent View
1.7.8 Final Restoration
1.7.9 Panoramic View

**Table B.9: Full mouth restoration (lower jaw, 6 implants)**

<b>1.8 Full Mouth Restoration (Lower Jaw, 6 Implants)</b>
1.8.1 Loss of Vertical Dimension
1.8.2 Edentulous Upper & Lower Jaw
1.8.3 Panoramic View of Edentulous Upper & Lower Jaw
1.8.4 Edentulous Lower Jaw, 6 implants
1.8.5 Following Osteointegration Abutments Delivered
1.8.6 Cementation of Final Restoration
1.8.7 Final Restoration Transparent View
1.8.8 Panoramic View

**Table B.10: Full mouth restoration (lower jaw, 8 implants)**

<b>1.9 Full Mouth Restoration (Lower Jaw, 8 Implants)</b>
1.9.1 Loss of Vertical Dimension
1.9.2 Edentulous Upper & Lower Jaw
1.9.3 Panoramic View of Edentulous Upper & Lower Jaw
1.9.4 Edentulous Lower Jaw, 8 implants
1.9.5 Following Osteointegration Abutments Delivered
1.9.6 Cementation of Final Restoration
1.9.7 Final Restoration Transparent View
1.9.8 Panoramic View



**Table B.11: Overdentures main category items**

<b>2- OVERDENTURES</b>
2.1- Single Tooth Restoration
2.2- Single Tooth Restoration (Anterior Region)
2.3- Implant Supported Fixed Partial Restoration
2.4- Internal Sinus Lifting & Implantation

**Table B.12: Bar-retained removable overdentures (4 implants)**

<b>2.1 Bar-Retained Removable Overdentures, (4 Implants)</b>
2.1.1 Loss of Teeth & Bone
2.1.2 Totally Edentulous Mandible
2.1.3 Panoramic View
2.1.4 Delivery of Octa Abutments
2.1.5 Delivery of Bar Construction
2.1.6 Bar Construction Fixed by screw
2.1.7 Attachment
2.1.8 Overdenture Cross-Section
2.1.9 Delivery of Overdenture
2.1.10 Transparent View

**Table B.13: Bar-retained removable overdentures (2 implants)**

<b>2.2 Bar-Retained Removable Overdentures, (2 Implants)</b>
2.2.1 Loss of Teeth & Bone
2.2.2 Totally Edentulous Mandible
2.2.3 Panoramic View
2.2.4 Delivery of Octa Abutments
2.2.5 Delivery of Bar Construction
2.2.6 Transparent View
2.2.7 Overdenture Reinforcement with Metal Construction
2.2.8 Overdenture Cross-Section

**Table B.14: Ball-retained removable overdentures (2 implants)**

<b>2.3 Ball-Retained Removable Overdentures, (2 Implants)</b>
2.3.1 Loss of Teeth & Bone
2.3.2 Totally Edentulous Mandible
2.3.3 Panoramic View
2.3.4 Delivery of Ball Abutments
2.3.5 Delivery of Attachments
2.3.6 Cross-Section
2.3.7 Transparent View

**Table B.15: Kerator-retained removable overdentures (4 implants)**

<b>2.4 Kerator-Retained Removable Overdentures, (4 Implants)</b>
2.4.1 Loss of Teeth & Bone
2.4.2 Totally Edentulous Mandible
2.4.3 Panoramic View
2.4.4 Delivery of Kerators
2.4.5 Transparent View
2.4.6 Delivery of Attachments
2.4.7 Cross-Section of Attachments
2.4.8 Final Restoration
2.4.9 Transparent View

## CURRICULUM VITAE

**Name Surname :** Erokan CANBAZOĞLU  
**Address :** Abide-i Hürriyet Tepesi No: 316  
Şişli / İSTANBUL  
**Date and Place of Birth :** 12.05.1980 ANKARA  
**Languages :** Turkish (native), Tatar (native), English  
(fluent)  
**Elementary Education:** Cumhuriyet Elementary School 1993  
**Secondary Education:** Şehitler High School of Science, 1997  
**B. S. :** Marmara University, 2003  
**M. S. :** Bahçeşehir University, 2013  
**Institute :** The Graduate School of Natural and  
Applied Sciences  
**Program :** Computer Engineering  
**Publications :** -  
**Work Experience :** Şişli Anatolian Vocational High School  
*IT Instructor* (Istanbul, 2003 – 2013)  
TeknoAkademi  
*Web Designer* (Istanbul, 2006 – 2013)