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MULTIMODAL INTERACTION IN ELECTRONIC CUSTOMER LOYALTY MANGMENT SYSTEMS: AN EMPIRICAL INVESTIGATION

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An empirical investigation of the application of multimodal metaphors in electronic Customer Loyalty Management Systems (e-CLMS) to improve usability and user satisfaction

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In the name of God, most compassionate, most merciful

Dedication

This thesis is especially dedicated to the most precious people in my life. First and foremost, to the soul of my dearest late father who always lives in my heart, my compassionate mother for her support my wife for her outstanding partnership and to my sweet daughter (Latin) for her wonderful well-wishing drawings.

I also dedicate this thesis to all my friends for their support and friendship.

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ABSTRACT

This thesis investigates the application of multimodal metaphors in electronic Customer Loyalty Management Systems (e-CLMS) in terms of efficiency, effectiveness, user satisfaction, and understandability of the customisation tasks and information communicated. The potential of users developing loyalty as a result of better usability and user satisfaction is also accessed via questionnaires. The first experiment investigated issues of usability and the users' views of an e-commerce platform developed for these experiments using three conditions with three independent groups. A visual group (VICLMS, n=25) that was communicated information within the platform using text with graphics, a multimodal group (MICLMS, n=25) that usedrecorded speech, earcons and auditory icons and an expressive avatars group(AICLMS, n=25) that was predominantly communicated information using avatars. The second experiment evaluated three avatar-based multimodal conditions using a dependent group (n=50). This experiment evaluated user satisfaction, perceived convenience, enjoyment, ease of use and customisation, and successful completion of user tasks. The conditions were avatars with earcons (AEICLMS), avatars with auditory icons (AAICLMS) and avatars with both earcons and auditory icons (AICLMS).The use of expressive avatars in the e-CLMS interface contributed to the positive predisposition of usersto develop loyalty. Multimodal metaphors contributed more significantly to complex customisation tasks. A set of empirically derived guidelines and a validation approach is suggested for designing multimodal E-CLMS interfaces.

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Acronyms

AAICLMS	Avatar auditory icons interaction customer loyalty management system
AEICLMS	Avatar earcons interaction customer loyalty management system
AICLMS	Avatar interaction customer loyalty management system
CG	Control group
CL	Customer loyalty
CLM	Customer loyalty management
CLMS	Customer loyalty management system
CLV	Customer lifetime value
CRM	Customer relationship management
CV	Control variable
DV	Dependent variable
E-CLMS	Electronic customer loyalty management system
EG	Experimental group
EPC	External product customisation
IMC	Integrated Marketing Communication
IPC	Internal product customisation
IV	Independent variable
M	Management
MC	Mass customisation
MICLMS	Multimodal interaction customer loyalty management system
NOR	Number of requirements
PC	Personal computer
PSC	Product service customisation
T1, T2.....	Task one, task two.....
UI	User interface
VICLMS	Visual interaction customer loyalty management system

Chapter 1: Introduction

1.1 Introduction

This thesis evaluates innovative multimodal interfaces in an e-commerce platform. Currently, e-commerce end-users often experience information overload with the e-commerce interfaces. This overload often weakens user performance and reduces usability. It may also discourage users to customise products or services on-line [69 and 72]. Previous studies have shown a positive impact of incorporating visual or auditory metaphors in multimodal interfaces (e.g. text, speech, photos, or video) [180].

Multimodal metaphors often help support the quality of the user interaction and the ease of use. It may also help to decrease the time taken by users to complete tasks with the interface [133]. Highly usable multimodal interfaces may also help the user to develop loyalty towards the system [180]. However, the field of loyalty within B2C interfaces needs further investigation, particularly with the use of multimodal metaphors in E-CLMS interfaces. This thesis furthers the understanding of e-CLM by investigating the use of multimodal interaction metaphors, to increase usability of mass customisation and potentially facilitate the development of user loyalty.

1.2 Aims and Objectives

The aim is to examine the role of multimodal metaphors on the usability of e-CLMS. Different multimodal designs ranging from a visual-only approach to earcons, auditory icons, and avatars were implemented and evaluated. Usability was measured in terms of efficiency, effectiveness, and user satisfaction.

Post-experimental questionnaires measured the potential of customer loyalty and the user likability of the interface.

The study consisted of two experiments. The first experiment had three conditions. The first condition used visual communication metaphors (e.g. text, colour, and graphics) to convey information, in order for the users to accomplish typical tasks in e-CLMS (VICLMS).The second condition investigated the role of combined multimodal metaphors, that included auditory output (speech and non-speech), in addition to the visual communication metaphors (MICLMS).The third condition used avatars with facial expressions (AICLMS).

The second experiment investigated the use of avatars with three avatar-based conditions. These conditions communicated information to users using avatars with earcons (AEICLMS), avatars with auditory icons (AAICLMS) and avatar with earcons and auditory icons (AICLMS).The evaluation included the measurement of the user likability of the e-CLMS interface. The measurements included questionnaire obtained data on user perceived convenience, enjoyment, customisation and ease of use.

1.3 Method

The method involved a literature review on e-CLMS, user interfaces and multimodality. An experimental e-commerce platform was developed to test the proposed multimodal designs. Hypotheses were formulated, and the experiments were performed using opportunistic samples. A control group (VICLMS) and two experimental groups (MICLMS and AICLMS) were recruited. The three conditions compared usability results between a visual approach, with text and graphics, and two multimodal approaches with speech, earcons, auditory icons and avatars. The parameters measured were efficiency, effectiveness and user satisfaction. These results combined with the views of users, were in turn, used to determine the predisposition of users to developing loyalty. Three groups of users (n=25 for each group) evaluated the three conditions.

Users in each group were requested to complete the six tasks (of increasing difficulty) for each condition.

Results demonstrated that multimodal metaphors improved usability. This led to the gathering of users' views relating to perceived convenience, enjoyment, ease of customisation and use. This experiment evaluated the conditions by using one dependent group (n=50).Users performed six different tasks. The results (including the user views) were recorded and analysed. Finally, the results enabled the development of a set of empirical guidelines, for the use of multimodal metaphors in e-commerce interfaces.

1.4 Hypothesis

The overall hypothesis is that innovative multimodal designs can improve the usability and potential development of user loyalty in e-CLMS interfaces. Multimodal metaphors can improve user effectiveness (successful completion of tasks), efficiency (quick completion of tasks) and the overall user satisfaction.

1.5 Contribution

This thesis introduces innovative multimodal user interfaces for mass customisation and e-commerce transactions in e-CLMS. The designs combine multimodal communication metaphors (e.g. speech, earcons, auditory icons and avatar) in a way that increases the volume of information communicated to users. The multimodal designs increased usability in terms of effectiveness, efficiency and user satisfaction, when compared to a typical visual approach to interaction.

This thesis also gives a set of empirically derived guidelines for the use of multimodal metaphors in e-commerce interfaces. A two-stage validation approach for designers to verify their designs is suggested. This research also contributes to the potential

development of user loyalty, by linking usability to user satisfaction and by extrapolation to user loyalty.

1.6 Outline

The thesis consists of six chapters and nineteen appendices. A brief description of each Chapter is provided below.

Chapter 1introducesthetopic of the thesis, aims and objectives, places the work into context and the contribution to the literature. The importance of the research is described in terms of applying and evaluating multimodal metaphors to e-ECLM interfaces.

Chapter 2 presents a literature review on CLM and multimodal interactions metaphors. A critical assessment on the reviewed literature is also provided, with regard to applying multimodal metaphors in e-CLM interfaces.

Chapter 3 presents the E-CKMS experimental platform and the experimental results of the three conditions evaluated. The conditions were text with graphics (VICLMS), speech, earcons, and auditory icons (MICLMS) and expressive avatars with speech, earcons and auditory icons (AICLMS).

Chapter 4 presents an evaluation of three different avatar-based multimodal designs using the same experimental platform. The method included a quantitative measurement on user task completion and a qualitative measurement of user perceived views on convenience, enjoyment, and customisation.

Chapter 5 presents the empirical derived guidelines and their application. A validation approach to these guidelines during the design phase is also described.

Chapter 6 presents the overall conclusions of the experiments, the limitations of the work, and suggestions for future work.

Chapter 2: CLM and Multimodality

2.1 Introduction

This Chapter discusses the generic model of CLM, the environment of MC, the contributing factors to user loyalty, and the notion of explanation. It also reviews the use of multimodality and its application on MC.

2.2 Customer Loyalty Management (CLM)

Customer Loyalty Management (CLM) is divided into Customer Loyalty(CL) and Management (M) [1]. CL refers to the attitudes and feelings of users towards, for example, a brand or a website. The M is the management that takes the decisions to improve the performance or profitability of a company. Thus, CLM is the process of making informed decisions to increase the level of customer loyalty [1]. The study of customer loyalty requires the understanding of the Customer's Lifetime Value (CLV) to a brand, website or company [2 and 4]. The CLV helps to make business decisions in order to increase customers, purchases, average customer life and profits. Customer Relationship Management (CRM) is the process that aims to develop a long-term customer relationship that, in turn, can be transformed and developed into customer loyalty [1 and 4]. CRM develops the communication with customers in order to create a stronger customer base. CLV and CLM help CRM to improve the customer relationship [2 and 4]. CLM aims to increase level of loyalty and satisfaction, reduces the time and effort of customer interaction [3 and 4]. The concept of CLM on a mass customisation (MC) environment is an effective factor to increase the level of loyalty [1]. MC includes configuration styles (e.g. product customisation and service

customisation) [70 and 71] as well as issues of MC (e.g. overload of information, fussy MC and user confusion) [69, 72 and 123].

2.2.1 The Generic Model of CLM

The elements that have an effect upon CLM are e-commerce, Customer Loyalty, Customer Relationship Marketing (CRM), and Integrated Marketing Communication (IMC).The following sections present a discussion of those elements, as it has been demonstrated to have appositive effect upon the environment of CLM.

2.2.1.1 E-commerce

E-commerce is related to on-line shopping (e.g. purchase an item) and to commercial exchanges and services [5]. It represents a subset of e-business [5]. E-business includes additional elements to e-commerce. E-commerce is divided into Business-to-Customers (B2C), Business-to-Business (B2B), Business Processes, Customer-to-Customer (C2C) and Business-to-Government (B2G) [6]. The process of selling or providing services to customers via the Internet is referred to as Business-to-Costumer (B2C). The process of supplying (or selling) services and products to business via the Internet is referred to as Business-to-Business (B2B). The concept of business processes is the use of information to obtain the needs of customers in order to support the purchasing process. The Customer-to-Customer (C2C) allows the users to conduct business transactions. The Business-to-government category involves transactions between business and government. Thus, products and services are the basis of the application of e-commerce, to allow customers or business to conduct transactions effectively [5 and 7]. Companies often aim to increase customer loyalty by reducing the cost of transactions, improving the quality of the customer interface, and increasing user trust [8]. Therefore, there is a need to improve the user interface in terms of accessibility and ease of use, in order to

gain loyalty toward the company across the customer (user) base. User interface designers need to understand and improve the interface technologies with users, in order to produce e-commerce interfaces that have the potential to increase the customer base of businesses [7 and 8].

2.2.1.2 Customer Loyalty

Customers often seek overall solutions to their procurement needs. As a result, companies go beyond providing single products to providing an overall sustained service of operations. This causes a transitional revolution in companies to correctly identify the needs of their customers. This creates added value for the customer and leads to better customer satisfaction [8, 9 and 10] and repeat purchasing [9 and 180].Satisfied customers often promote products or services. Unsatisfied customers often leave or do not recommend the products [11].The majority of research studies focus on the behavior of loyal customers to the brand. Recently, the development of a customer relationship with a brand via an e-commerce system is used in order to increase customer loyalty [12]. Shammout, Zeidan and Polonsky [13] suggest that a strong customer relationship helps to maintain and increase the customer base of a brand. The understandingof the behaviour of customers also helps to identify the most effective tools tosupport and build user loyalty for an organisation [14, 15 and 16].Loyalty is based on attitude and feelings towards specific products or services [17 and 18]. A key aspect of user loyalty is thepositive attitude towards a website or a product [19].Customer relationship is complex and future behavior of customers cannot necessarily be predicted by past behavior [20 and 21]. Aaker [23] describes four levels of brand loyalty as shown in Figure 2.1.

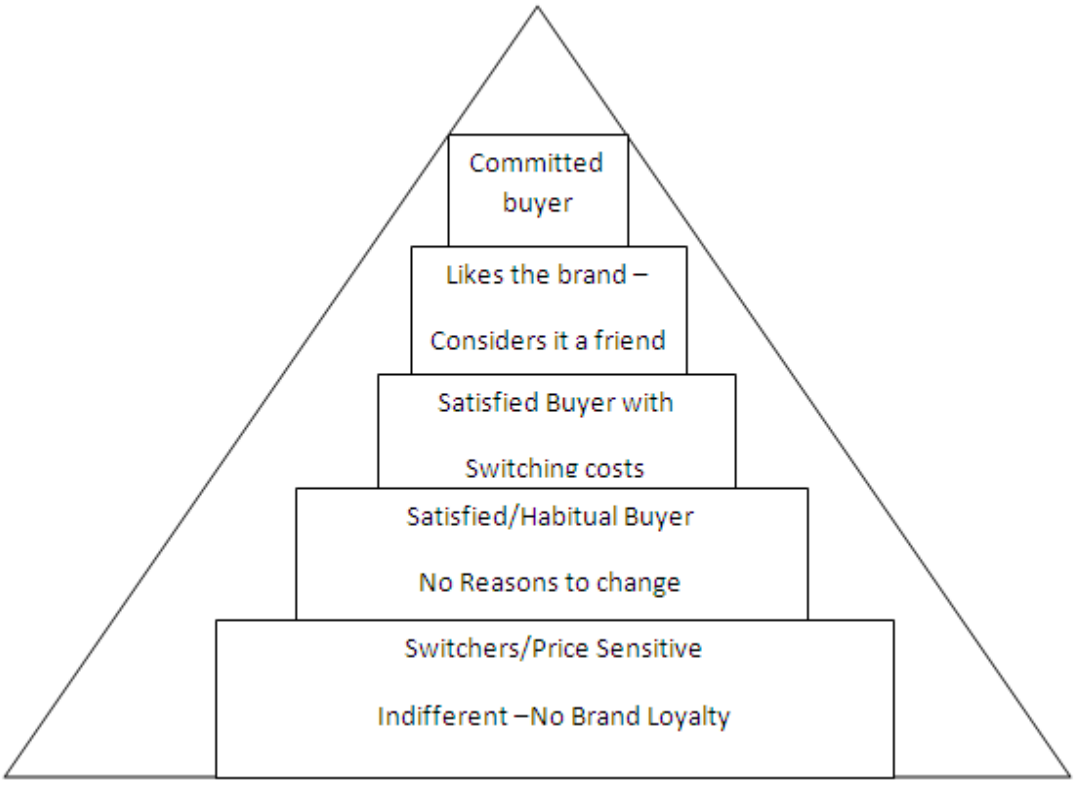

Figure 2.1. The loyalty pyramid [taken from 23].

Level one consists of customers who will not be influenced significantly by the brand name in their purchase decision. At this level, customers would buy almost any brand based on availability [23 and 25]. Level two consists of customers who are generally satisfied with a specific brand, and there is no reason for a change. Level three consists of customers that are mindful to the cost of changing brands. Level four consists of loyal customers who are attracted to a specific brand or product. Level five consists of the most loyal customers to a brand [26]. Maintaining an existing customer base is less expensive than attracting new customers. Customer loyalty is also an effective protection against competitors [27]. Building loyalty requires the measurement of customer satisfaction [28]. A positive customer attitude increases user satisfaction of a brand [29 and 30]. Approaches have been developed to measure customer satisfaction

[31]. Dawei [27] has suggested that profitability and sustainability of businesses depends on the success of their loyalty strategy.

2.2.1.3 Customer Relationship Marketing (CRM)

Customer Relationship Marketing (CRM) aims to develop customer loyalty that is based on a long-term relationship [32 and 33], and enhanced using information provided by the users. A database is created that includes customer related data. Reports are then produced on behavioral factors of the users [34].Organisations use different ways (e.g. e-mail or telephone)to communicate with their customers in order to build customer loyalty. Customers are often provided with privileges in order for the companies to gain their loyalty [33 and 34]. Listening to customers and acting upon the information received, is another way for companies to increase loyalty [35]. Customer participation in the organisation or brand development also provides an opportunity to create a better customer relationship. At an advanced level, customers are regarded as partners. This offers the opportunity to exchange ideas about a product design, marketing strategies or the interaction and interface mechanisms offered by the company's website[36]. CRM aims to develop communication with customers in order to create a strong customer capital that consists of customers that provide value to the institution [37, 38, and 39]. There are determinants of customer capital such as perceived value. This refers to the product value compared against the cost and effort to obtain it [40, 41 and 42]. Loyalty schemes help to create a repository of the customers' personal data, needs and consuming behavior[43 and 44].e-CRM uses the online environment as a tool to communicate with a wider range of customers [45 and 46]. CRM is the business strategy to develop a long-term customer relationship and loyalty [44 and 35].

2.2.1.4 Integrated Marketing Communications (IMC)

Integrated marketing communications are promotional tools to convey the objectives and goals of an organisation to customers [47]. The success of an organisation depends on innovative services or products that create added value and benefit customers. The effectiveness of IMC also depends on the ability of a company to communicate information about their products and services [47 and 48]. IMC also seeks to gain new target audience by advertising (e.g. Internet or TV) or personal selling (e.g. sale presentations) in order to create a customer obligation, or strengthen the relationship with a customer. Public relations, by event sponsorship, are another way to promote a product or service to consumers, in a way that builds a positive perception for the brand. Promotional events, with purchase incentives (e.g. coupons or discounts), also aid increased sales. Finally, direct marketing is achieved via surface mail, email, catalogues in order to encourage the testing of new products or to increase sales [48 and 49]. Integrated marketing communications create a competitive advantage that improves sales. This approach strengthens the relationship with the target audience and provides a competitive advantage. Furthermore, a strong customer relationship contributes to customer loyalty and enables companies to keep customers longer, and increase profitability [47 and 48]. Target audiences need to be analysed in terms of interests, preferences, needs and emotions prior to the design of the message that needs to be communicated to customers [47 and 51].

2.2.1.5 Creating Value for Customers

The concept of perceived value is a key objective in order to gain customer loyalty [52]. Organisation aim to provide products with a highly-perceivedvalue that exceeds customer expectation in order to build a high level of customer satisfaction, which in turn will develop into customer loyalty [52].

Users develop their perceived value with the product or website interface based on cost and quality. Cost relates to the price and the psychological effort needed to use a product[49 and 52].Organisations aim to provide high quality e-service technologies in order to reduce the user cost [57]. Quality relates to performance, reliability and durability of a product [50 and 51]. The perceived e-service also influences loyalty [53 and 54]. Loyalty-building programmes also contribute to the perceived value. They strengthen the relationship between customers and organisations, and increase customer satisfaction [61, 62 and 67]. Customer satisfaction is an important factor in developing user loyalty [63, 64 and 66].

2.2.2 Benefits and Limitations

CLM is the process used by organisations to increase customer loyalty. It is also used in on-line services. A service customisation is considered an important factor to create customer loyalty [70]. The factors that affect CL in interfaces include usability of mass customisation (e.g. effectiveness, efficiency, satisfaction), and user confusion (e.g. excessive information and memory overload, similarity and fuzzy presentation) [72 and 69]. The clarification of product features and usability reduce user confusion [1 and72]. Previous research studies have partially associated usability with user loyalty. The focus of usability was on graphical presentation, understanding user requirements and responsive feedback. The lack of usable e-service interfaces negatively influences loyalty [180 and176]. For example, lack of clarity during customisation. e-CLMS needs highly usable interfaces to facilitate effective user mass customisation [69]. Excessive information, or memory, overload negatively on loyalty growth of a user, as it weakens performance, creates confusion, and lack of user understanding [182]. It also impacts negatively on mass customisation of electronic customer loyalty [182 and 72]. User confusion resulting from the presentation of similar products can be reduced by a better

product representation. This will lead to a better product or service understanding by the user (e.g., performance of product, colour, style and packaging) [182].

Lack of face-to-face interaction also impacts negatively on customer loyalty [183].

2.3 Mass Customisation (MC)

MC was first introduced by Stanley Davis[89]. MC is significantly involved in on-line sales, as mass production is in manufacturing [90].Determining the customers' needs and product preferences enables the customised production at a reasonable cost [91] and profit growth [92 and 96]. Other advantages include: satisfying specific needs of customers, online process (no need for personal contact), accuracy of the customised result, reduction in product sale channels and inventory, and capital mobility [93 and 94]**.** On-line MC needs to be effective in the presentation of information [95] as this is an evaluation parameter of the e-service quality [71 and 76].

2.3.1 Mass Customisation Techniques

Lampel and Mintzberg's [73] classified customisation strategies into pure, segmented, standardised, and tailored. These strategies involve design, fabrication, assembly and distribution.

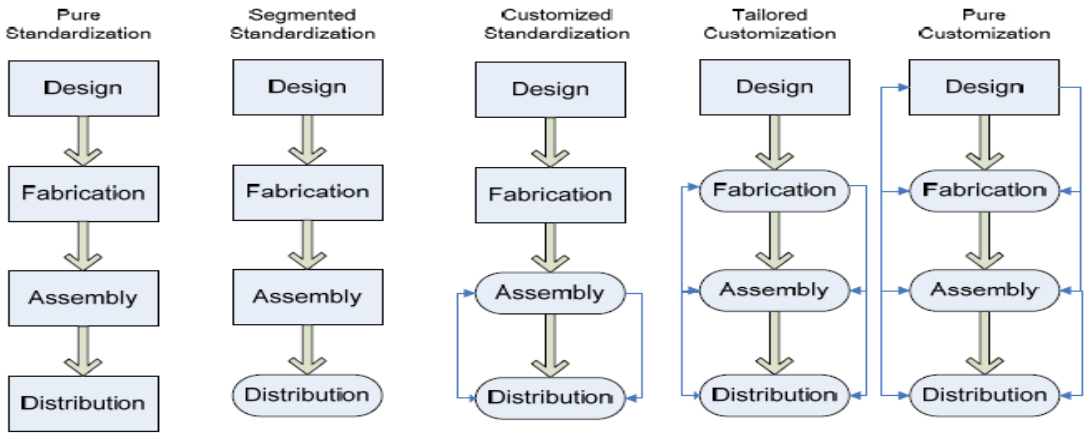

Figure 2.2 Five strategies for product customisation [73].

The standardised approach provides arrange of products (e.g. car colour). The segmented approach does not involve users in the design or production process. Customised standardisation is the process that allows the user to configure during the assembly stage of the value chain, using standard components (e.g. a car order that allows the customer to specify trim and engine). This tailored approach requires user input for the fabrication stage (e.g. design of a pre-fabricated house). Pure customisation requires user input at the design stage when a product is customised from conception (e.g. special order of jewellery based on user provided design) [73 and 74]. Figure 2.2 shows the five main customisation strategies.

Gilmore & Pine's Technique [75 and 73] suggest collaborative, adaptive, cosmetic and transparent approach to MC, as shown in Figure 2.3. The collaborative approach uses a dialogue style interaction to help users specify their needs. Adaptive allows modifications on a standard product. Cosmetic involves the repackaging of a standard product (e.g. packaging mixed nuts for different supermarket chains). Transparent provides custom products based on customer recommendations (e.g. Amazon is increasingly using this model of customer behaviour).

Change	**Transparent**	**Collaborative**
P R O D U C T	**Adaptive**	**Cosmetic**
No Change		
	No Change	Change
	PEPRESENTATION	

Figure 2.3 The four approaches of MC[75].

Non make-to-stock (Non-MTS) is another approach to customisation [77]. Non-MTS can be Assemble-to-Order (ATO), Make-to-Order (MTO) and Engineer-to-Order (ETO). The Assemble-to-Order (ATO) process uses standard parts. The Make-to-Order (MTO) process will produce products on receipt of an order. The Engineer-to-Order (ETO) process will require a specific customer design to be followed [78]. Coates and Wolff [80] suggest a soft and a hard customisation approach to MC. In the soft approach, the user does not participate or contribute to the manufacturing of a product. The user is rather significantly involved in the hard customisation approach [81].

Duray, et al. [83] characterises MC as groups of *fabricators, involvers, modularises*, and *assemblers*. The fabricators are engaged in the design of a product using a modular approach to build a product to customer needs. Involvers engage users in the design and fabrication phases. The modularises involve customers during assembly and delivery. This is considered to be a low cost approach to customise a specific product. For example, a customer chooses a specific type of upholstery and so on. Figure 2.4 shows these four types of mass customisation [83 and 84]. Pousttchi, et al. [85] presented three customisation approaches in mobile commerce. These were device adaptation, application adaptation and service composition.

Point of customer involvement	**Design**	**Fabricati**	**Assembly**	**Use**
Design	1 FABRICATORS		2 INVOLVERS	
Fabrication				
Assembly	3 MODULARISERS		4 ASSEMBLERS	
Use				

Figure 2.4 The four types of mass customisation according to fabricators[83].

Device adaptation allows the customisation of the device itself. Application adaptation allows individualised personal (graphical) user interfaces to adapt to respective devices (e.g. mobile commerce). Service composition allows customers to add specific services to a product [85 and 86].

Findlater and McGrenere [87] suggest three levels of customisation in adaptable menus. These are: coarse-grained, fine-grained or a combination of both. Adaptable menus are dynamic and user controlled. The main advantage of adaptable menus is the relative simple design approach. The coarse-grained technique allows items in a menu to be moved to the top or bottom partition. The fine-grained technique allows items in a menu to be positioned in specific locations within the top partition. Coarse-grained and fine-grained techniques allow items to be moved to the top or bottom partition and to specific locations within the top partition of a menu [87].

A study incorporated combinations of earcons and speech in coarse-grained and fine-grained, in order to allow users to customise menus in an incremental customisation strategy. System earcons notified users about recommendations during customisation [88]. Table 2.1 summarises the techniques of mass customisation.

2.3.2 Relationship between Mass Customisation and Customer Loyalty

Loyalty is linked to the customer's perceived value and increases the likelihood of understanding the needs and preferences of users across MC [70].

MC is based on the concept of user desire and the presence of an impression of freedom of choice, in terms of providing a focus on user’s desire, and assisting e-commerce to increase loyalty [100]. MC also reduces the cost of product service, more than that for standard product, and helps to build a strong positive user perception.

Source	Technique	Experiences Field	Multimodal
Lampel and Mintzberg (1996)	Pure	Physical Product	Text & graphics
	Segmented		
	Customised		
	Tailored		
	Pure customization		
Gilmore & Pine (1997)	Collaborative	Physical Product	Text & graphics
	Adaptive		
	Cosmetic		
	Transparent		
Amaro, et al. (1999)	Assemble-to-Order	Physical Product	Text & graphics
	Make-to-Order		
	Engineer-to-Order		
Coates & Wolff (1995)	Soft	Physical Product	Text & graphics
	Hard		
Duray, et al. (2002)	Fabricators	Physical Product	Text & graphics
	Involvers		
	Modularisers		
	Assemblers		
Pousttchi, et al. (2002)	Device adaptation	Digital Product	Text & graphics
	Application adaptation		
	Service composition		
Findlater&McGrenere (2004)	Coarse grained	Digital Product	Text, graphics
	Fine-grained		
	Combination of both		
Al-Omar &Rigas (2009)	Static	Digital Product	Text, graphics Speech & non-speech [earcons]
	Adaptive		
	Adaptable		
	Mixed-initiative		

Table 2.1 Techniques used in Mass Customisation and Customisation fields.

However, a better and real match between the customer and the product in an MC environment increases the level of loyalty [101].

A suitable MC is capable to accurately configure a product or service for a user by reducing the time to complete the process by eliciting the requirements. User satisfaction and loyalty increases when the MC process is successfully completed [102].

A study for a private retailer (Land's End) has used text with graphics to increase customer loyalty. The on-line mass customisation system had a strong positive impact

on its customer base [103]. Organisations have identified the strong relationship between MC and loyalty and sought to develop customer loyalty using MC systems [70]. A facility in MC satisfies users' needs and creates a user desire for the product or service. An electronic customisation process was found to be an important factor to improve attitudes towards an online interface that leads to gaining customer loyalty [102]. In summary, there is a direct correlation between loyalty and MC.

2.3.3 Mass Customisation Styles

The MC market utilises *business-to-customer* (B2C) to sell directly to consumer by using toolkits that allow customers to co-create products with specific characteristics (e.g. a laptop) [92]. The nature of the customisation derives from the user's needs and has two angles. The first angle is product customisation and the second angle is service customisation that needs to be provided by an interface [92 and 120]. There is a correlation between product and service in MC. It creates a unique value for the customer as the product and service matches the user specifications and needs [120]. The customer is considered as a "co-creator" [121]. In product customisation, mutual benefit between the creation of new products and companies is an important aspect in continuous product enhancement. Product customisation is generally divided into two parts. The first part is the external appearance of a product in terms of the properties that acustomer can easily view (e.g. screen or mouse). The second part is the internal parts of a product in terms of the properties that a customer cannot easily view such as internal components of a computer (motherboard or hard disc) [122]. In service customisation, the existence of an "after-care" service helps to lengthen the relationship between the consumer and the company [122].

2.4 Explanation

Explanation is defined as a set of statements, instructions or presentation of information that describe a specific topic [106]. In interactive systems, several communication metaphors (e.g. text, sounds, video and graphics) may be used for explanation [106]. Explanation serves as a help facility to users [110]. In the CLM context, explanation helps users with product configuration and contributes to usability and user acceptance [112 and 113]. It also improves user awareness, confidence and decision-making [111, 114 and 115]. All these contributions to user performance have a positive influence to the potential development of user loyalty [116, 117, 118 and 119].

2.5 Interactive Systems and Multimodality

Interactive systems are software systems that facilitate communication between the user and the computer. The user-centred approach is often used to develop the interfaces of interactive systems [123 and 124].

Human-Computer Interaction (HCI) has always depended upon the usability in terms of ease of use, efficiency, effectiveness, and user satisfaction [123 and 125].User interface designers aim to design usable e-commerce interfaces that are enjoyable, fun to use and engaging in order to keep customers longer and gain their loyalty. It is also essential for designers to understand user experience and behaviour [123 and 126].

Multimodal interfaces combine communication metaphors from the perceptual channels (i.e. auditory, visual, kinaesthetic) that correspond to the human senses [127 and 131]. They aim to make the interaction similar to the way humans interact [128]. This helps the interface to mimic a *face-to-face* communication [129 and 130]. The use of multimodal interaction is demonstrated by several research studies [132, 133, 134 and 135] and in interfaces for disabled users [127 and 128].

2.5.1 Auditory Metaphors

Auditory metaphors are stimuli that can be broadly classified into earcons, auditory icons and spoken output [138].These metaphors can improve usability in interfaces [139, 140 and 141] and they have been successfully applied to interfaces for visually impaired users [136 and 137].

2.5.2 Earcons

Earcons are short musical sounds that are used to communicate information in the interface about events, operations, and objects [136,142 and 144]. Earcons can increase usability of interfaces even when complex information needs to be communicated [145]. Earcons are classified into one-element, compound, hierarchical and transformational.

A one-element has a single sound (musical note) to communicate a specific function. For example, "file edit" has been enabled. A compound earcon combines one-element earcons to communicate more information. For example, "file edit" and "file save" can be combined sequentially using the corresponding sound of "file edit and save". Hierarchical earcons are created from a set of one-element and compound earcons, and additional musical parameters (e.g. timbre, register, pitch, rhythm). The transformational earcons involve a modification in its musical attributes, but maintain the musical structure of the original earcon [146 and 147]. When earcons are combined with other communication metaphors (e.g. visual), the volume of the communicated information increases with a small (if any) information overload to users. Earcons have been successfully applied in several interface applications [148] such as menus [149 and 151] and tool palettes [152]. When earcons were used in graphical widgets, task completion time, number of errors, and mental workload of users was reduced [153]. Earcons have also been successful in interfaces for mobile devices, given the rather limited display space[154 and 156]. Other domains that earcons have been

applied successfully include interfaces for visually impaired users [157 and 158], stock control systems[160 and 161], knowledge methods [162] and email [143].

2.5.3 Auditory Icons

Auditory icons are used in everyday environmental sounds to communicate information in the interface. They were introduced by Gaverin the SonicFinder interface [164, 165 and 167]. For example, the sound of a "door opening" can be used to communicate the opening of a folder [166].ARKOLA [168] is another interface with auditory icons. Auditory icons have also been combined with speech and earcons to communicate information in mobile telephony interfaces [144] and other applications [169]. However, users may misinterpret auditory icons when their sounds are similar (e.g. the sound of hammering sound was confused with walking) [171].

2.5.4 Speech

Speech output is classified into natural and synthesised [185]. Natural speech is pre-recorded [109 and 175]. For example, a switch board telephone interfaces [186 and 187]. Synthetic speech is produced using different techniques [174]. Natural recorded speech is preferable in terms of user understanding [175 and190]. The use of speech in interfaces can enhance the interface [173 and 174] with successful application. For example, in email browsing [175], internet [143], e-note [155], knowledge management [170] and visually impaired users [108].

2.5.5 Avatars

An avatar or virtual human is a multimodal interaction metaphor that can enhance the usability of an interface [191]. Avatars communicate information using non-verbal (i.e. expressions) and verbal (i.e. speech) communication [192 and 193].

Avatars can be *realistic, symbolic* and *naturalistic* [194]. A realistic avatar uses real-time rendering with the animations being based on static or video images (e.g. use image of a face) [194 and 195]. A naturalistic avatar is a humanoid that is animated [194 and 195]. A symbolic avatar is a cartoon-like character with restricted animation (animated assistants in the MS Office) [194]. The human-like avatar displays an animated human with facial expressions and body gestures [196 and 197]. Several studies demonstrate the importance of avatar technology [198]. Avatars are often used in virtual environments and web-based applications [199]. Fabri et al. demonstrated [201] that facial expressions improve the usability of avatars. Facial expressions help to facilitate visual articulation [202].The design challenge for the inclusion of avatars in multimodal interfaces is to combine them with other multimodal metaphors in order to communicate information successfully [203].Rigas and Gazepidis demonstrated a prima facie case for the use of expressive avatars and suggested the most applicable facial expressions and body gestures [204]. Gong [205] also found that happy expressions positively influence the attitudes of users. Facially expressive avatars were also used as the virtual lecturers[206and 207].The facial expressions suggested for use in avatars are happy, amazed, and positively surprised. Expressions such as sad, bored and disgusted should be avoided [208].

2.6 Critical Concluding Assessment

Online CLM is closely associated with the MC in e-commerce and is referred to as e-CLMS. This topic is important to organisations as it is linked to customer and profit growth. However, there is a general lack of empirical research to improve e-commerce interface interaction and usability as a direct result of multimodal metaphors. Literature suggests that user perceived value develops customer loyalty. Other research suggests

that the development of usable user e-CLMS interfaces facilitates growth in user loyalty [9, 47, 52 and 54]. The challenges therefore are:

1. Lack of interfaces that aid user loyalty
2. Clarification on MC lacks suitable explanation
3. MC interfaces tend to use visual metaphors (e.g. text and graphics) resulting to a visual information overload to the user
4. Lack of empirical evidence in CLM interfaces

This research aims to investigate some of these gaps. Although some research is reported, there is scope for this thesis to evaluate the hypothesis that uses multimodal interaction in e-CLMS in order to improve usability, understandability and facilitate the potential of customer loyalty growth. The empirical measurements described in this thesis demonstrate an overall significant improvement (see Chapter 3) that was in agreement with user views regarding the multimodal interface (see Chapter 4).

Chapter 3: Experiments using Visual, Audio and Avatars to Communicate Information in e-CLMS

3.1 Introduction

Three interface approaches to communicate information in an e-CLMS platform are evaluated. The three designs (conditions) include innovative multimodal interaction metaphors aiming to improve the usability of interaction, mass customisation and in turn aid customer loyalty. The results demonstrate that the proposed multimodal interface designs played an effective communication role that helped to increase customer loyalty in the context of e-business, while addressing issues discussed in the CLMS literature (e.g. overload of information, fuzzy MC and confusion).

3.2 Aims and Objectives

The aim of this experiment was to compare the usability of the three conditions and examine the potential of aiding customer loyalty when increased usability occurs. The three interface conditions on the experimental platform aim to improve the usability of the communicated information with regard to product customisation, in order to facilitate customer loyalty. Also, the significant differences of the multimodal designs are investigated in the presence and absence of earcons, auditory icons and expressive avatars.

The views of users on the conditions presented were also measured. The usability parameters evaluated were effectiveness, efficiency, satisfaction and users' views that in turn determined user loyalty and understandability.

The objectives include the experimental platform that was used as bases for the implementation of the three experimental conditions. These were:

1. Text with graphics (VICLMS).
2. Earcons, auditory icons and recorded natural speech (MICLMS).
3. Expressive avatars with speech, earcons and auditory icons (AICLMS)

Three independent groups of users (n=25) were used for the evaluation. The evaluation parameters were:

1. Effectiveness was measured by the successful completion of each task by each user
2. Efficiency was measured by: the time taken by each user to complete each task, number of mouse clicks taken to complete a task, and the number of errors made during the completion of a task
3. User satisfaction, predisposition to loyalty and understandability was measured using post-experimental questionnaires

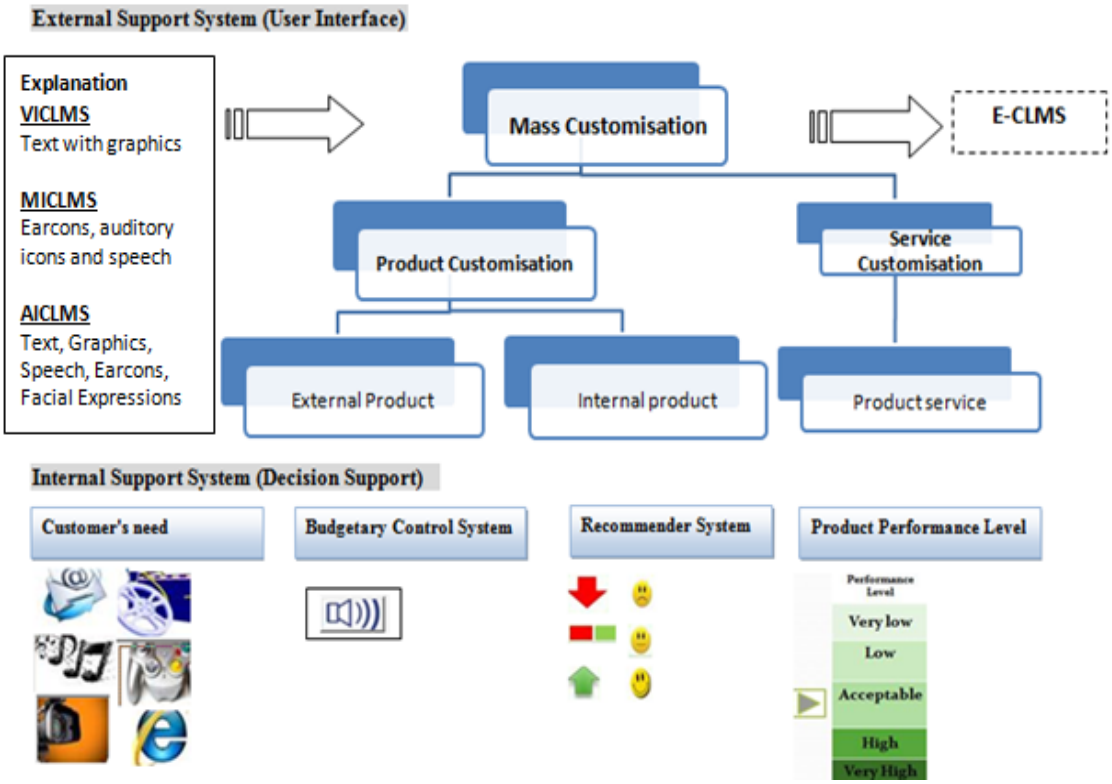

Figure 3.1: A visual example of the e-CLMS experimental platform.

Communicated Information	Interaction Style										
	MICLMS					AICLMS					
	Text	Graphics	Earcons	Auditory Icon	Recorded Speech	Text	Graphics	Earcons	Auditory Icon	Speech Avatar	Facial Expressions
Mass customisation	√	√	√		√	√	√	√		√	
External Product		√			√		√			√	
Internal Product		√			√		√			√	
Software		√			√		√			√	
Services	√	√	√	√	√	√	√	√	√	√	
Customisation stages	√	√	√			√	√	√			
Recommender System		√	√				√	√			√
Customer needs	√	√				√	√				
Budgetary Control System	√		√			√		√			
Performance Level		√	√				√	√			√
Perceived Value	√			√		√			√		
Conformation	√			√		√			√		

Table 3.1: Allocation of metaphors in MICLMS and AICLMS conditions.

3.3 e-CLMS Experimental Platform

An experimental platform was developed to act as a basis for the experiments. The platform consisted of an external support system (User Interface) and an internal support system (Decision Support). The user interface of the platform technically accommodated the multimodal design including: earcons, auditory icons, recorded natural speech, and avatars [56 and 122]. Evidence in the literature suggests that these metaphors have a positive impact on usability in other problem domains [133 and 147]. Table 3.1 shows the allocation of the multimodal communication metaphors that were used in the design of the two experimental conditions. The text and graphics (visual condition) is not included. It is divided into three sections (one for each interface) that show the way that the various functions were communicated.

Action	Earcons				Action Details
	Level	Rhythm	Timbre	Duration	
Recommender system	1 -3				
Non-recommended	1	Single pitch	Guitar	01 sec	Disagree
Recommended	2	Lowering pitch	Whistling	01 sec	Agree
Strongly Recommended	3	Rising pitch	Whistling	01 sec	Strongly agree
Product Services Customisation	1-4				
Home Installation	1-4	Rising pitch	Bass	01 sec	Alert level of installation
Data Recovery	1-2	Rising pitch	Piano	01 sec	Alert level of recovery
Warranty	1-4	Single pitch	Bell	01-03 sec	Alert level of warranty
Customisation stages	1-4				
External Product Customisation	1	Rising pitch	Fanfare	01 sec	Transaction 1
Internal Product Customisation	2	Rising pitch	Harp	01 sec	Transaction 2
Software	3	Rising pitch	Cello	01 sec	Transaction 3
Product Services Customisation	4	Rising pitch	Drum	01 sec	Transaction 4
Budget		Single pitch	Piano	02 sec	Alert when a budget overruns

Table 3.2: The design of earcons.

When more than one box was ticked, it meant that more than one metaphor was used to communicate the relevant information of the function. As an example, guitar and whistling were used by the recommender system to inform three levels of user recommendation related to product compatibility with customer needs.

Rising pitch (01 sec duration) was used to communicate the position of performance level for each product.

Table 3.2 shows the design of the earcon that used rhythm and timbrein the status of the recommendation (i.e. not-recommended, recommended and strongly recommended) in the AICLMS. Timbre was used to communicate the three levels of recommendation that related to product compatibility.

The rising pitch metaphor was used to communicate the position of the performance level for each product. The design of the AICLMS interface also had a consistent correlation between the rhythm and the expressions of the avatar. MICLMS did not have this consistent correlation as its design was based on different principles. Services have different timbre (i.e. bass, piano and bell). The use of different timbre helps the user to disambiguate the information communicated. For example, item details presented using expressive avatars, but with specific interventions of auditory stimuli, in particular instances of the interaction to support user decision with the MC. The researcher anticipates that this will contribute to improve the performance of users during product customisation.

Table 3.3 shows the association of metaphors with the information communicated. This technique is efficient and effective in user interfaces, helping listeners to understand and recognise events easily. For that reason, the MICLMS interface utilised clapping, which was considered to preserve its value in motivating purchase and earning customer loyalty.

An auditory icon (door closing) informs the user about the completion of the transaction. The workshop auditory icon sound comes from machines, and sound that reflects installation periods (e.g. 01 sec for one day, 02 sec for 2 days and 03 sec).

Action		Auditory icons	Duration	Recorded natural speech
Perceived value		Clapping	02 sec	
Conformation		Close door	01 sec	
Build time				
	Build time 1	Workshop	01 sec	
	Build time 2	Workshop	02 sec	
	Build time 3	Workshop	03 sec	
Product Features				
	EPC			Recording (External information)
	IPC			Recording (Internal information)
	Software			Recording (Software information)

Table 3.3 Auditory icons and recorded natural speech to communicate different types of information on the interface of the E-CLMS platform.

Recorded natural speech has become one of the most important channels in multimedia and is considered a natural manner of human communication in terms of attracting the user to understand the product customisation in E-CLMS.

3.4 Facial Expressions and Speech

An expressive avatar simulates human activity in an interface in order to convey information between interfaces and users in a way that resembles face-to-face human interaction. Figure 3.2 shows the concept based on some emotionally expressive avatars using facial expressions to communicate a positive effect (happy, amazed), a negative effect (sad, disgusted) and a normal effect (normal, thinking).

This finding is in agreement with other studies that show that some facial expressions created positive feelings in users. Happy, amazed, normal and thinking; and sad and disgusted expressions recoded most users ‘feelings to dislike [184].

Positive Face	Negative Face	Natural Face
 **Happy**	 **Sad**	 **Normal**
 **Amazed**	 **Disgusted**	 **Thinking**

Figure 3.2: Facial expressions used in the design of the avatars.

Facial expressions with speech were used to convey specific expression via phases of task types (EPC, IPC and PSC). Table 3.4 shows a summary of expressive avatars combined with recorded speech to communicate information for each product. The expressions included two positive, two negative and two neutral. During MC, avatars with three facial expressions communicated the status of the recommender system in order to support user decisions.

For example, a "*sad facial expression*" of an avatar communicated that this product customisation was not recommended; a "*neutral facial expression*" communicated that the product customisation was recommended; and a "*happy facial expression*" communicated that the product customisation was strongly recommended. In MC task performance, three facially expressive avatars communicated to users their progress with the product customisation.

Components of UI	Avatar Interaction	
	Facial Expressions	**Speech**
Recommender system		
Non-recommended	Sad	
Recommended	Normal	
Strongly Recommended	Happy	
Performance Level		
Low performance	Disgusted	
Acceptable performance	Thinking	
High performance	Amazed	
Mass customisation		
External Product		Recording (external information)
Internal product, Software		Recording (internal information)
Services		Recording (Provided service) Information)

Table 3.4 Facial expressions and speech in the AICLMS.

A "*disgusted facial expression*" communicated that the product customisation was not progressing well. A "*thinking facial expression*" communicated that it was progressing well. An "*amazed facial expression*" communicated that it was progressing very well, and was about to be completed. Speech was used to describe services and external or internal products.

3.5 Hypotheses

The hypotheses of the experiment were that:

H1: The MICLMS and AICLMS will outperform the VICLMS in terms of:

1. Time required by users to complete each task (efficiency)successfully
2. Tasks completed by users (effectiveness)successfully
3. Less user errors or incorrect sequence of user actions (effectiveness)
4. Fewer mice clicks to complete a task (effectiveness)

5. A better user understanding of the tasks
6. Better user satisfaction

H2: The AICLMS will outperform the MICLMS in terms of the same evaluating parameters as described in H1.

3.6 Experimental Tasks

A plan of the task design is shown in Table 3.5. There were six tasks in each experimental scenario, three task types (IPC, EPC and PSC),and three levels of complexity (simple, moderate and complex). The number of requirements determines the number of product customisation steps that need to be taken by the user to successfully complete each task.

Tasks were categorised as simple (T1 and T2), moderate (T3 and T4), and complex (T5 and T6) [138 and 162]. The type of mass customisation was based on the concepts of EPC, IPC and PSC applied to each product. For example, usersperformingT1 were provided with a scenario where they were asked to assume that they wanted to purchase a computer from the website, and then use the described requirements to customise the PC and its software.

Tasks	**Complexity**	**Type**	**Standard task time**	**Number of requirements**	
T1, T2	Simple	EPC	120 sec	T1=10	T2=10
		IPC	240 sec	T1=16	T2=16
		PSC	120 sec	T1=7	T2=6
T3, T4	Moderate	EPC	180 sec	T3=11	T4=10
		IPC	360 sec	T3=16	T4=15
		PSC	180 sec	T3=8	T4=8
T5, T6	Complex	EPC	240 sec	T5=11	T6=11
		IPC	480 sec	T5=15	T6=13
		PSC	240 sec	T5=8	T6=7

Table 3.5: The experimental tasks to be completed by users in all conditions.

EPC				NOR
Most frequent activity: surfing the Internet				1
Budget > £1000				1
Product name	**Product information**	**Price**	**Recommender system**	
Case & Lock	2 front USB ports	< £15	Recommended	4
Monitor	22 inch widescreen	≤ £133.80	Strongly recommended	4

Table 3.6: Task requirements for T1 of the EPC

3.6.1 External Product Customisation (EPC) Tasks

Scenarios were provided for each EPC task. In T1, the user was given a simple task with an EPC scenario, to select the activities that the computer would be used most. The system would then start to interact automatically with the recommender system, guiding the user through the options of suitable products. Next, the user was asked to provide the system with a budget greater than £1000 and to choose Case & Lock as the product name. The system was restricted to products that can be mass customised. In terms of product information, the user was required to choose a product with two front USB ports, at a cost of less than £15. In the recommender system, the user had to choose a recommended item, and this requirement was a demonstration of the product that matched the user's needs. Table 3.6 below illustrates this, regarding the requirements of the first EPC task.

3.6.2 Internal Product Customisation (IPC) Tasks

The IPC tasks also had different scenarios and three levels of complexity (simple, moderate, complex); widening the NOR range of individual products. For this type of task, more complex product information and product performance levels were associated with each item. Table 3.7 summarises the requirements of these IPC tasks.

IPC

Product Name	**Product Information**	**Price**	**Recommender System**	**NOR**
Motherboard	Max bus speed = 1333 MHz	< £37 and >£36	N/A	4
Graphics card	Maximum power usage = 56W	< £54	N/A	3
Memory - 2nd hard disk	Cache = 32 MB	≥ £50 and < £70	Recommended	5
Software				
Product Name	**Product Information**	**Price**	**Recommender System**	
Operating system	Windows Vista	> £109.9 and < £168	N/A	4

Table 3.7 Task requirements for T3 of the IPC

In T3, the user was given the scenario of a moderate task requiring 16 steps to be taken in order to complete the task successfully. A requirement of this procedure was that these steps should be taken to specify the name of a product that contained certain elements. Each element had particular specifications related to the level of product performance and a price, which coincided with the budget specified by the user. The requirements gave motherboard as the product name and a maximum bus speed of 1333 MHz, as product information at a price less than £37 and greater than £36. The user was asked to continue to complete all of the requirements shown in Table 3.7.

3.6.3 Product Service Customisation (PSC) Tasks

Four PSC services (home installation, data recovery, built time and warranty) were available to users. These tasks had no recommender system. The PSC tasks were not all complicated. Table 3.8 illustrates that T6 had six requirements for each user. It involved two services associated with a specified price (the range of cost of build time was greater than £29 and less than or equal to £59), and the warranty service was 2 years collect, 2 years parts, at a price greater than £69.

PSC				
Service	**Service type**	**Price**	**Recommender system**	**NOR**
Build time	N/A	> £29 and ≤ £59	N/A	3
Warranty	2 years collect, 2 years parts	> £69	N/A	3

Table 3.8: Task requirements for the PSC T6.

Appendix (A-2) gives full details of the design plan for the six tasks.

3.6.4 Dependent and Independent Variables

The dependent variables that measured effectiveness, efficiency, understandability, satisfaction and perceived loyalty are shown in Table 3.9 (see also Appendix A-3).

DV1 measured the successfully completed tasks by users (effectiveness). This was dependent on users following the correct steps of product configuration and task requirements, in order for the task to be deemed successfully completed.

DV2 measured the time taken by users to complete the task (efficiency).

DV3 measured the number of mouse clicks performed by each user.

DV4 measured the number of user errors, during the user engagement with each task.

DV5 measured the user satisfaction; as assessed by a post-experimental questionnaire, using user satisfaction statements and a 5-point Likert scale for user response.

DV6 measured user understandability, and similarly to DV5, used a post-experimental questionnaire.

DV7 measured user views for potential development of their customer loyalty. This was similar to DV5 and DV6, but had statements relating to loyalty, such as:"recommending others to purchase the product", "purchasing the same product", "purchasing different products", and "choosing this website again".

The independent variables (IV) consisted of the three conditions, task complexity, and task type as shown in Table 3.9.

The independent variables were:

IV1 Interaction style: An experimental E-CLMS was developed that provided typical functions found in websites for the mass customisation of personal computers, and was executed by using three interaction styles: VICLMS, MICLMS and AICLMS.

IV2 Issue complexity: The experimental tasks were performed at three different complexity levels: simple, moderate, and complex, throughout the scenarios.

IV3 Task type: Three types of task were designed for user interaction: EPC, IPC and PSC.

Metrics	**Code**	**Description**
Effectiveness	DV1	Tasks completed successfully
Efficiency	DV2	Time taken by users to complete tasks
	DV3	Mouse clicks needed to complete tasks
	DV4	Frequency of user errors
Satisfaction	DV5	SUS approach
Understandability	DV6	Easy to understand
Views that aid Loyalty	DV7	A range of parameters that measure user views and intentions based on their overall experience
Conditions	IV1	VICLMS, MICLMS and AICLMS
Task complexity	IV2	Simple, Moderate and Complex
Task types	IV3	External Product Customisation (EPC) Internal Product Customisation (IPC) Product Service Customisation (PSC)

Table 3.9: Dependent (DV) and Independent Variables (IV).

3.6.5 Control Variables

Control variables in an experiment were those that may affect the dependent variables, and those made not to change, in order to not affect the results [59]. The control variables for this experimental platform were:

CV1 Familiarity with the experiment: Users were given a short lesson about the experiment, of which they had no previous experience, so that they would all be equally familiar with it.

CV2 Content of the experiment: This was fixed to ensure that users were able to retrieve the same data from both experimental platforms.

CV3 Layout of design: The two experiments had the same basic layout.

CV4 Procedures of the tasks: The same tasks relied on the same procedures throughout the experiment.

CV5 The concept of perception and understanding: This factor depended on the mandatory requirements prior to the experiment. Because of this, the users were not allowed to start the experiment until they understood all the required steps.

CV6 Time to accomplish the task: A specific time was allocated for the completion of testing, to avoid any differences affecting the course of the experiment.

3.7 User Sample and Tasks

Three independent groups of 25 users each were opportunistically recruited to evaluate the three experimental conditions. All users had some previous experience in Internet shopping and they were mainly international students.

Each user of the three independent groups performed six tasks. They also had to complete pre- and post-experimental questionnaires (see Appendix A-1). The tasks were categorised as simple, moderate and complex, and they were of three types (EPC, IPC and PSC). Table 3.10 summarises the classification of tasks.

Users	Task Complexity							
1-4	Pre- session questionnaire	Simple	Usability assessment	Moderate	Usability assessment	Complex	Usability assessment	Post- session questionnaire
5-8		Simple		Complex		Moderate		
9-12		Moderate		Simple		Complex		
13-16		Moderate		Complex		Simple		
17-20		Complex		Simple		Moderate		
21-25		Complex		Moderate		Simple		

Table 3.10: Experimental rotation procedures used in the E-CLMS.

3.7.1 Data Collection Method

Pre-experimental questionnaires collected data on users' background, Internet usage, and experience with product customisation. During the experiment, data was collected from each user in accomplishing the six tasks, in terms of effectiveness and efficiency. Tasks required users to achieve a set of product customisations and to complete scenarios involving mass customisation. Data was related to users performance in terms of tasks completed successfully, or task accomplishment time. The post-experimental data collection involved three questionnaires. The first questionnaire gathered users' views regarding their perceived loyalty (choosing the interface again, recommending it to others, purchasing by using the same technique and overall level of loyalty to the interface).

The second questionnaire gathered data on how well they thought they understood the information communicated (the information is clear, easy to find information, information is easy to understand, information is effective in helping to complete the scenarios and the organisation of information was logical). Users were required to respond to these statements on a four-point rating scale. The third set measured the satisfaction of users. It had ten statements to which users were required to respond on a five-point scale of agreement [79] (see Appendix A-4).

3.7.2 User Background

Figures 3.3 and 3.4 show the profile of the user samples per condition (see Appendix A-1). The typical age profile was between 31 and 40. Several users in the samples were postgraduate students. The typical computer experience of the users was around 10 hours per day with experience in on-line shopping. According to "how often do you purchase product on the Internet" and "purchase monthly", the highest reported percentage in VICLMS, MICLMS, and AICLMS was 56%, 48% and 40% respectively.

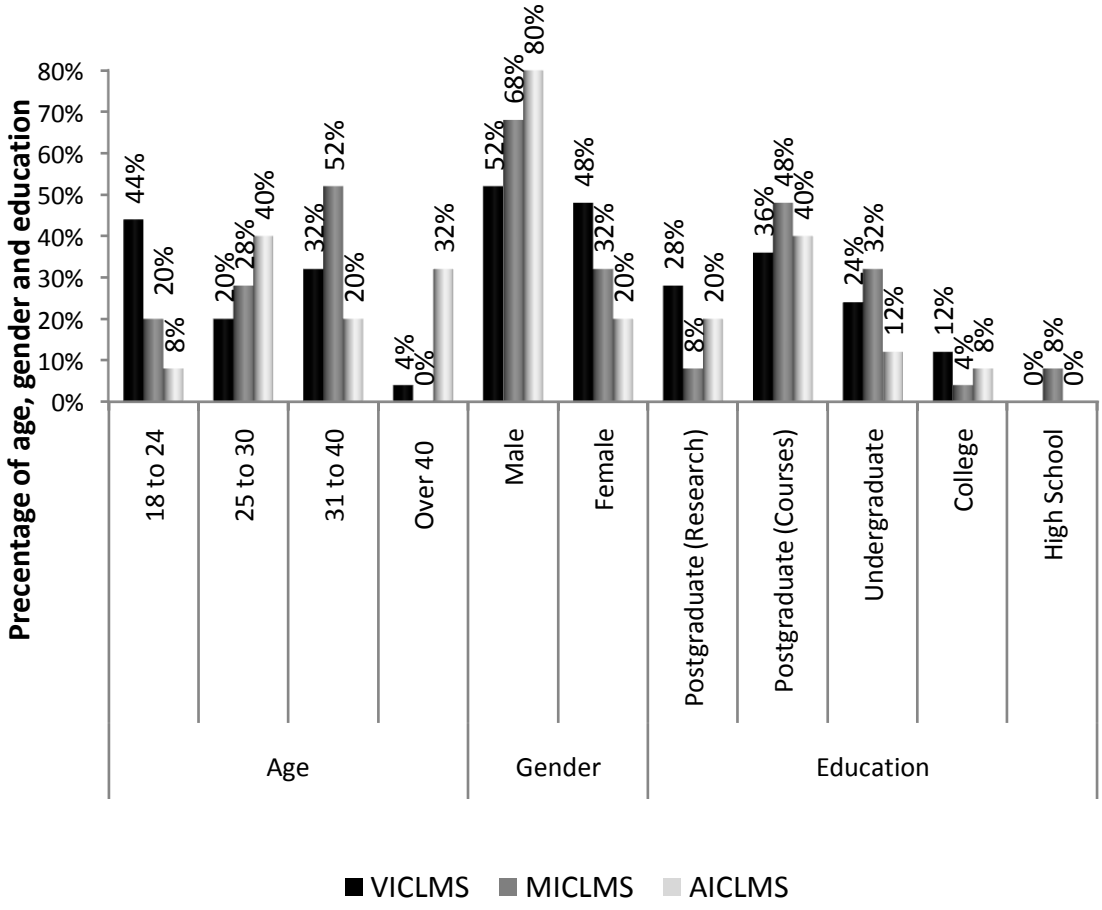

Figure 3.3 Background information of the user sample per condition.

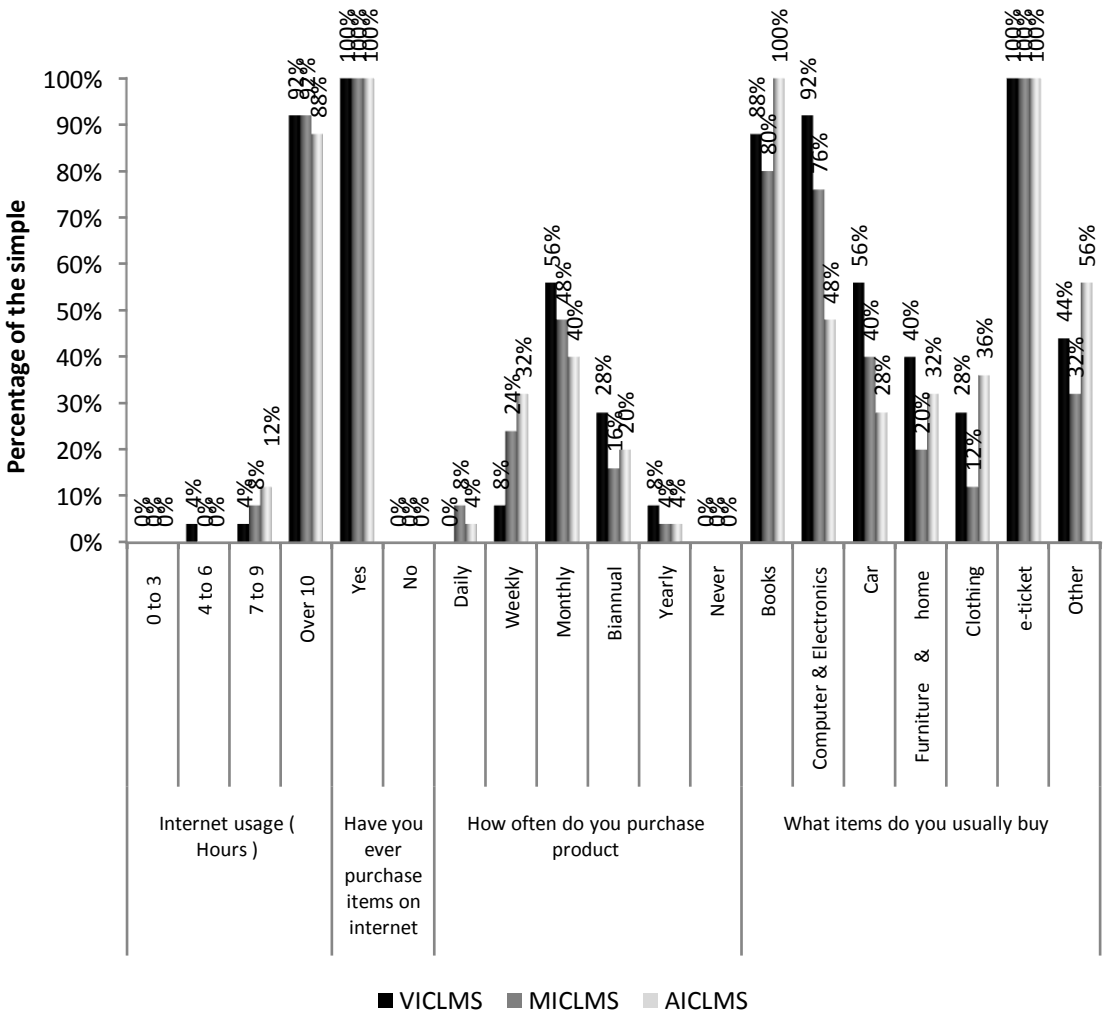

Figure 3.4: Previous Internet experience of the user sample per condition.

In terms of "what items do you usually buy", the VICLMS, MICLMS and AICLMS groups showed 88%, 80% and 100% respectively for books purchase, 92%, 76% and 48% respectively for electronics,56%, 40% and 28% for car,40%, 20% and 32% for furniture,28%, 12% and 36% for clothing, 100%, 100% and 100% for e-ticket purchase, and44%, 32% and 56% for other purchases.

Figure 3.5 shows the experience of users with online product customisation. The sample distribution for product customisation experience was 76% for VICLMS, 84% for MICLMS, and 68% for AICLMS.

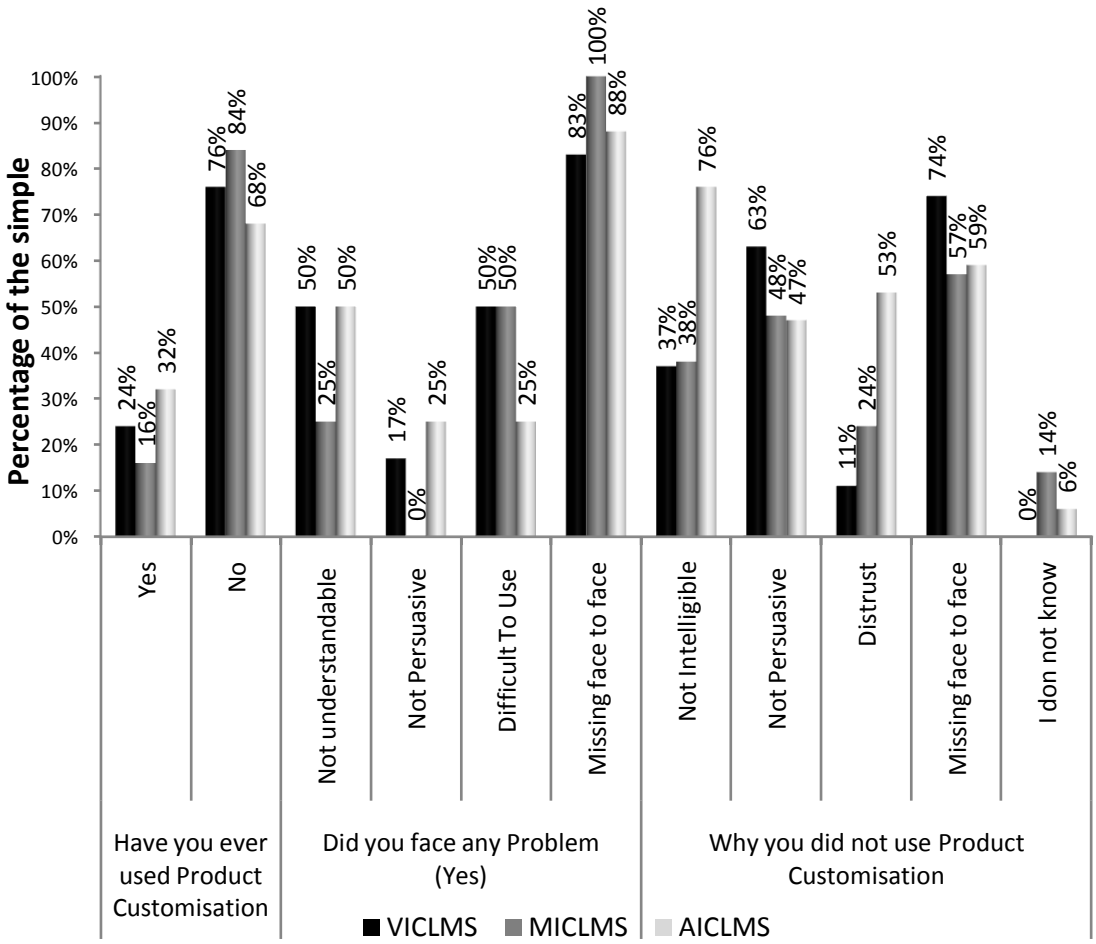

Figure 3.5: Previous product customisation experience of the user sample.

This analysis highlights that the sample that used on-line shopping, did miss the face-to-face experience you get when physically visiting a shop. A difficulty was also reported in using mass customisation.

3.8 Comparative Analysis

The analysis compares the three conditions in terms of user performance using frequencies, chi-square descriptive statistics and t-tests [79].

Descriptive statistics (e.g. means, standard deviations and confidence intervals) and inferential tests (e.g. of sampling error) were also used [82].

3.9 Effectiveness

The analysis of the effectiveness results is related to the three IVs, conditions (VICLMS, MICLMS and AICLMS), level of task complexity (simple, moderate and complex),and task type (EPC, IPC and PSC), as well as each task individually.

3.9.1 Comparing the Interaction Style (Conditions)

Figure 3.6 shows the results of successfully completed tasks for each condition. On overall, 365 (81%) out of 450 (19%) tasks were completed successfully in all three experimental platforms. Figure 3.7 (Chart 3) presents the results of successfully completed tasks for each condition. The avatar-based condition (AICLMS) was the best performing with 98%. The difference between the other two conditions was 10% and the variance between AICLMS and VICLMS was 41%. The variance was calculated using the chi-square test. The three conditions were significantly different (x^2=92.01, df=2, p<0.05) and between AICLMS and MICLMS (x^2=10.5, df=1, p<0.05).A highly significant difference was also found between AICLMS and VICLMS (x^2=73.1, df=1, p<0.05).

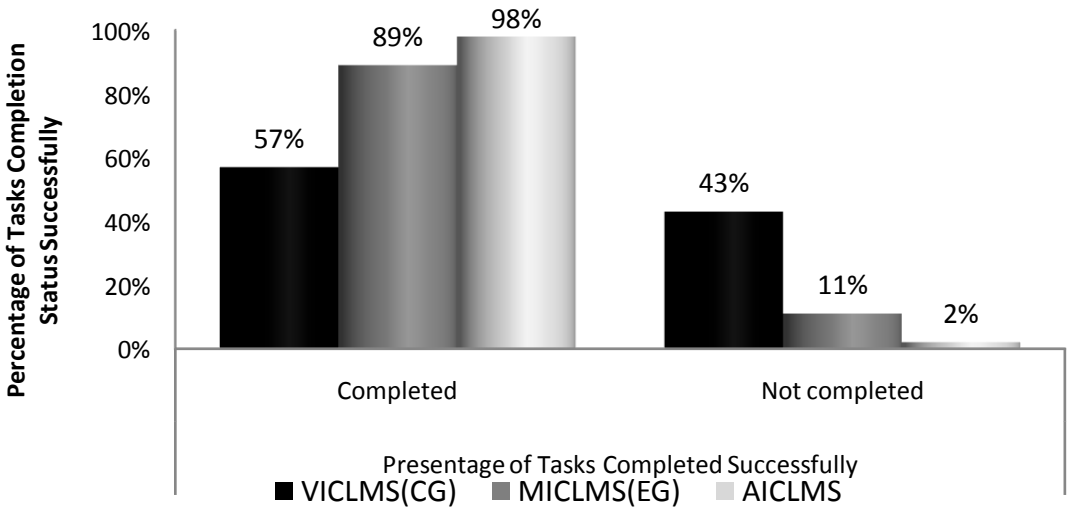

Figure 3.6 Tasks successfully completed by the three groups per condition.

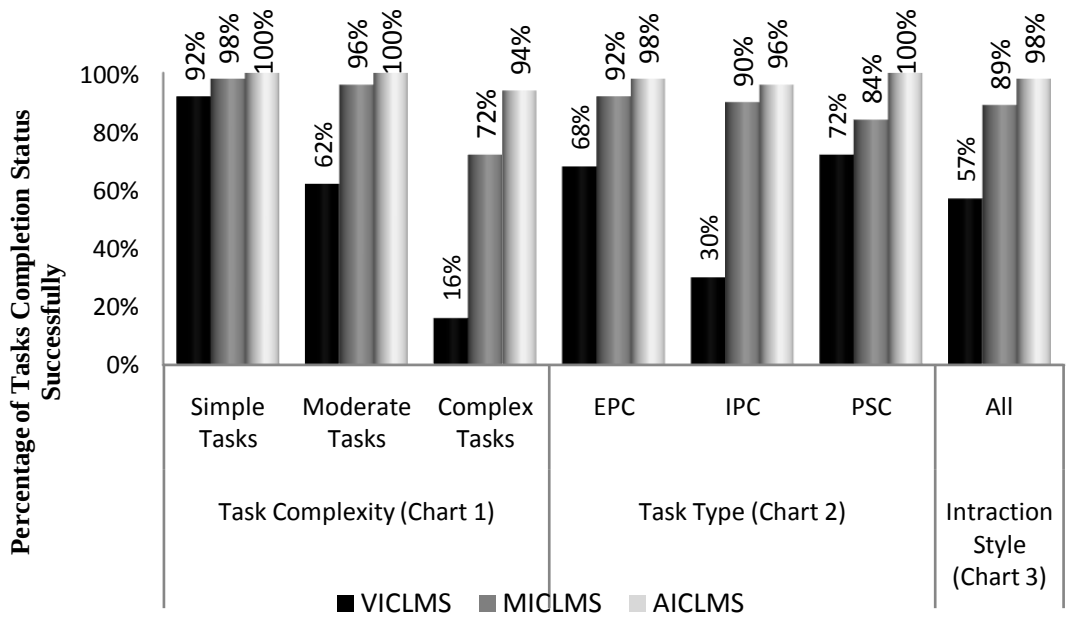

Figure 3.7 Tasks completed successfully per condition (Chart 3) and by complexity (Chart 1), and task type (Chart 2).

3.9.2 Task Complexity

The experimental tasks were divided into three levels: level one was simple, level two, moderate, and level three, complex). For example, a simple task (level one) required the user to perform a relatively straightforward product customisation, and a moderate or complex task required the user to perform a progressively more difficult task.

Results show that the number of successfully completed tasks decreased gradually from simple tasks (145 tasks, 96.7%), moderate (129 tasks, 86%) to complex (91 tasks, 60.7%). A significant difference between the three levels of complexity in the successfully completed tasks was observed (x^2=66.95, df=2, p<0.05). Figure 3.7 (Chart 1), shows the percentages of successfully completed tasks by complexity (simple, moderate and complex) in the VICLMS, MICLMS and AICLMS experimental platforms. There was a small difference in the successfully completed simple tasks in all three conditions. The reason there was no noticeable difference, is due to the lack of significant user mental effort needed to complete the task. In moderate tasks, there was

a difference between the percentages of successfully completed tasks. These were 4% between AICLMS and MICMS, and 34% between AICLMS and VICLMS. The Chi-Square test for moderate tasks showed no significant difference between AICLMS and MICLMS (x^2 =24.6, df=1, p>0.05), but a highly significant difference between AICLMS and VICLMS (x^2 =57.9, df=1, p<0.05). A considerable difference was observed in the successful completion of complex tasks. This was 22% between AICLMS and MICLMS, and 78% between AICLMS and VICLMS. A significant difference was observed between AICLMS and MICLMS (x^2=8.6, df=1, p<0.05). A higher significance was also observed between AICLMS and VICLMS (x^2=61.5, df=1, p<0.05). For moderate and complex tasks, a significant difference was found in moderate tasks (x^2=36.2, df=2, p<0.05) and in complex tasks (x^2=67.8, df=2, p<0.05). There was insufficient difference in the simple tasks. However, users in the AICLMS platform achieved the highest percentage successfully completed tasks when compared to MICLMS and VICLMS.

3.9.3 Task Completion

Tasks were divided into three different types (EPC, IPC and PSC) in the mass customisation. These tasks needed to be communicated to users with a scenario for each task. For example, the product configuration tasks included the external, internal and service of product customisation. Results showed that users performed differently for each task types of EPC (129 tasks, 86%), IPC (108 tasks, 72%) and PSC (128 tasks, 85.3%). This difference was significant (x^2=12.21, df=2, p<0.05). Figure 3.7 (Chart 2) shows the mean value (in percentage) of successfully completed tasks. The IPC tasks showed the lowest user achievement rate, as users encountered difficulties with the customisation process of the internal product.

Figure 3.7 (Chart 2) shows that users in the AICLMS achieved 98%, 96% and 100% in the EPC, IPC and PSC respectively. The chi-square test was used for each task type. In EPC, the difference between AICLMS and MICLMS was not significant (x^2=1.9, df=1, p>0.05), but between AICLMS and VICLMS it was significant (x^2=15.95, df=1, p<0.05). In IPC tasks, AICLMS was better than the MICLMS by 6% (not significant atx^2=1.4, df=1, p>0.05) and VICLMS by 66% (significant atx^2=46.72, df=1, p<0.05). In PSC, AICLMS performed better than MICLMS (significant at x^2 =8.7, df=1, p<0.05),and nearly double that of VICLMS (significant atx^2=16.3, df=1, p<0.05). For all task types (simple, moderate and complex), the three conditions were significant in user task completion for EPC (x^2=20.93, df=2, p<0.05), IPC (x^2=66.1, df=2, p<0.05) and PSC (x^2=15.77, df=2, p<0.05).

In summary, users in the AICLMS successfully completed more product customisation tasks, of all types.

3.9.4 Individual Tasks

Figure 3.8 shows the percentages of users who successfully completed each of the six tasks per condition. The graph shows that complex tasks (T5 and T6) had a completion rate of 96% and 92% respectively. In the simple task T1, there was a variance of 12% between VICLMS and MICLMS, and 4% between MICLMS and AICLMS, and 16% between VICLMS and AICLMS. Thus, the AICLMS condition performed best for task T1. However, T2 demonstrated a similar performance in all conditions. The moderate task, T3, had the lowest task completion results in the VICLMS condition, but the highest in AICLMS.

A significant difference was found between AICLMS and VICLMS (x^2=9.5, df=1, p<0.05). The use of expressive avatars in the AICLMS condition, demonstrated the highest results for effectiveness, in terms of percentage of tasks completed successfully.

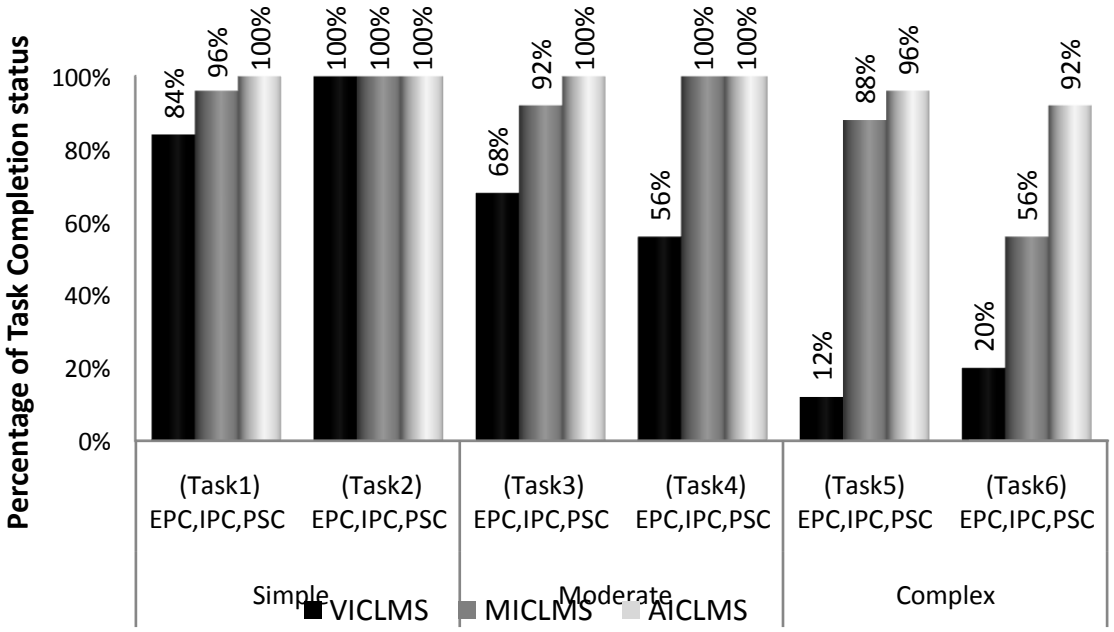

Figure 3.8: Task completion rates of the six tasks attempted by users in the VICLMS, MICLMS and AICLMS.

A statistically significant difference amongst the three conditions was identified (x^2=12, df=2, p<0.05).

However, task completion for task T4 was similar in the AICLMS and MICLMS, but a significant difference of 44% (x^2=4.1, df=1, p<0.05) between VICLMS and AICLMS was observed. Task T5 also had a significant difference amongst the condition for task completion. AICLMS was the best performing for task T5 (x^2=35.5, df=1, p<0.05),and for all three conditions, a statistical difference was identified (x^2=47.5, df=2, p<0.05). For task T6, an approximate 36% difference between the conditions was observed. T6 was completed successfully by 54% of the users in AICLMS than MICLMS. This difference was significant (x^2=8.4, df=1, p<0.05). VICLMS was much higher (72%) than the AICLMS, and significant (x^2=26.3, df=1, p<0.05). An overall comparison of the three interaction styles was also significant (x^2=31.4, df=2, p<0.05). Therefore, effectiveness increased with the use of the avatar.

3.10 Efficiency

Figure 3.9 shows mean values of the time taken by users to complete tasks (Chart 1), mouse clicks (Chart 2), and errors (Chart 3) per condition. On overall, AICLMS performed better that MICLMS and VICLMS. The mean value of time taken by users to complete tasks in VICLMS was 13% higher, and 19% in the MICLMS from the AICLMS. A significant difference was found between AICLMS and MICLMS (t_{48}=12.6, cv=2.02, p<0.05) and between AICLMS and VICLMS (t_{43}=32.4, cv=2.02, p<0.05). Figure 3.9 (Chart 2) shows the mean value of mouse clicks. The AICLMS was 5% less from the MICLMS (significant with t_{39}=10.4, cv=2.04, p<0.05) and 17% less from the VICLMS (significant with t_{29}=17.4, cv=2.04, p<0.05). Figure 3.9 (Chart 3) shows the mean values of errors. AICLMS had 16% less user errors from the MICLMS (significant with t_{47}=8.9, cv=2.02, p<0.05) and 33% less from the

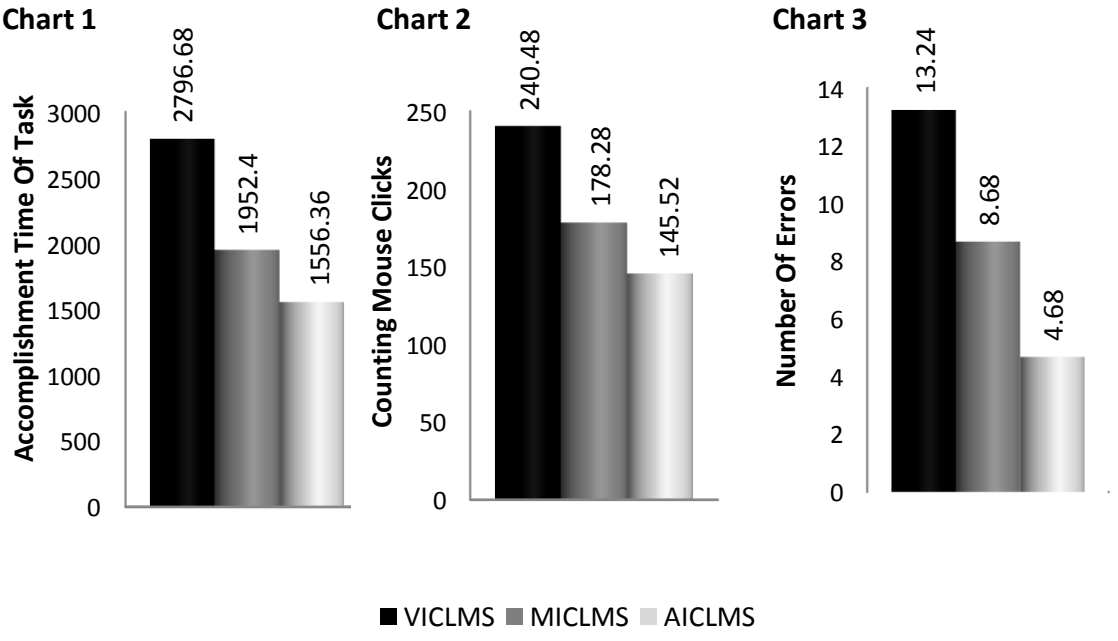

Figure 3.9 Mean values of the time taken by users to complete tasks (Chart 1), number of mouse clicks (Chart 2) and errors (Chart 3).

VICLMS (significant with t_{46} =15.8, cv=2.02, p<0.05). In conclusion, AICLMS achieved an improvement in efficiency compared to MICLMS and VICLMS.

3.10.1 Task Complexity

Figure 3.10 shows the mean values of time taken by users to complete tasks (Chart 1) and mouse clicks (chart 2), according to task complexity (simple, moderate and complex) per condition. Figure 3.10 (Chart 1) shows the mean values of time taken by users to complete simple, moderate and complex tasks. In simple tasks, the mean value of task time in the AICLMS platform was significantly lower than the tasks completed using the MICLM platform (t_{42}=8.9, cv=2.02, p<0.05),and the VICLMS (t_{37}=21.1, cv=2.04, p<0.05). In moderate tasks, the mean values of task completion time in the AICLMS interface were significantly higher than those of MICLMS (t_{40}=6.9, cv=2.04, p<0.05) and VICLMS (t_{32}=17.6, cv=2.04, p<0.05).

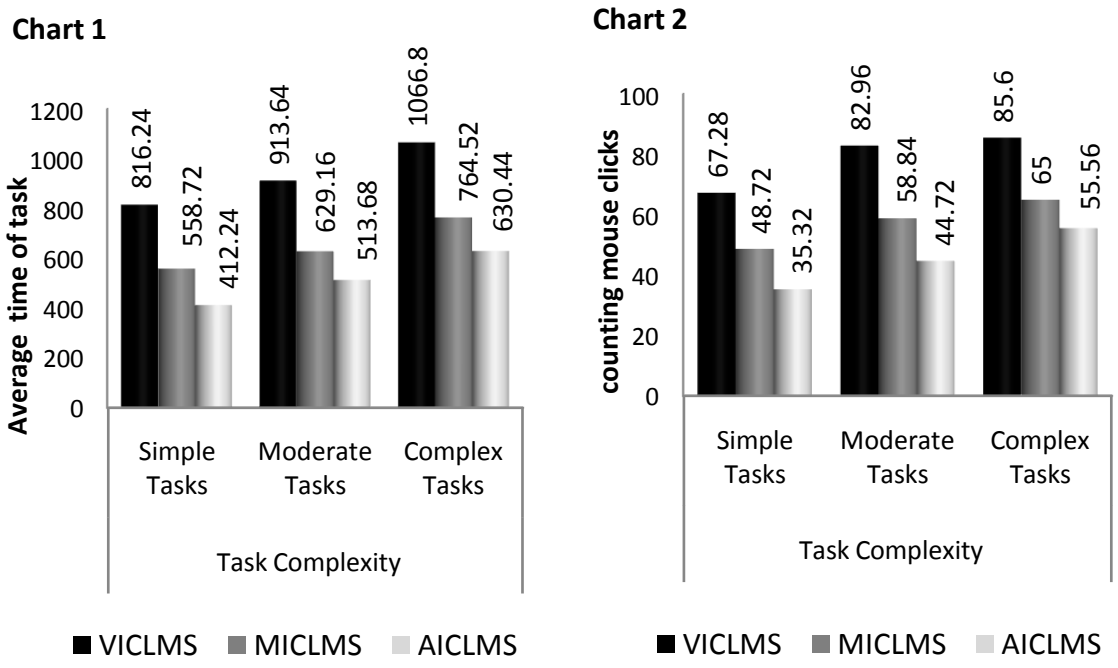

Figure 3.10 Mean values of task time (chart 1) and mouse clicks (chart 2) shown in terms of simple, moderate and complex tasks.

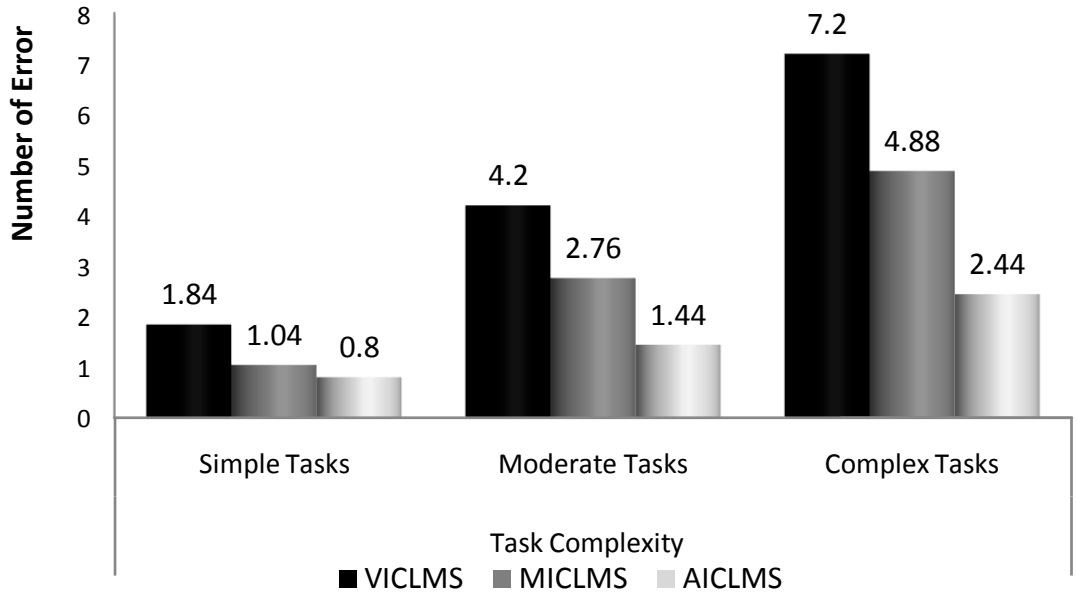

Figure 3.11 Mean value of number of errors of the VICLMS, MICLMS and AICLMS interfaces.

In complex tasks, the mean values of AICLMS were also significantly higher than those of MICLMS (t_{40}=17.6, cv=2.02, p<0.05), and almost doubled in the VICLMS platform (t_{48} =8.6, cv=2.02, p<0.05). Figure 3.10 (Chart 2) shows the difference between AICLMS and MICLMS in mouse clicks. The number of mouse clicks gradually increased with task complexity. In simple tasks, the mean values of mouse clicks were significantly lower in the AICLMS than those of the MICLMS platform(t_{39} =9.6, cv=2.02, p<0.05), and considerably lower than those of VICLMS (t_{29}=13.7, cv=2.04, p<0.05). Similarly in moderate tasks, the mean values of mouse clicks were significantly lower in AICLMS than MICLMS (t_{29} =8.6, cv=2.04, p<0.05) and VICLMS (t_{26}=15.7, cv=2.06, p<0.05). Similarly, significant results for the AICLMS were observed in complex tasks when compared to those in MICLMS (t_{32} =6.2, cv=2.04, p<0.05) and VICLMS (t_{28}=13.3, cv=2.05, p<0.05). The AICLMS enabled users to complete tasks faster with the least number of mouse clicks, regardless of the level of difficulty associated with the task when compared to VICLMS and MICLMS.

The number of errors was also another measurement to evaluate efficiency across the three conditions. In simple tasks, the data was insufficient to measure the difference, as the frequency of error was similar. However, it can be observed that the frequency of error was considerably different in both moderate task and complex. Figure 3.11 shows the error data. The mean value of the number of errors observed for simple tasks in AICLMS was 0.8 compared to 1.04 in MICLMS. This difference was not significant (t_{47}=0.9, cv=2.02, p>0.05), but the difference in error between AICLMS and VICLMS was significant (t_{48}=3.7, cv=2.02, p<0.05). In moderate tasks, the mean value of errors in AICLMS was 1.44. This was slightly different to the one observed in MICLMS (2.76). A greater difference, however, was observed in VICLMS (4.2). The variations between the AICLMS and MICLMS were not significant (t_{48}=4.3, cv=2.02, p>0.05), but significance was found between AICLMS and VICLMS (t_{46}=8, cv=2.02, p<0.05). In complex tasks, the error rate for AICLMS was 2.44 compared to 4.88 for the MICLMS and 7.2 for the VICLMS. The t-test results showed that the variation between the AICLMs and MICLMS interfaces was significant (t_{48}=7.2, cv=2.02, p<0.05). Moreover, the mean value of number of errors in the AICLMS was considerably lower than VICLMS (significant att_{46}=13.02, cv=2.02, p<0.05). In conclusion, the number of errors was significantly reduced in the AICLMS group compared to MICLMS and VICLMS.

3.10.2 Task Type

Figure 3.12 shows the mean values of mouse clicks and time taken by users to complete the three task types (EPC, IPC and PSC) per condition. Overall, it can be observed that the AICLMS was the best performing condition for all types of tasks. The user performance with IPC tasks was better than EPC and PSC for all types of task difficulty (simple, moderate and complex).

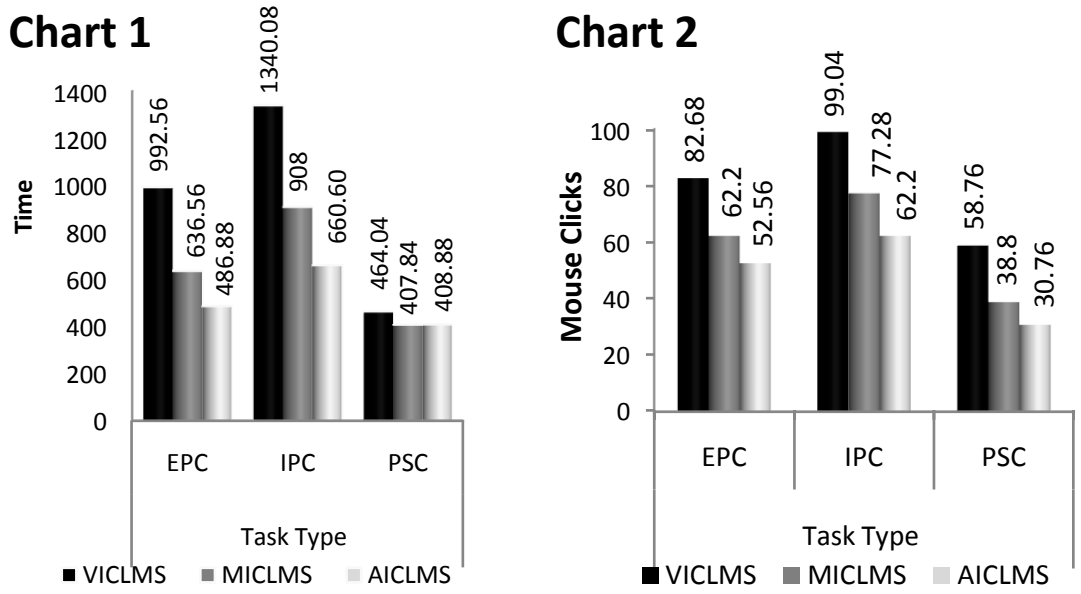

Figure 3.12 Mean values of time taken to complete task (chart 1) and frequency of mouse clicks (chart 2) of the VICLMS, MICLMS and AICLMS conditions.

The AICLMS mean value of task time for EPC tasks was considerably lower than MICLMS and VICLMS. In fact, the VICLMS measurement was over double than that of AICLMS. Similarly, the IPC tasks had nearly the same difference. Users customised products significantly faster than their counterparts in the MICLMS condition, and over twice as fast compared to the VICLMS condition. In PSC tasks, the time in the AICLMS was slightly lower than MICLMS, and slightly higher than VICLMS. The mean values of time for task accomplishment showed a significant difference between AICLMS and MICLMS in EPC tasks (t_{17} =5.1, cv=2.11, p<0.05) and IPC tasks (t_{35} =8.4, cv=2.04, p<0.05), but the difference was not significant for the PSC tasks (t_{47} =0.06, cv=2.01, p>0.05). In addition, the difference in mean value of time was significant between AICLMS and VICLMS in EPC tasks (t_{44} =15.5, cv=2.02, p<0.05) and IPC tasks (t_{43} =29.6, cv=2.02, p<0.05). However, no significance was found in the PSC tasks (t_{44} =2.9, cv=2.02, p<0.05). In conclusion, these results demonstrate the effectiveness of users for EPC and IPC tasks was enhanced by the AICLMS, compared to the MICLMS and VICLMS. However this was less the case for the PSC tasks. Figure

3.12 (Chart 2) shows the mean values of mouse clicks. Users in the AICLMS used significantly less mouse clicks for all task types compared to MICLMS and VICLMS. In EPC tasks, the mean value of mouse clicks in the AICLMS version was significantly lower than the corresponding number in MICLMS (t_{35} =6.6, cv=2.04, p<0.05)and VICLMS(t_{28} =12.7, cv=2.05, p<0.05). Similarly, IPC tasks were significant for the mean value of mouse clicks between AICLMS and MICLMS (t_{38}=10.9, cv=2.04, p<0.05), as well as between AICLMS and VICLMS (t_{30}=18.6, cv=2.04, p<0.05). In PSC tasks, the mean value of mouse clicks in the AICLMS version was significantly lower than MICLMS (t_{42}=6.6, cv=2.02, p<0.05), as well as AICLMS and VICLMS (t_{30}=14.1, cv=2.04, p<0.05).

Therefore, AICLMS demonstrated the most significantly reduced time in all task types compared to the VICLMS and MICLMS. In addition, AICLMS required the least amount of mouse clicks compared to the VICLMS and MICLMS.

Furthermore, AICLMS also demonstrated the lowest number of errors compared to MICLMS and VICLMS for all task types. Figure 3.13 shows the mean value of errors of EPC tasks in AICLMS (1.44) and MICLMS (2.76). The differences were significant between AICLMS and MICLMS (t_{48} =5.8, cv=2.02, p<0.05), as well as between AICLMS and VICLMS (t_{40}=7.8, cv=2.02, p<0.05). For IPC tasks, the AICLMS mean value was 2.48, which was significantly different to the4.24 of MICLMS (t_{43}=5.5, cv=2.02, p<0.05), and even more significantly different to6.32 of VICLMS (t_{41}=11.3, cv=2.02, p<0.05). In PSC tasks, AICLMS recorded a mean value of error of 0.76, which was significantly less than 1.72 of MICLMS (t_{47}=4.3, cv=2.02, p<0.05), and 3.04 of VICLMS (t_{36} =7.4, cv=2.04, p<0.05). This shows that the number of errors was significantly fewer in the AICLMS compared to MICLMS and VICLMS interfaces. Figure 3.14 shows the mean values of time of tasks (chart 1) and the number of mouse clicks (chart 2) for all users that completed each of the six tasks.

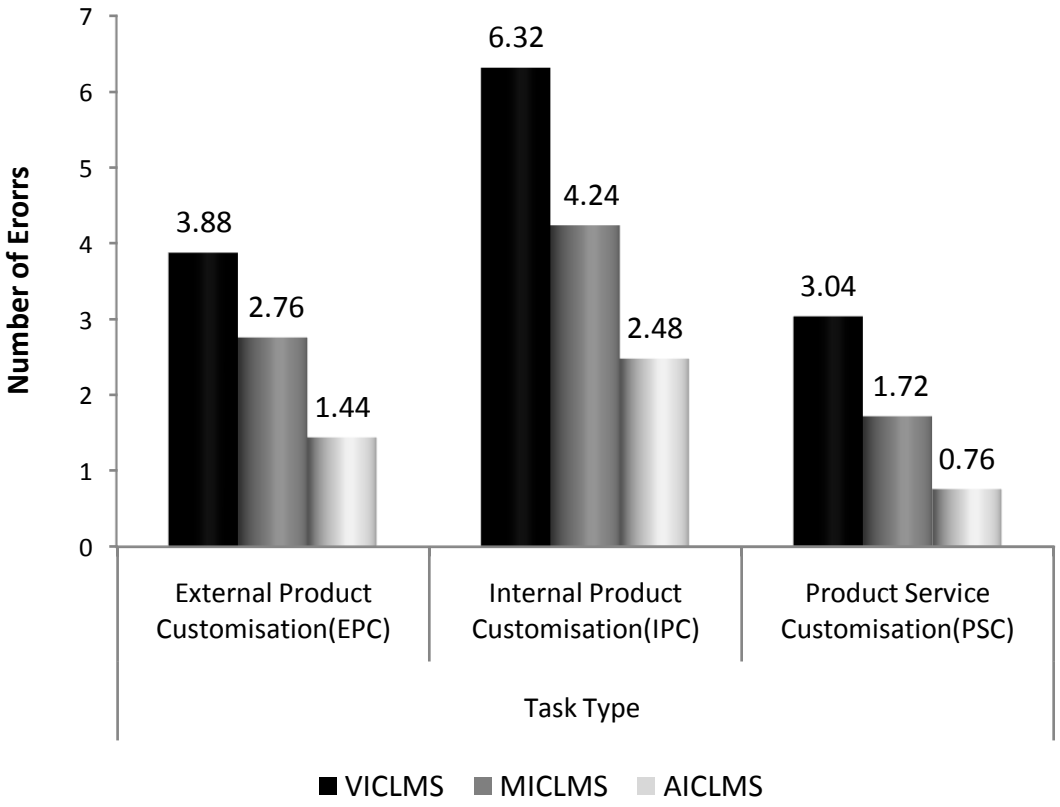

Figure 3.13 Mean values of the number of errors of the VICLMS, MICLMS and AICLMS interfaces.

3.10.3 Analysis of Each Task

Efficiency was greater in terms of both time and mouse clicks when expressive avatars were used (VICLMS and MICLMS). Figure 3.13 (chart 1) illustrates that for all tasks. The time performance of users was better using AICLMS than MICLMS and VICLMS. T1 and T2 took less time to perform than the other tasks on both interfaces, because they were easier; whereas T5 and T6 took longer as they were relatively complex. The mean values of time for task T1 in AICLMS were lower than MICLMS and VICLMS. T-test values showed a significant difference between AICLMS and VICLMS (t_{30}=12.3, cv=2.04, p<0.05). The use of expressive avatars was the most efficient in terms of mean value of time taken to complete tasks. In addition, AICLMS was lower than that for MICLMS, and t-test values were significant (t_{32}=4.7, cv=2.04, p<0.05).

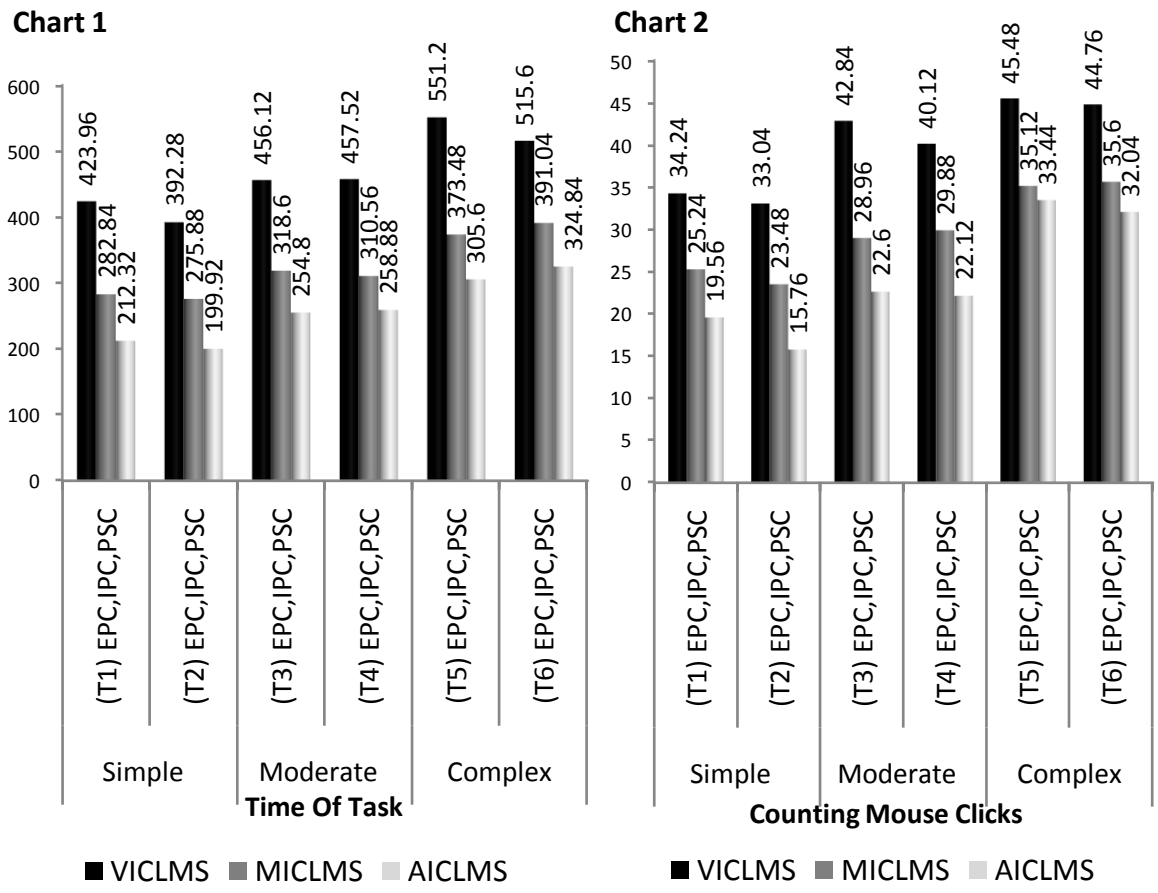

Figure 3.14 Mean values of time taken by users to complete tasks (Chart 1) and frequency of mouse clicks (Chart 2) for the six tasks of the VICLMS, MICLMS and AICLMS.

Similarly, the performance in terms of task time was significantly better for the experimental interface on T2 AICLMS compared to VICLMS (t_{33} =13.9, cv=2.04, p<0.05),and AICLMS compared to MICLMS (t_{41}=7.5, cv=2.02, p<0.05); T3 AICLMS vs. VICLMS (t_{32}=11.9, cv=2.04, p<0.05),AICLMS vs. MICLMS (t_{41}=5.3, cv=2.02, p<0.05), T4 AICLMS vs. VICLMS (t_{30} =14.8, cv=2.04, p<0.05), AICLMS vs. MICLMS (t_{36}=5.2, cv=2.04, p<0.05), T5 AICLMS vs. VICLMS (t_{34}=16.8, cv=2.04, p<0.05),AICLMS vs. MICLMS (t_{30}=7.3, cv=2.04, p<0.05), T6 AICLMS vs. VICLMS (t_{36}=11.7, cv=2.04, p<0.05), and AICLMS vs. MICLMS (t_{44}=5.3, cv=2.02, p<0.05). As shown in Figure 3.14 (Chart 2), the mean value of number of mouse clicks in the AICLMS interface was again better on all tasks than VICLMS and MICLMS.

Again, the difference between the two interfaces on this measure was significant, as assessed by the t-test for all tasks: T1 AICLMS vs. VICLMS (t_{31}=9.9, cv=2.04, p<0.05) and AICLMS vs. MICLMS (t_{42}=6.2, cv=2.02, p<0.05), T2 AICLMS vs. VICLMS (t_{28}=12.6, cv=2.05, p<0.05) and AICLMS vs. MICLMS (t_{33}=8.03, cv=2.04, p<0.05), T3 AICLMS vs. VICLMS (t_{25}=8.2, cv=2.06, p<0.05) and AICLMS vs. MICLMS (t_{33}=6.7, cv=2.05, p<0.05), T4 AICLMS vs. VICLMS (t_{29}=15.7, cv=2.04, p<0.05) and AICLMS vs. MICLMS (t_{32}=8.6, cv=2.04, p<0.05), T5 AICLMS vs. VICLMS (t_{28}=7.2, cv=2.05, p<0.05) and AICLMS vs. MICLMS (t_{32}=1.4, cv=2.04, p>0.05) and T6 AICLMS vs. VICLMS (t_{28}=9.8, cv=2.05, p<0.05) and AICLMS vs. MICLMS (t_{40}=4.9, cv=2.02, p<0.05).

Figure 3.15 shows the mean values of user errors for all the tasks in all conditions. The AICLMS condition performed better than VICLMS and MICLMS. T1 and T2 had a small user error difference. The t-tests showed no significance difference for T1 between AICLMS and VICLMS (t_{44}=1.8, cv=2.02, p>0.05),as well as between AICLMS and MICLMS (t_{48}=0.5, cv=2.02, p>0.05).

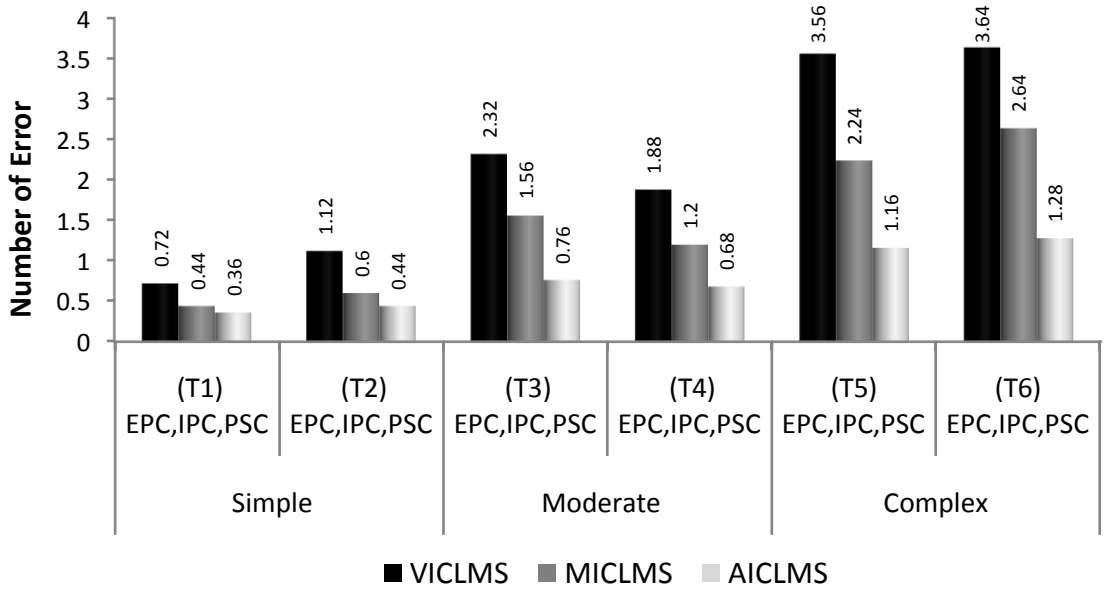

Figure 3.15Mean values of user error for the different types of tasks.

Similarly, T2 between AICLMS and VICLMS (t_{48}=3.7, cv=2.02, p>0.05), as well as between AICLMS and MICLMS (t_{48}=0. 9, cv=2.02, p>0.05).For T3, significance was found between AICLMS and VICLMS (t_{42}=6.6, cv=2.02, p<0.05),as well as between AICLMS and MICLMS (t_{48} =4.1, cv=2.02, p<0.05). Similarly,T4 also achieved significance between AICLMS and VICLMS (t_{45}=5.4, cv=2.02, p<0.05), as well as between AICLMS and MICLMS (t_{47}=2.4, cv=2.02, p<0.05). For T5, the results were highly significant between AICLMS and VICLMS (t_{43}=9.4, cv=2.02, p<0.05) as well as between AICLMS and MICLMS (t_{48} =5.01, cv=2.02, p<0.05). T6 also had a significant difference between AICLMS and VICLMS (t_{36}=7.4, cv=2.04, p<0.05), as well as between AICLMS and MICLMS (t_{44}=5.5, cv=2.02, p<0.05).

This analysis demonstrates that the AICLMS condition significantly enhanced efficiency on moderate and complex tasks with regard to time of task, mouse clicks and number of user errors. Users in all groups performed simple tasks similarly in all three conditions. The use of multimodal metaphors did not improve the evaluating parameters.

This result suggests that multimodal metaphors become more effective as the complexity of the tasks increase. T3 and T4 (moderate tasks) showed a marginal significance, but T5 and T6 (the complex tasks) were highly significant. This shows that users benefited more from the multimodal metaphors when they were engaged with complex tasks. Complex tasks require a larger volume of information to be communicated. This may be one of the reasons that make multimodal metaphors more helpful to users.

3.11 Variance

Table 3.11 shows the results of the single-way ANOVA [68 and 79] for the three experimental conditions. These calculations were based on the mean values of the six

tasks in the three levels of complexity, according to the type of task for each condition. When the probability (p) was less than the significance level α (0.05), the sign of (*) indicated that the result was significant at $p<0.05$.

In T1, the difference amongst the VICLMS, MICLMS and AICLMS for efficiency (TOT and CMC) was significant, except the efficiency of NOE and effectiveness of TCS. For T2, the difference of efficiency was also significant, except the effectiveness (TCS). For simple tasks (TCS), no significant difference was identified. Tasks T3, T4, T5 and T6 were significant for both efficiency and effectiveness. Using a single-way ANOVA test, there was a significant difference in the three conditions with regard to task type, and all tasks.

Tasks (IVs)	**DVs**			
	Efficiency			**Effectiveness**
	TOT	**CMC**	**NOE**	**TCS**
Task 1	71.6(*)	59.01 (*)	2.1	F=2.9
Task 2	106.6 (*)	84.95(*)	7.4(*)	F=2.6
Task 3	82.6(*)	46.44(*)	23.8(*)	F=6.9(*)
Task 4	122.8(*)	120.47(*)	14.1(*)	F=18.9(*)
Task 5	184.1(*)	31.77(*)	48.1(*)	F=62(*)
Task 6	76.5(*)	61.84(*)	29.1(*)	F=19.4(*)
Simple	453.8(*)	133.71(*)	8.2(*)	F=2.9
Moderate	246.9(*)	133.71(*)	34.1(*)	F=30.2(*)
Complex	1057.4(*)	99.96(*)	67.5(*)	F=81.8(*)
EPC	130.5(*)	97 (*)	36.6(*)	F=8.2(*)
IPC	290.5(*)	191.99(*)	60.3(*)	F=60.5(*)
PSC	6.3(*)	82.56(*)	31.6(*)	F=12.2(*)
All Tasks	609.2(*)	185.18(*)	146.5(*)	F=94.9(*)
Note: Sign of (*) indicates significance ($p<0.05$)				

Table 3.11: Single-way ANOVA (F) for the six tasks (p value is less than the significance level α (0.05) and F critical value is 3.12).

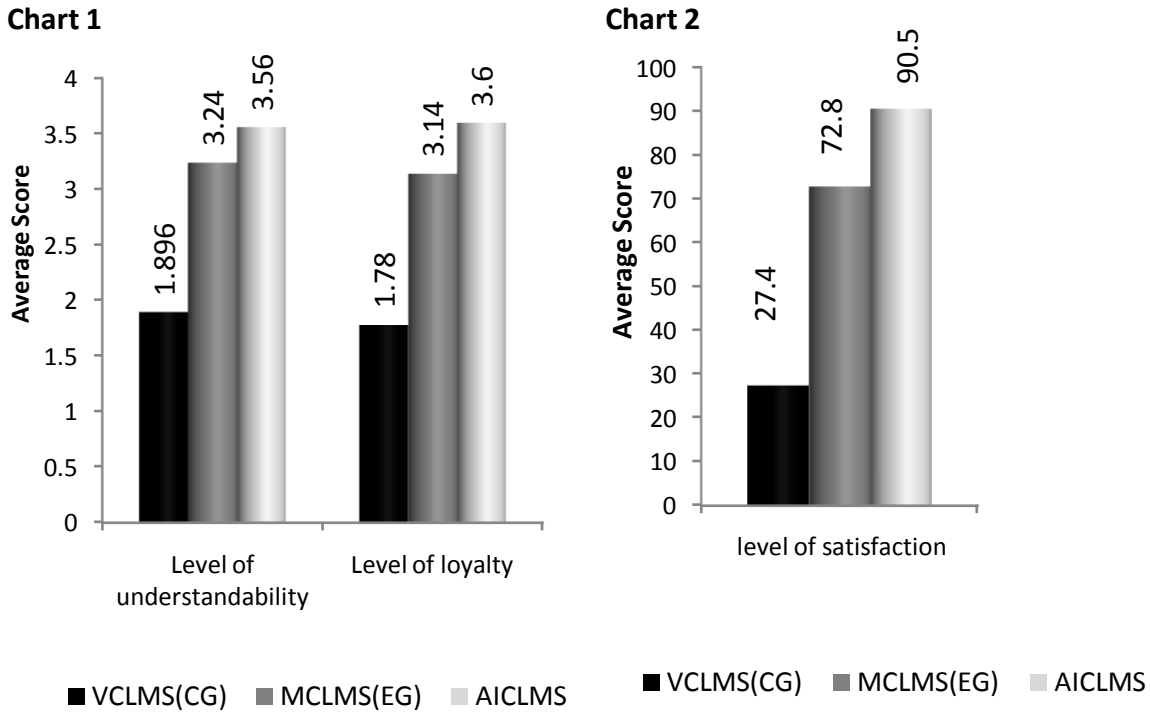

Figure 3.16 Mean values of the scores of user understandability and predisposition to loyalty (Chart 1), and user satisfaction (Chart 2).

3.12 Post-Experiment User Views

Figure 3.16 shows the mean values of user satisfaction, understandability and their predisposition to loyalty for the interface. The results show that views were different across the three experimental conditions. The AICLMS condition performed better on user views compared to the VICLMS and MICLMS.

The mean values of user satisfaction, understandability and positive predisposition to loyalty for the VICLMS were 27.4, 1.89 and 1.78 respectively. These results were considerably lower than the ones in the AICLMS (90.5, 3.56 and 3.6 respectively). The MICLMS were also lower with 72.8, 3.24 and 3.14. These differences were significant in terms of user satisfaction between VICLMS and AICLMS (t_{48}=37.42, cv=2.02, p<0.05), user understandability (t_{248}=18.57, cv=1.96, p<0.05), and predisposition to loyalty (t_{198}=20.1, cv=1.96, p<0.05).

Statements (presented to users)	Conditions (n=25 for each group)					
	VICLMS		MICLMS		AICLMS	
	Disagree	Agree	Disagree	Agree	Disagree	Agree
Choose this Interface again (CIA).	84	16	20	80	8	92
Recommend interface to others (RIO)	92	8	12	88	0	100
Purchase using the same technique (PST).	84	16	28	72	16	84
Overall, how loyal are you with this interface (OLI)	88	12	8	92	4	96

Table 3.12: The results (in percentages of users) of statements that aid customer loyalty for the VICLMS, MICLMS and AICLMS conditions.

Similarly, a significant difference was found between MICLMS and AICLMS (t_{48}=10.83, cv=2.02, p<0.05), user understandability (t_{248}=3.61, cv=1.96, p<0.05) and predisposition to loyalty (t_{198}=4.9, cv=1.96, p<0.05). A significant difference in the three conditions was also identified using the single-way ANOVA for user satisfaction (F=669.65, cv=3.12, p<0.05), user understandability (F=178.36, cv=3.02, p<0.05), and predisposition to loyalty (F=209.11, cv=3.03, p<0.05). Therefore, the AICLMS condition had a significant positive impact on all post-experiment user views, than the other two conditions.

3.12.1 Potential Growth of User Loyalty

Table 3.12 presents the results on post-experiment user views that can potentially aid the growth of user loyalty. The results show that 92% of the users agreed that the AICLMS was an interface that they would wish to use again, compared to 80% and 16% for MICLMS and VICLMS respectively. Similarly, all users in the AICLMS condition would recommend the interface to others. The results for MICLMS and VICLMS conditions were 88% and 8% respectively. An 84% of users were willing to use the same technique of this interface for repeat purchasing in the AICLMS. The agreement for MICLMS and VICLMS was 72% and 16% respectively.

Interaction Style	Users View	Statements of Understandability (%)				
		CI	FI	EI	HI	OI
VICLMS	Disagree	84	80	84	88	80
	Agree	16	20	16	12	20
MICLMS	Disagree	20	12	16	16	8
	Agree	80	88	84	84	92
AICLMS	Disagree	0	4	8	8	4
	Agree	100	96	92	92	96

Table 3.13: Users views (in percentages, n=25 for each group) on the way they thought information communicated was understood in the VICLMS, MICLMS and AICLMS conditions.

The AICLMS users were the only group that declared their loyalty to the interface by 96%. The other two conditions had significantly smaller percentages.

3.12.2 User Views on Understandability

Table 3.13 presents the post-experiment user views on how well they thought to understand the information communicated by the VICLMS, MICLMS and AICLMS conditions. The user views (in percentages) are given per statement (right) along with four statements of level of understandability.

The statements were:

1. "The information provided in the system was clear" (CI).
2. "It was easy to find the information I needed" (FI).
3. "The information provided for the system was easy to understand" (EI).
4. "The information effectively helped me complete the tasks and scenarios" (HI).
5. "The organisation of information was clear" (OI).

Users in the AICLMS expressed a stronger agreement that the overall approach was understandable than their counterparts in the MICLMS and VICLMS groups. The scores regarding the clarity of information were 100%, 80% and 16% respectively; for finding the information needed, 96%, 88% and 20%; with respect to ease of

understanding, 92%, 84% and 16%; on effectiveness in helping to complete the tasks, 92%, 84% and 12%; and with respect to the organisation of information, 96%, 92% and 20% respectively. In summary, users have responded from the overall understandability, suggesting that AICLMS improved the way they understood information. As these results derived from independent groups, users did not have a comparison reference point. This makes these results even stronger as users expressed their dissatisfaction for the MICLMS in the absence of experiencing a better way of information presentation.

3.13 Discussion

The experiment with the three experimental conditions sought to improve the following:

1. Usability in terms of effectiveness, efficiency and user satisfaction; and views of users for each of the condition tested within the e-CLMS experimental platform.
2. Explanation during product customisation in order to enable the user to complete the task successfully.
3. Reduce the user errors by presenting information better using multimodal metaphors.
4. Understanding the process of MC and a better user satisfaction, which is linked to the potential development of user loyalty.

The results indicate significantly better results of the evaluating parameters when expressive avatars (AICLMS condition) were used, compared to the other two conditions (VICLMS and MICLMS). It also demonstrates that usability improves progressively with the introduction of more multimodal metaphors.

The expressive avatars (AICLMS condition) enabled users to successfully complete more tasks compared to the other two conditions. The expressive avatar attracted the attention and focus of users. Explanation during the MC product configuration was also better facilitated, as the information communicated was distributed using different

communication metaphors. This enabled the information to be communicated faster and understood by users. This rapid multimodal presentation benefited the recommender system when product information needed to be communicated during the MC process. This meant that users spent significantly less time to successfully complete tasks. As a result, users were more satisfied, which is an essential pre-condition for developing user loyalty. The simultaneous deployment of several multimodal metaphors in AICLMS condition provided a more natural communication between the interface and the user. Expressive avatar with recorded speech enabled AICLMS users to "hear and watch" the product features, instead of reading long product descriptions.

The use of facial expressions in the avatars helped to increase the positive feelings, attraction to the interface and confidence of users during transactions. These user conditions paved the way towards creating the circumstances under which user loyalty can be developed. The explanation feature raised the user understanding and satisfaction during the MC, as less user mental effort in decision-making was needed.

In thepost-experimental user survey, users recorded their satisfaction for the experimental conditions. AICLMS users felt that it was easy to understand the product configuration and enjoyed working with this system. Their user satisfaction and predisposition to developing loyalty was improved as a result of the AICLMS condition.

3.14 Concluding Summary

Three experimental conditions, using an e-CLMS experimental platform, were designed and evaluated. Each of these conditions had a particular approach to the design of the interactive metaphors used. The VICLMS condition used text with graphics. MICLMS used earcons, auditory icons and speech. AICLMS used avatar and facial expression. They were evaluated with three opportunistically obtained independent groups of users (25 for each group). The objective was to improve usability (effectiveness, efficiency

and satisfaction), and understandability during MC. The MC user interaction for each condition was evaluated by measuring quantitative data (e.g. tasks successfully completed, time taken by users to complete tasks and so on), and qualitatively (e.g. user satisfaction and views). These measurements were necessary as they are preconditions to the development of user loyalty.

AICLMS demonstrated the best results in all the parameters measured. The second best performing condition was the MICLMS. The VICLMS condition was the least well performing one. The two multimodal conditions (AICLMS more than MICLMS) enabled users to complete more tasks successfully, needless time and mouse clicks and make the least number of errors. The presence of avatars and facial expressions enhanced the communication of information during explanation and customisation. The more multimodal metaphors used, the better the results for the tasks of moderate and high complexity. This was not observed to be the case with the simple tasks. The use of multimodal metaphors did not produce a significantly noticeable change. Therefore, the data gathered points to the fact that multimodality is more applicable to complex tasks. Chapter 4 evaluates different combinations of multimodal metaphors (based on avatars) with different tasks scenarios that consist of more complex requirements for MC.

Chapter 4: Avatar-based Experiment: A User Satisfaction and Views Approach

4.1 Introduction

Chapter 3 compared three interaction styles that used different types of communication metaphors. It demonstrated the successful use of avatars, earcons, auditory icons and recorded speech to communicate information to users during mass customisation tasks. The two multimodal conditions, particularly the avatar-based condition, outperformed the "text with graphics" condition.

The following experiments take, as a basis, the expressive avatar, and combine it with earcons (AEICLMS condition) and auditory icons (AAICLMS condition), and with both earcons and auditory icons (AICLMS condition). This evaluation of user satisfaction examines user perceived convenience, enjoyment, ease of customisation and use, and the number of tasks that users successfully completed. These evaluating parameters of user satisfaction are linked to the potential development of customer loyalty [71 and 99].

4.2 Aims and Objectives

The aim is to evaluate the impact of combining expressive avatars with other multimodal metaphors on user satisfaction that, in turn, facilitates the growth of user loyalty. The objectives involve the development of three conditions that combine expressive avatars (the main communication metaphor) with other auditory metaphors. The first condition was the AEICLMS interface that used *expressive avatars with earcons.* The second was the AAICLMS interface that used *expressive avatars with auditory icons*. The third was the AICLMS interface that used *expressive avatars with earcons and auditory icons.*

Communicated Information	Conditions (Interaction Styles)																
	AICLMS						AEICLMS					AAICLMS					
	Text	Graphics	Earcons	Auditory Icon	Speech Avatars	Facial Expressions	Text	Graphics	Earcons	Expressive Avatars	Facial Expressions	Text	Graphics	Auditory Icon	Expressive Avatars	Facial Expressions	
Co-creation	√	√	√	√	√		√	√	√	√		√	√	√	√		
External Product		√			√			√		√			√		√		
Internal Product		√			√			√		√			√		√		
Software		√			√			√		√			√		√		
Services	√	√	√	√	√		√	√	√	√		√	√	√	√		
Transaction Mode		√	√					√	√				√	√			
Recommender System		√				√		√			√		√			√	
Customer needs	√	√	√				√	√	√			√	√	√			
Budgetary Control System	√			√			√		√			√		√			
Performance Level		√	√			√		√	√		√		√	√		√	
Perceived Value	√			√			√	√				√		√			
Conformation	√			√			√	√				√		√			

Table 4.1: The allocation of metaphors in the three avatar-based conditions.

The evaluation had one group of dependent users (n=50). The tasks were different in the scenarios from the ones used in chapter 3, as they were based on the *co-creation principle* in mass customisation. The parameters measured, include user perceived convenience, enjoyment, customisation, ease of use and the number of tasks successfully completed by users.

4.3 Experimental Conditions

Table 4.1 shows the allocation of the multimodal metaphors.

Expressive avatars with both earcons and auditory icons are used in the AICLMS.

Expressive avatars with earcons are used in the AEICLMS.

Expressive avatars with auditory icons are used in the AAICLMS.

Action	Level	(Earcons) Rhythm	(Earcons) Timbre	(Auditory icons) Rhythm
Services	1-4			
Home Installation	1-4	Rising Pitch	Bass	Big drill
Data Recovery	1-2	Rising Pitch	Piano	Jackhammer
Build Time	1-3	Rising Pitch	Whistling	Workshop
Warranty	1-4	Single pitch	Bell	Camera
Customisation stages	1-4			
External Product	1	Rising Pitch	Fanfare	Hatch
Internal Product	2	Rising Pitch	Harp	Machine
Software	4	Rising Pitch	Cello	Projector
Services	5	Rising Pitch	Drum	Vacuum
Budget		Single pitch	Piano	Ding
Performance Level	1-5	Rising Pitch	Brass	Human voice
Perceived Value		Single pitch	Guitar	Clapping
Conformation		Rising Pitch	Whistling	Close door

Table 4.2: The way earcons and auditory icons were allocated and designed.

4.3.1 Earcons and Auditory Icons

The AEICLMS condition used earcons and the AAICLMS auditory icons. Table 4.2 shows their allocation to the information communicated to users. Earcons used rhythm,and timbre communicated information about services, customisation stages, budget, performance level, perceived value and confirmation. For example, rising pitch communicatedinformation for each product with a consistent correlation between rhythm and avatar expressions. The AEICLMS condition also used rhythm and timbre (fanfare, harp, cello and drum) to communicate customisation stages (external product, internal product, software and services). AAICLMS has various auditory icons (e.g. hatch, machine, projector and vacuum) to communicate customisation stages (external product, internal product, software and services). Earcons and auditory icons were presented during the avatar interaction with the users in order to support their decision-making process for the task.

4.4 Hypotheses

The hypotheses in this experiment were:

H3: The use of avatar with earcons and auditory icons will outperform the use of avatar with earcons only,in terms of task completion, user satisfaction and views of the interface.

a. The AICLMS will outperform the AEICLMS in terms of the user convenience, enjoyment, customisation and ease of use.
b. The AICLMS will enable users to complete (level 1) more tasks than the AEICLMS.

H4: The use of avatar with earcons and auditory icons will outperform the use of avatar with auditory icons, only in terms of task completion, user satisfaction and views of the interface.

a. The AICLMS will outperform the AAICLMS in terms of the user convenience, enjoyment, customisation and ease of use.
b. The AICLMS will enable users to complete (level 1) more tasks than the AAICLMS.

4.5 New Experimental Tasks

This experiment introduces new experimental tasks for two reasons. First, the simple tasks needed to be upgraded in terms of MC difficulty. Previous experiments identified (see Chapter 3) that multimodal metaphors did not contribute significantly in simple MC tasks. Therefore, these new experimental tasks raise progressively, the difficulty of the simple, moderate and complex tasks. Second, although the user sample was new, some users had previously been exposed to the previous experiments. The introduction of new tasks therefore, reduced any possible learning effect that might have affected a small number of users who were previously exposed to the tasks.

Tasks	Task Complexity	Task style	Number of Requirements	
T1, T2	Simple	Co-creation	T1=21	T2=21
T3, T4	Moderate	Co-creation	T3=26	T4=26
T5, T6	Complex	Co-creation	T5=23	T6=21

Table 4.3: Experimental tasks.

The new tasks enabled the experimenter to determine how well users perform in a variety of circumstances and levels of difficulty. The raised task difficulty for this experiment was divided into three levels (similar to the previous experiment in Chapter 3,with level one being simple, level two being moderate and level three being complex). The design of tasks is shown in Table 4.3.

4.6 Co-creation Task

Scenarios were provided in each co-creation tasks. Table 4.4 shows the scenario requirements of the co-creation tasks.

For example, T1 co-creation task requires the user to provide menu selections with the recommender system, guiding the user to the best item according to the previous user input. The user provides the parameters and the customisation process continues. According to the product information, the user was required to choose, for example, a product with 2 front USB ports feature, and the price to be less than £15. In the recommender system, the user had to choose an item that the recommender system had recommended, and this requirement was a demonstration of the product that matches the users need. In this way, the user continued to complete all the requirements in the scenario.

Co-creation					**NOR**
Working activity					1
Budget (<£1000.00)					1
Stage	**Product**	**Product Information**	**Price**	**Recommender System**	
External	Case & lock	2 front USB ports	< £15	Recommended	5
Internal	Memory	Size is 8GB	< £60	Recommended	5
Software	Operating System	Windows 7 professional	< £130	Strongly Recommended	5
Service	Home Installation	Family surf Control	≥ £79	==========	4

Table 4.4: Task requirements for task (T1) using co-creation.

4.7 Dependent and Independent Variables

The dependent variables were:

DV 1: *Perceived convenience* (PC) was measured by a questionnaire in which users had to choose one of the following statements:

1. *"Purchase without much help"* (PWH).
2. *"User friendly interaction"* (UF).
3. *"Very convenient interaction"* (VC).

DV 2: Perceived enjoyment (PE) was measured similarly to DV1, but with the following statements:

1. *"Interesting website"* (IW).
2. *"Entertaining website"* (EW).
3. *"Pleasant website"* (PW).
4. *"Very enjoyable website"* (VEW).

DV 3:*Perceived value of customisation* (PVC) was measured with the following statements:

1. *"Recommendations matched my needs"* (RMN).
2. *"Feeling unique customer"* (FUC)
3. *"Customised products easily"* (CPE).

Users	Pre- session questionnaires	Simple Tasks	Usability assessment	Moderate tasks	Usability assessment	Complex Tasks	Usability assessment	Post- session questionnaires
1-8		AEICLMS		AAICLMS		AICLMS		
9-16		AEICLMS		AICLMS		AAICLMS		
17-24		AAICLMS		AEICLMS		AICLMS		
25-32		AAICLMS		AICLMS		AEICLMS		
33-40		AICLMS		AEICLMS		AAICLMS		
41-50		AICLMS		AAICLMS		AEICLMS		

Table 4.5: Rotation order of the conditions.

DV 4:*Perceived ease of use* (PEU) was measured by the following statements:

1. *"Easy to use for product customisation"* (EUPC).
2. *"Easy to find information quickly"* (EFIQ).
3. *"Clear and understandable"* (CAU).

DV 5: Successful completion of tasks by users (Level of success - LOS) was measured using three levels of task completion. A fully completed task by the user was recorded as "Level 1 completion", a partially completed task as "Level 2 partial completion", and a failed task as "Level 3 failed".

The independent variables were:

IV 1: The AEICLMS, AAICLMS and AICLMS conditions.

IV2: The simple (T1 and T2), moderate (T3 and T4) and complex (T5 and T6) tasks.

4.8 Sample

An opportunistically recruited dependent group of users (n=50) was the evaluating sample of the three conditions.

The experiment had three phases. The first phase required users to complete a pre-experimental questionnaire, the second phase was the actual experiment, and the last phase required users to complete a post-experimental questionnaire. The experimental platform presented the conditions and tasks to users in the rotation shown in Table 4.5. Each user was requested to perform the experimental tasks in a computer laboratory setting.

4.9 Procedure

The procedure of the experiment consisted of three stages:

1. The sample provided background information associated with previous e-commerce and product customisation experience.
2. Users were instructed to complete the six experimental PC (with co-creation) tasks using AEICLMS, AAICLMS and AICLMS conditions, in the rotation indicated in Table 4.5.
3. A set of questionnaires was administered that aimed to collect the user satisfaction and user views on convenience, enjoyment, value of customisation and ease of use.

4.10 User Background

Figure 4.1 shows the information provided by users in the pre-experimental questionnaire (see Appendix C-1). Figure 4.3 shows the percentages of users who have experience with online product customisation. The results showed that 64% of the users had no prior experience with product customisation. 78% of on-line users of the sample reported that miss the face-to-face interaction in e-commerce transactions. 67% of users reported that it was ‘difficult to use’ e-commerce. Both of those items reported by the sample as issues in MC mass environment. 56% had not attempted product customisation.

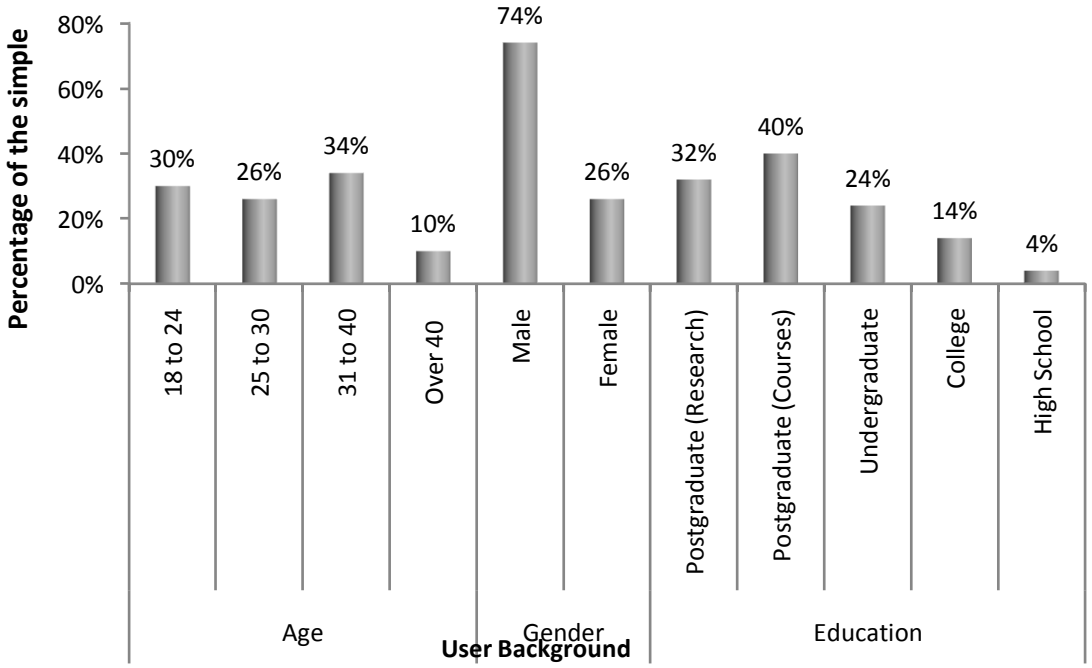

Figure 4.1: The user background data of the sample.

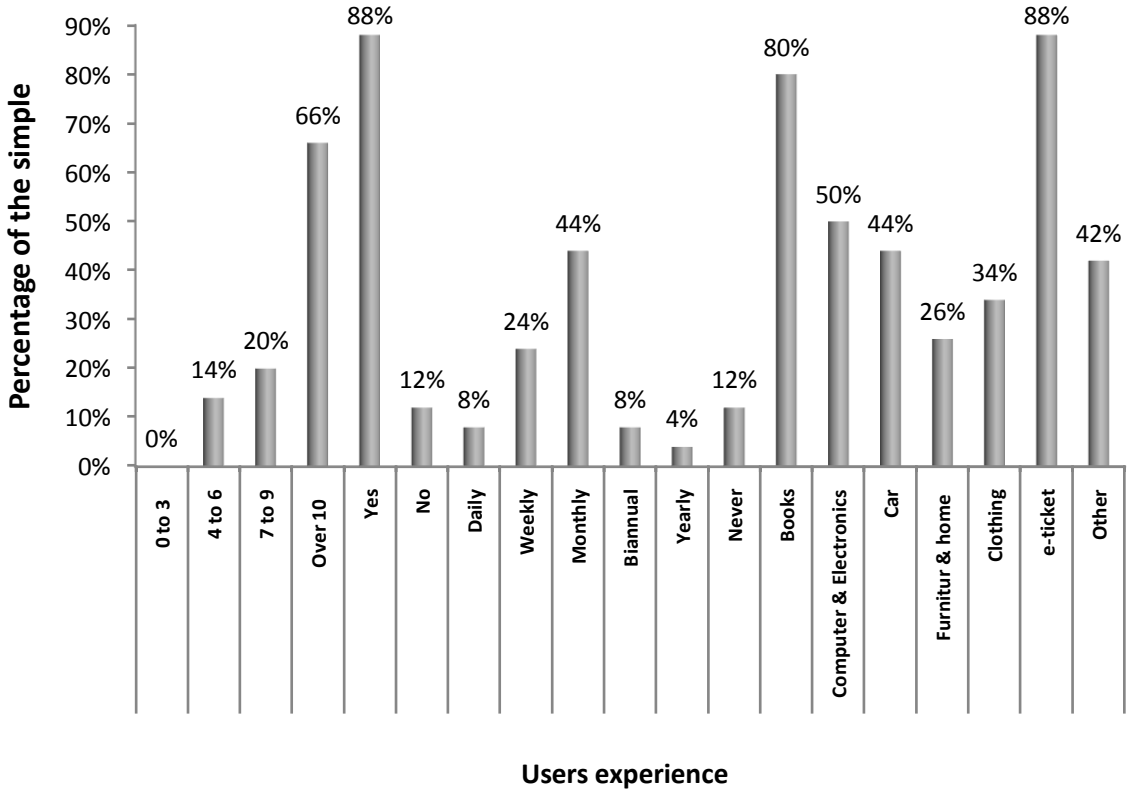

Figure 4.2: Experience of users with theInternet.

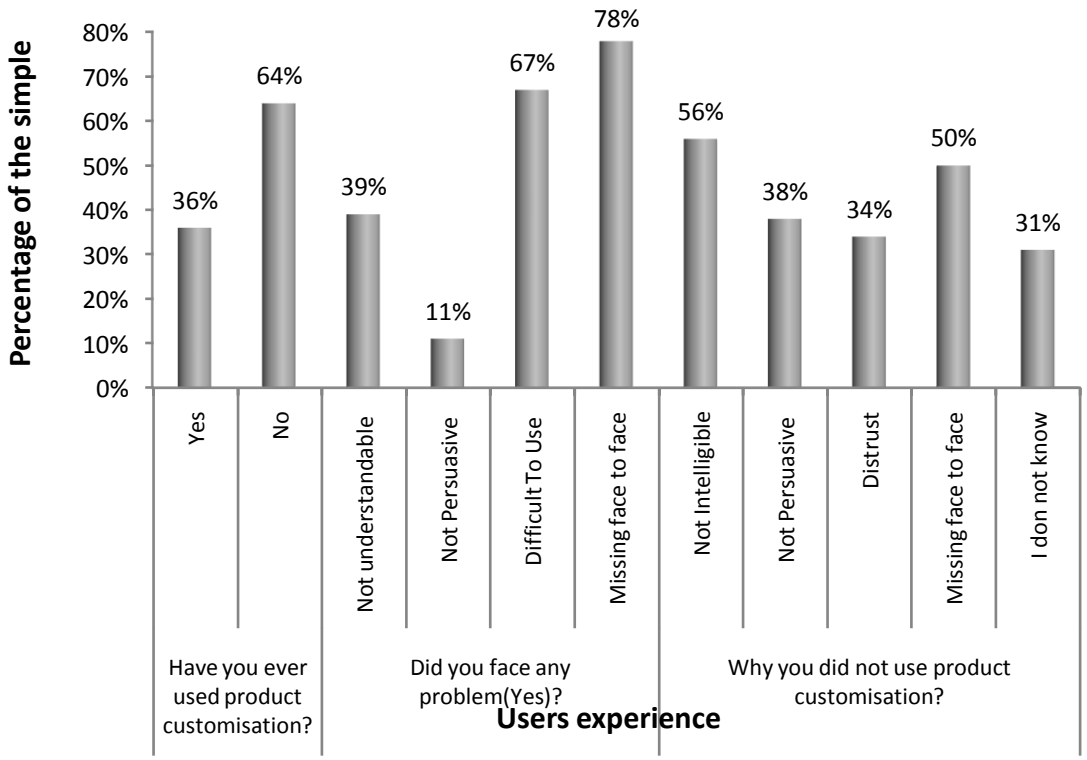

Figure 4.3: Users experience with regard to online product customisation.

4.11 Task Completion

Figure 4.4 shows the results of user task completion for each condition (AEICLMS, AAICLMS and AICLMS). The AICLMS condition was the best performing as users successfully completed 96% of the tasks. The difference between the AICLMS and AEICLMS was 11%, and the variance between the AICLMS and AAICLMS was 20%. The variance amongst the three conditions was calculated using the Chi-square test. The difference amongst the three conditions was significant (x^2 =56.4, df=4, p<0.05). Similarly, there was a significant difference between AEICLMS and AAICLMS (x^2=12, df=2, p<0.05),AEICLMS and AICLMS (x^2=21.8, df=2, p<0.05), and AICLMS and AAICLMS (x^2 =51.5, df=2, p<0.05). These results demonstrate a significant improvement in user task completion when the AICLMS was used.

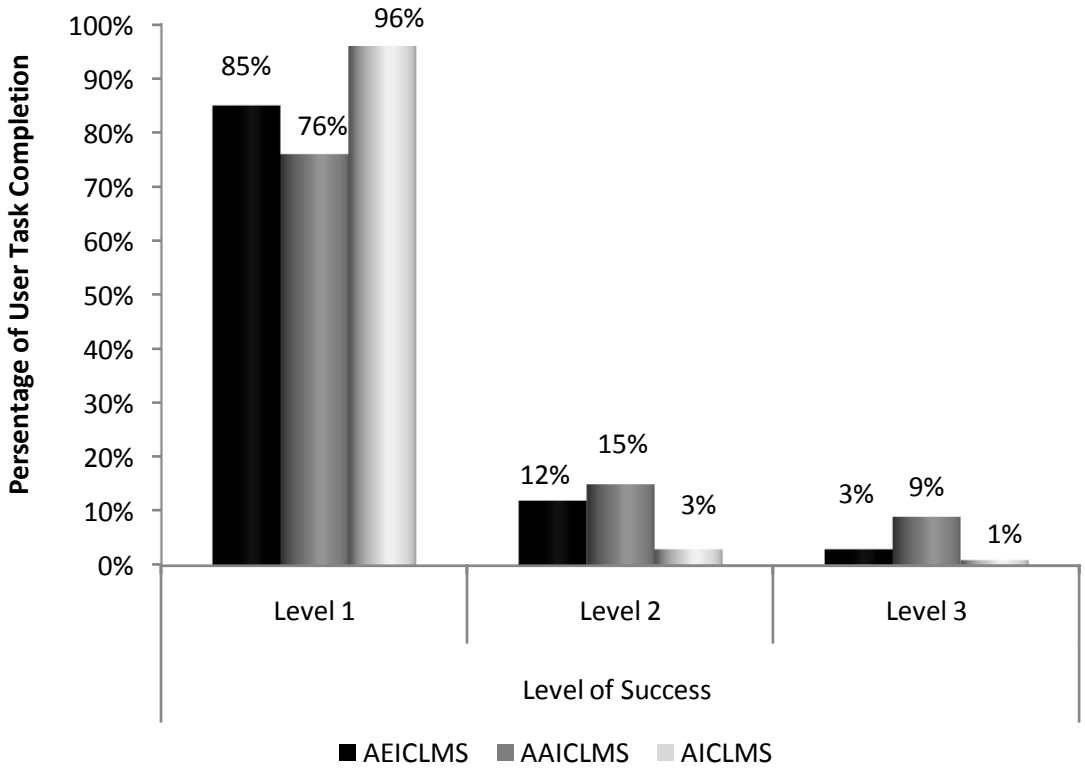

Figure 4.4: Results of user task completion for AEICLMS, AAICLMS and AICLMS respectively, with regard to complete success (Level 1), partial success (Level 2) and complete failure (Level 3).

4.11.1 Task Complexity

Figure 4.5 shows theresults in terms of the task complexity (i.e. difficulty). The tasks completed successfully decreased gradually from simple (288 tasks, 96%), moderate (260 tasks, 87%), to complex (226 tasks, 75%). However, the percentage of partial success increased gradually from simple (12 tasks, 4%), moderate (32tasks, 11%), to complex (46 tasks, 15%). The failed tasks also increased slightly from moderate (8 tasks, 3%) to complex (28 tasks, 9%). There was nocomplete failure in simple tasks. Chi-Square test was used for all levels of task complexity. The difference was found to be significant in task complexity (x^2=61.6, df=4, p<0.05

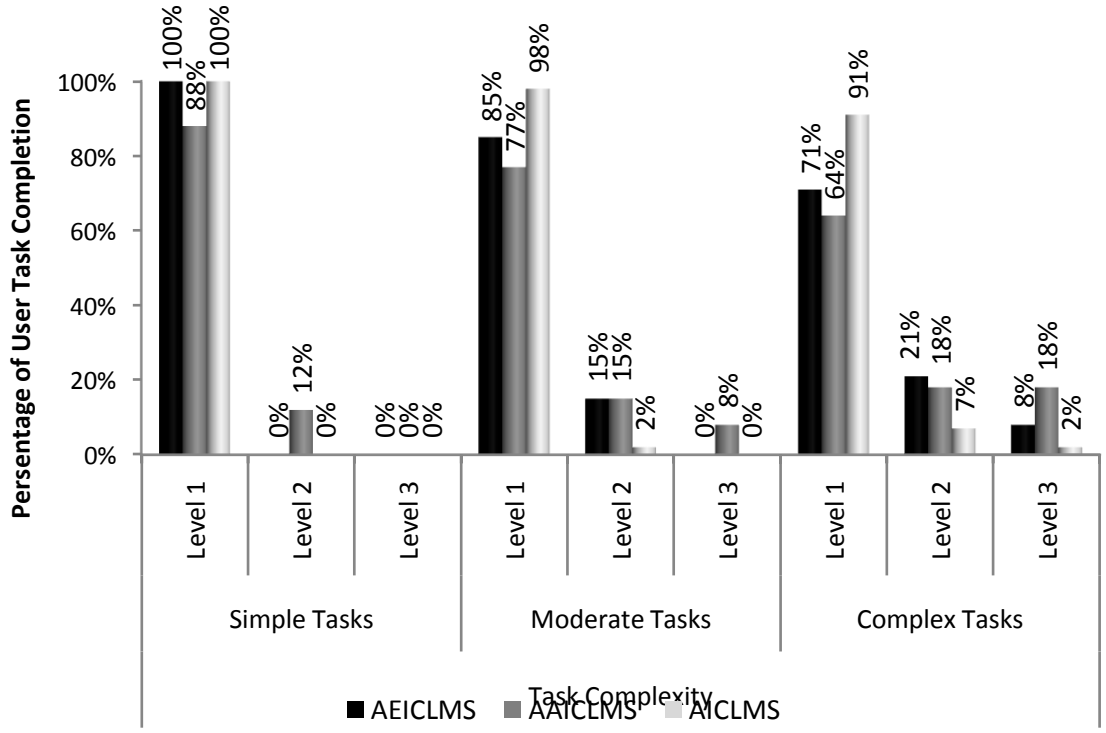

Figure 4.5: The results of user task completion for the AEICLMS, AAICLMS and AICLMS conditions. A task completed successfully is indicated as *level 1*, a half the way or so completed is indicated as *level 2* and a failed task as *level 3*.

). Figure 4.6 shows the difference of user task completion according to task complexity (simple, moderate and complex) for the three conditions. In simple tasks, there was no noticeable difference amongst the conditions.

These tasks did not place great demands on the user's mental effort. The task completion for AAICLMS was decreased by 12% compared to the other two conditions. However, a variance in the completion of moderate and complex tasks was identified. Moderate tasks demonstrated a 13% difference between AICLMS and AEAICMS, and 21% difference between AICLMS and AAICLMS. Complex tasks showed a difference of 20% between the percentages of complete successin AICLMS and AEICLMS, and 27% difference between AICLMS and AAICLMS. AICLMS achieved the highest percentage of complete success, compared to AEICLMS and AAICLMS.

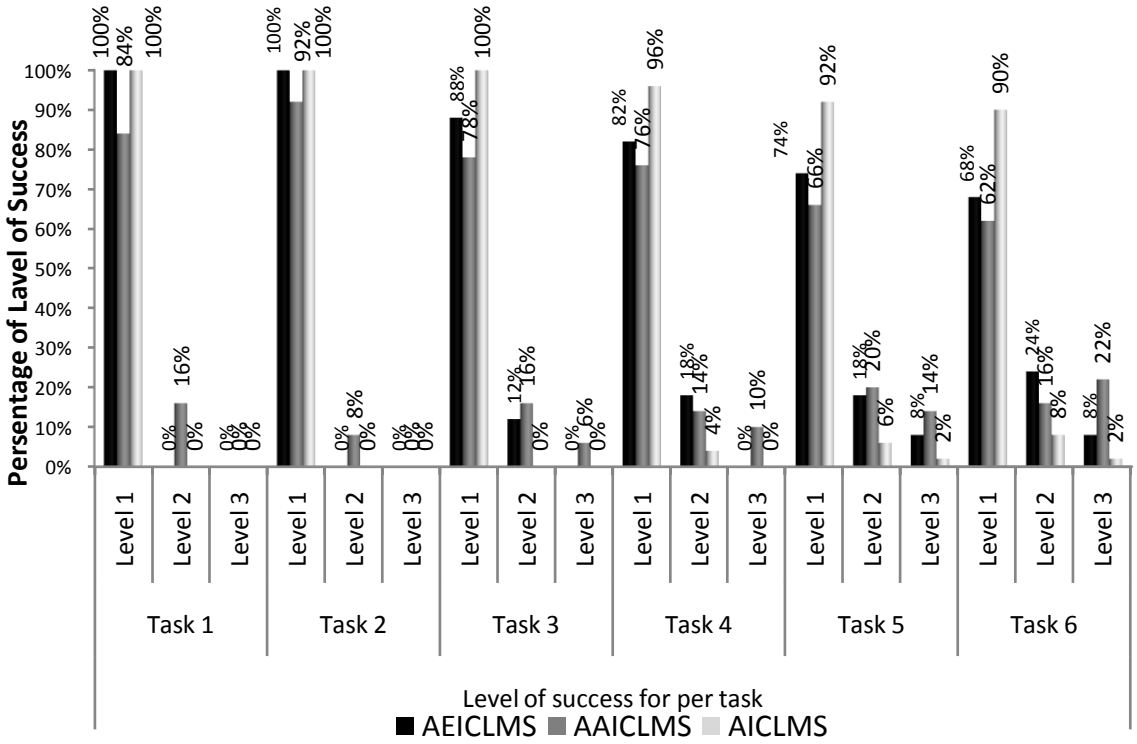

Figure 4.6: Task completion results: complete success (Level 1), partial success (Level 2) and complete failure (Level 3) for AEICLMS, AAICLMS and AICLMS conditions.

4.11.2 Individual Task

Figure 4.6 shows percentages of the tasks completed (level 1), partially completed (level 2) and task failed (level 3) by users in the AEICLMS, AAICLMS and AICLMS conditions. T1 showed 16% variance in user completion (level 1) between AEICLMS and AAICLMS, and 16% between AICLMS and AAICLMS. AEICLMS and AICLMS were not significant.T2 was performed similarly well by users in the AEICLMS and AICLMS, but declined by 8% in the AAICLMS. T3 performance in AAICLMS was decreased by 22% with 10% in level 1 category, compared to AICLMS and AEICLMS respectively. The performance was decreased by 12% in AECLMS compared with AICLMS. Chi-square (x^2) values showed that there was not only a significant difference between AICLMS and EICLMS (x^2=6.4, df=1, p<0.05), but also achieved asignificant difference between AICLMS and AAICLMS (x^2=12.4, df=1, p <0.05).

AEICLMS and AAICLMS were not significant. T4 did not demons trate a difference for level 1, whereas the percentage of complete success in the AEICLMS and AAICLMS had a 6% difference. AICLMS was higher than AEICLMS and AAICLMS by 14% and 20% respectively; and Chi-square (x^2) values did not show a significant difference between AICLMS and AEICLMS (x^2=5.01, df=1, p<0.05), and between AICLMS and AAICLMS (x^2=8.9, df=2, p<0.05). T4 showed a significant difference (x^2=15.6, df=4, p<0.05) between the three conditions. T5 also showed a significant difference (x^2=15.6, df=4, p<0.05). T6 results showed that AAICLMS had the lowest level 1 completed tasks and AICLMS the highest. AICLMS was higher by 22% and 28% compared to AEICLMS and AAICLMS respectively.

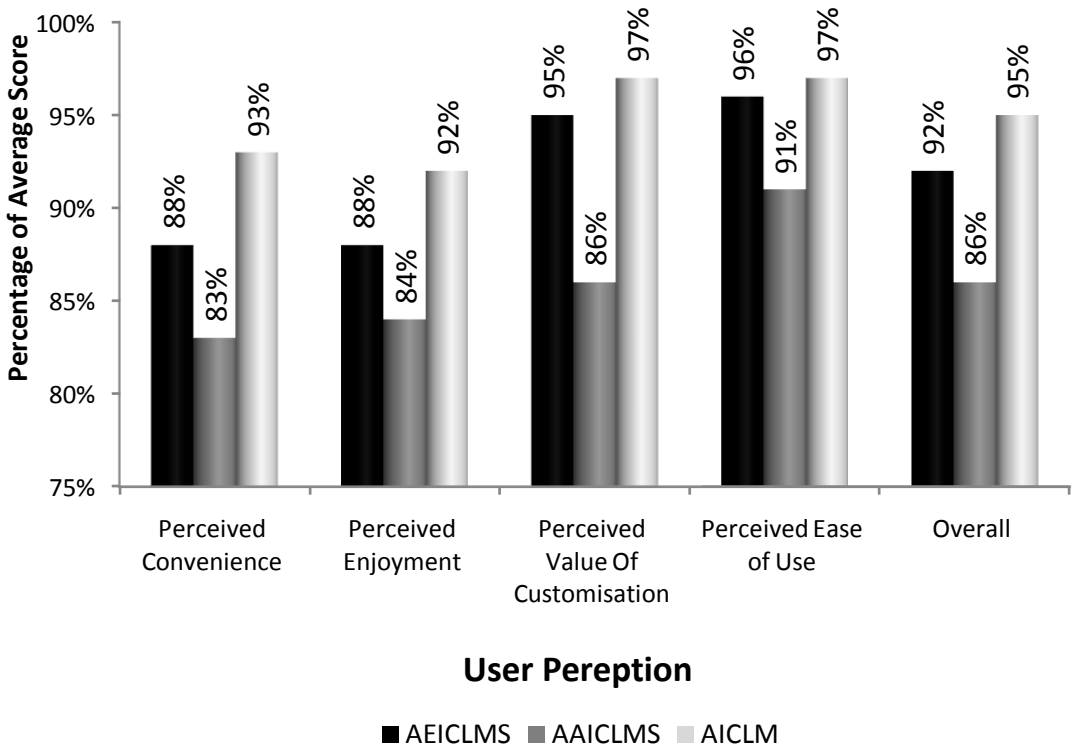

Figure 4.7: Mean values of user perceived convenience, enjoyment, value of customisation, ease of use, and overall user satisfaction.

T6 showed a significant difference (x^2=16.8, df=4, p<0.05). In conclusion, when earcons, auditory icons and avatar were used together in the e-CLMS experimental platform, users completed successfully (level 1) more tasks.

4.12 User Perceptions

Figure 4.7 shows the results of user perceived convenience, enjoyment, value of customisation, ease of use, and overall user satisfaction of the AEICLMS, AAICLMS and AICLMS conditions. There was a difference amongst the three interaction styles. AEICLMS was higher by 5% from the AAICLMS, and lower by 5% from the AICKMS. AICKMS was higher by 10% from the AAICLMS. Using a paired sample t-test, there was a significant difference in the percentage of average score between AEICLMS and AAICLMS (t_{149}=4.13, cv=1.96, p<0.05), AICLMS and AEICLMS (t_{149}=7.7, cv=1.96, p<0.05) and AICLMS as well as AAICLMS (t_{149}=3.1, cv=1.96, p<0.05).

A difference was also measured in users perceived enjoyment of the conditions. AEICLMS was 4% higher from the AAICLMS and 4% lower by 4% from the AICKMS. The mean value for AICKMS was 8% higher from the AAICLMS. A significant difference was identified between AEICLMS and AAICLMS (t_{199}=3.3, cv=1.96, p<0.05), AICLMS and AEICLMS (t_{199}=3.1, cv=1.96, p<0.05), and AICLMS and AAICLMS (t_{199}=6.9, cv=1.96, p<0.05).

The user perceived value of customisation was also different between the three conditions. The mean value of user responses for AEICLMS was 9% higher from the AAICLMS and 2% lower from the AICKMS, and AICKMS was 11% higher from the AAICLMS. This difference was significant between AEICLMS and AAICLMS (t_{149}=5.2, cv=1.96, p<0.05), AICLMS and AEICLMS (t_{149}=2, cv=1.96, p<0.05), and AICLMS and AAICLMS (t_{149}=7.8, cv=1.96, p<0.05). Similarly for the user perceived

ease of use, AEICLMS was 5% higher by 5% from AAICLMS and 1% lower by 1% from AICKMS but AICKMS was 6% higher from AAICLMS. Significance was found between AEICLMS and AAICLMS (t_{149}=3.4, cv=1.96, p<0.05) and AICLMS and AAICLMS (t_{149}=7.8, cv=1.96, p<0.05). However, there was no significant difference between AICLMS and AEICLMS (t_{149}=1.7, cv=1.96, p>0.05).

As a result, AICLMS was better perceived by users in all parameters evaluated. AICLMS was thought by users to be significantly better than AAICLMS, and marginally better than AEICLMS (t_{649}=11.5, cv=1.96, p<0.05).The analysis of variance (ANOVA) for all user responses, for all three conditions, was also significant for user perceived convenience (F=22.74, cv=3.02, p<0.05), perceived enjoyment (F=20.37, cv=3.01, p<0.05), perceived value of customisation (F=31.42, cv=3.02, p<0.05), perceived ease of use (F=14.39, cv=3.02, p<0.05), and overall user satisfaction (F=54.39, cv=3, p<0.05).

In conclusion, AICKMS was the most preferred condition by the users and AAICLMS was the least preferred.

4.12.1 User Perceived Convenience

Table 4.6 shows values of means and modes of the three statements used to evaluate user perceived convenience (PC). Users expressed, most frequently, a strong agreement with AICLMS regarding the statements "purchase without much help" (PWH), "user friendly" (UF) and "very convenient" (VC). AEICLMS showed a user strong agreement with "purchase without much help" and "user friendly". However, users mentioned most frequently, agreement with AAICLMS in terms of statements "purchase without much help", "user friendly", and "very convenient".

Interaction Styles	Result	Perceived Convenience (PC)		
		Purchase without much help (PWH)	User friendly (UF)	Very convenient (VC)
AEICLMS	Mean value	3.54	3.58	3.48
	Mode	4	4	3
	Frequency	54%	58%	48%
AAICLMS	Mean value	3.32	3.327	3.28
	Mode	3	3	3
	Frequency	60%	54%	60%
AICLMS	Mean value	3.64	3.68	3.78
	Mode	4	4	4
	Frequency	46%	68%	78%

Table 4.6: Mean values, modes and frequencies of mode regarding three statements of perceived convenience (PC) in the AEICLMS, AAICLMS and AICLMS.

Table 4.6 shows that 46% of the AICLMS users strongly agreed with the statement "purchase without much help", compared to 66% of the AAICLMS users, and 54% of the AEICLMS users. The statement "the website is user friendly" showed that AICLMS achieved 68%, AEICLMS 58% and AAICLMS 54%. Furthermore, 78% of the users expressed strong agreement, that the AICLMS interface was very convenient, compared to AAICLMS and AEICLMS; that demonstrated a 60% and 48% agreement respectively.

In conclusion, AICLMS showed the highest percentage of frequency in terms of strong user agreement to completing purchasing tasks, in the absence of significant help, and that the user interface was user friendly and very convenient, compared with the AAICLMS and AEICLMS conditions.

4.12.2 User Perceived Enjoyment

Table 4.7 compares the mean, mode and frequency of mode, of the four statements of the perceived enjoyment (PE) in AEICLMS, AAICLMS and AICLMS.

Interaction Styles	Result	Perceived Enjoyment (PE)			
		Interesting website (IW)	Entertaining website (EW)	Pleasant website (PW)	Very enjoyable website (VEW)
AEICLMS	Mean	3.48	3.6	3.62	3.44
	Mode	3	4	4	3
	Frequency	52%	60%	62%	56%
AAICLMS	Mean	3.34	3.36	3.36	3.42
	Mode	3	3	3	3
	Frequency	62%	56%	64%	58%
AICLMS	Mean	3.7	3.76	3.66	3.62
	Mode	4	4	4	4
	Frequency	70%	76%	66%	62%

Table 4.7: Values of mean, mode and frequencies of mode for the perceived enjoyment (PE) statements.

The results showed that most AICLMS usersstrongly agreed with the statements "an interesting website (IW)" (70%), "entertaining website (EW)" (76%), "pleasant website (PW)" (66%), and "very enjoyable website (VEW)" (62%).

AEICLMS users reported frequently, agreement with statements such as "entertaining website" and "pleasant website". AAICLMS users reported frequently, agreement with statements such as "interesting website", "entertaining website", "pleasant website" and "very enjoyable website". Table 4.7 shows that 70% of the users expressed strong agreement that the AICLMS interface was the most interesting interface, compared to 62% and 52% of the users, who agreed with the AAICLMS and AEICLMS respectively.

Moreover, 76% of users reported that AICLMS was an entertaining interface compared to 60% for AEICLMS and 56% for AAICLMS. Furthermore, 66%, 62% and 64% strongly agreed that the AICLMS, AEICLMS and AAICLMS interfaces respectively were pleasant interfaces.

Interaction Styles	Result	Perceived Value of Customisation (PVC)		
		Recommendations matched my needs (RMN)	Felt unique customer (FUC)	Customised product easily (CPE)
AEICLMS	Mean	3.78	3.82	3.76
	Mode	4	4	4
	Frequency	78%	82%	76%
AAICLMS	Mean	3.6	3.42	3.34
	Mode	4	4	3
	Frequency	66%	54%	50%
AICLMS	Mean	3.88	3.92	3.82
	Mode	4	4	4
	Frequency	88%	92%	82%

Table 4.8: Values of mean, mode and frequencies of mode of user perceived value of customisation (PVC).

Also, the statement "very enjoyable" was strongly agreed by 62% of users in the AICLMS condition, compared to58% in AAICLMS and 56% in AEICLMS. In conclusion, AICLMS was thought by users to be a more enjoyable interface.

4.12.3 User Perceived Value of Customisation

Table 4.8 shows the mean, mode and frequencies of mode, of the three statements of perceived "*value of customization"* (PVC) in the AEICLMS, AAICLMS and AICLMS conditions. Users strongly agreed that the AICLMS and AEICLMS provided recommendations that matched their needs, felt unique as acustomer, and customisation was easily performed.

The user perceived value of customisation showed that 88% of users strongly agreed that the AICLMS interface provided product recommendations that matched their needs, compared to 66% of users who indicated a strong agreement in AAICLMS, and 78% of the users who reported a strong agreement in AEICLMS.

Interaction Styles	Result	Perceived Ease of Use (PEU)		
		Usable product customisation (EUPC)	Easy to find information quickly (EFIQ)	Clear and understandable (CAU)
AEICLMS	Mean	3.82	3.86	3.8
	Mode	4	4	4
	Frequency	82%	84%	80%
AAICLMS	Mean	3.76	3.6	3.56
	Mode	4	4	4
	Frequency	74%	66%	60%
AICLMS	Mean	3.88	3.94	3.86
	Mode	4	4	4
	Frequency	88%	94%	86%

Table 4.9: Values of mean, mode and frequencies of mode of the perceived ease of use (PEU) user response.

The statement "feel unique customer" was strongly agreed by 92% ofusers for AICLMS, 82% for AEICLMS, and 54% for AAICLMS. Furthermore, 82% strongly agreed that AICLMS provided facilities to customise products easily, compared to 76% in AEICLMS, and 50% in AAICLMS. In conclusion, AICLMS showed better results of the user perceived value of customisation.

4.12.4 User Perceived Ease of Use

Table 4.9 compares the mean, modes and frequencies of user responses for the perceived ease of use (PEU) inAEICLMS, AAICLMS and AICLMS conditions. Generally, users strongly agreed that all conditions were easy to use for product customisation, locate information quickly, and the interface was clear and understandable. Specifically, 88%, 82% and 74% ofusers strongly agreed that AICLMS, AEICLMS and AAICLMS respectively were easy to use for product customisation. AICLMS was better than AEICLMS by 6% and AAICLMS by 14%. The views of users for the statement “locating the required information” showed that 94% of users strongly agreed in theAICLMSinterface, 84% inAEICLMS and 66% in

AAICLMS. AICLMS was 10% and 28% better than AICLMS and AAICLMS respectively. The statement "interface is clear and understandable" was strongly agreed in AICLMS by 6% and 26%, compared to AEICLMS and AAICLMS respectively.

These user responses indicated that the AICLMS had a higher percentage frequency of strong agreement for ease of use for product customisation, easy to find information quickly, and interface is clear and understandable, compared with AAICLMS and AEICLMS.

4.13 Discussion

This experiment aimed to investigate parameters of user satisfaction on three avatar-based multimodal conditions with user tasks of varied difficulty. The H3 (a) hypothesis (see section 4.4) stipulated that AICLMS will outperform the AEICLMS in terms of user convenience, enjoyment and customisation. The results demonstrated that this hypothesis was accepted.

The AICLMS condition was the best performing in terms of strong user agreement to completing purchasing tasks, in the absence of significant help, and that the user interface was enjoyable and convenient compared to the AEICLMS interface (see sections 4.12.1, 4.12.2 and 4.12.3).However, the sub-hypothesis indicates the comparison between AICLMS and AEICLMS interfaces in a way that the AICLMS will outperform the AEICLMS in terms of the ease of use. This has not been achieved and the hypothesis is rejected (see section 4.12.4).

AICLMS was marginally better than AEICLMS for user strong agreement for ease of use for product customisation, easy to find information quickly and interface is clear and understandable.

According to the summary of hypotheses (see section 4.4), the sub-hypothesis(b) indicates a comparison between AICLMS and AEICLMS conditions in a way that the AICLMS will enable users to complete (level 1) more tasks than the AEICLMS. This was achieved and the hypothesis was accepted, as AICLMS achieved the highest percentage of successful product customisation tasks, compared to AEICLMS especially in complex task(see section 4.11).

Hypothesis H4 (a) stipulated that AICLMS will outperform the AAICLMS in terms of the convenience, enjoyment, customisation and ease of use. These were achieved and the hypothesis was accepted. Avatars, earcons and auditory icons in AICLMS achieved the highest percentage of strong user agreement compared to the AAICLMS interface (see sections 4.12.1, 4.12.2, 4.12.3 and 4.12.4). AICLMS also achieved the highest percentage of completed PC tasks (see section 4.11.1).

The avatar with earcons and auditory icons condition, showed the best results in all parameters examined. The avatar with earcons condition, showed marginally lower results than AICLMS. The avatar with auditory icons condition, showed significantly lower results than AICLMS in terms of task completion and user satisfaction.

The success of the auditory icons is attributed to the fact that the sound naturally implies the information it communicates. There was a small user mental effort needed to remember the type of information communicated. This is not the case with earcons. The user is required to associate the sound with the information communicated, and remember this during the interaction. The interpretation of an auditory icon is easier as these environmental sounds have been heard previously in the environment. Earcons on the other hand, are unfamiliar to users and they can be interpreted differently under different user perceptual context.

AICLMS (expressive avatar, earcons and auditory icons) enabled the user to develop a positive attitude about the e-commerce interface. This positive attitude influences the users to develop user satisfaction and to continue to use the e-commerce interface. These user circumstances are the pre-requisites to the development of user loyalty. A user dissatisfaction will almost certainly result to the user switching to a different website. One must keep in mind the importance of customer loyalty and retention that are critical factors to the success of an e-business system. This can also be influenced by consumer attitudes, such as reputation and familiarity to purchase online.

4.14 Concluding Summary

A comparative empirical evaluation was performed using three avatar-based multimodal conditions with a dependent sample of 50 users. The multimodal metaphors consisted of avatars with earcons (EAICLMS), auditory icons (AAICLMS) and earcons and auditory icons (AICLMS). Users were required to perform MC tasks of varied difficulty. The experiment measured, qualitatively, the user perceived convenience, enjoyment, value of customisation, ease of use, overall user satisfaction; and quantitatively, the number of tasks that were completed fully or partially. The AICLMS condition was the best performing. It facilitated users to perform effective MC, identify the right information, make the right decisions and engage with the presented information (features of product). Users were also most satisfied with this condition in all the parameters evaluated using questionnaires. These overall user satisfactions, as well as all the other perceived values, are pre-requisites to the development of user loyalty.

Chapter 5: Empirically Derived Guidelines and Validation

5.1 Introduction

These empirically derived guidelines are specifically for the design of multimodal metaphors in e-CLMS and should be read in conjunction with other guidelines in the literature [123, 127, 133, 138 and 162]. They should be used in the following circumstances:

1. Complex information needs to be communicated to non-expert users.
2. Information to be communicated is technical or descriptive.
3. Designers observed or suspect a visual information overload to users.
4. Improve usability as identified from user feedback.
5. Usability evaluation of an existing or new e-CLMS is below the set standards.

5.2 Guidelines

5.2.1 Multimodal Design Strategy

A multimodal design strategy is the roadmap of the information to be presented at any particular stage of the user interaction with the e-commerce interface. It is also the allocation of multimodal metaphors to the information to be communicated. A good way to start is to perform a task analysis of the interaction (a usual design activity in HCI), but the emphasis is in the information that needs to be communicated for each task. Once this volume of information is compiled, the allocation of the multimodal metaphors should start. For instance, list the multimodal metaphors chosen to be used in separate columns and insert the information than needs to be communicated horizontally for each metaphor per task. The method of allocation should remain consistent throughout this classification process. Most e-CLMS interfaces will use a combination of text, graphics, and multimodal metaphors.

Communicated Information	Metaphors					
	Text	Graphics	Earcons	Auditory Icon	Speech Avatar	Facial Expressions
Mass customisation	√	√	√		√	
External Product		√			√	
Internal Product		√			√	
Software		√			√	
Services	√	√	√	√	√	
Customisation stages	√	√	√			
Recommender System		√	√			√
Customer needs	√	√				
Budgetary Control System	√		√			
Performance Level		√	√			√
Perceived Value	√			√		
Confirmation	√			√		

Table 5.1: An example of allocating metaphors to the information that needs to be communicated.

It is therefore important to have a clear idea of the metaphors that are needed, prior to beginning the multimodal design, but after the task analysis, so that the information that needs to be communicated has been completed. Table 5.1 shows an example allocation of metaphors to the information that needs to be communicated.

5.2.2 Expressive Avatars and Spoken Messages

Expressive avatars aim to mimic a salesperson as in a face-to-face retail environment. The term expressive adds facial expressions and body gestures. These guidelines deal with facial expressions only. Information for suitable body gestures can be found in the literature [129 and 130]. Speaking avatars with facial expressions are suitable to present textual information. Recorded speech is often more natural, but speech synthesisers can

provide a programmable dynamic output. Product descriptions should be presented textually as well as by the avatar. A user controlled switch for both modes or one of them should be provided. Ensure that the spoken speed is not too fast or too slow when the spoken message is recorded. When a speech synthesiser is used, this parameter should be user controlled. Facial expression must be associated with the presented information as if a real person is presenting. The overuse of facial expressions may result in a comical presentation. For this reason, it is better to rehearse this in real life and note the expressions that need to be presented at the correct instance.

Avatars may also be used to issue guidance, explanation or user feedback during MC. The screen position of an avatar should remain constant during interaction. When avatars are not engaged in output, they should remain frozen (no facial expressions or head movements).

5.2.3 Auditory Icons

Auditory icons can be presented individually or combined with expressive avatars. Auditory icons will not require the user to extensively train to remember the sounds. These auditory messages, by their nature, imply the action they communicate as they derive from the environment. They should be short and succinct in their presentation. They can be naturally recorded from the environment or synthesised. Not all actions within an e-CLMS will have a direct equivalent to auditory icons. If this is the case, earcons should be examined.

5.2.4 Earcons

Earcons are short musical sounds. Earcons should be used when no suitable auditory icons can be found. An extensive set of earcons will require some user training. Each earcon is associated with an event, asit does not imply the event communicated.

Once users are trained, complex messages can be communicated. For instance consider that you have a MC of a product with ten stages. An earcon of ten rising pitch notes can be used in a way that each note communicates a stage. The user has to remember that each rising note represents a completed stage of the MC and so on. Earcons can utilise timbre, rhythm and inherited structure. Earcons can alert users to events such as incompatibility status during product customisation. They can be played over the spoken messages of the avatar to draw the user's attention to parts of the spoken message.

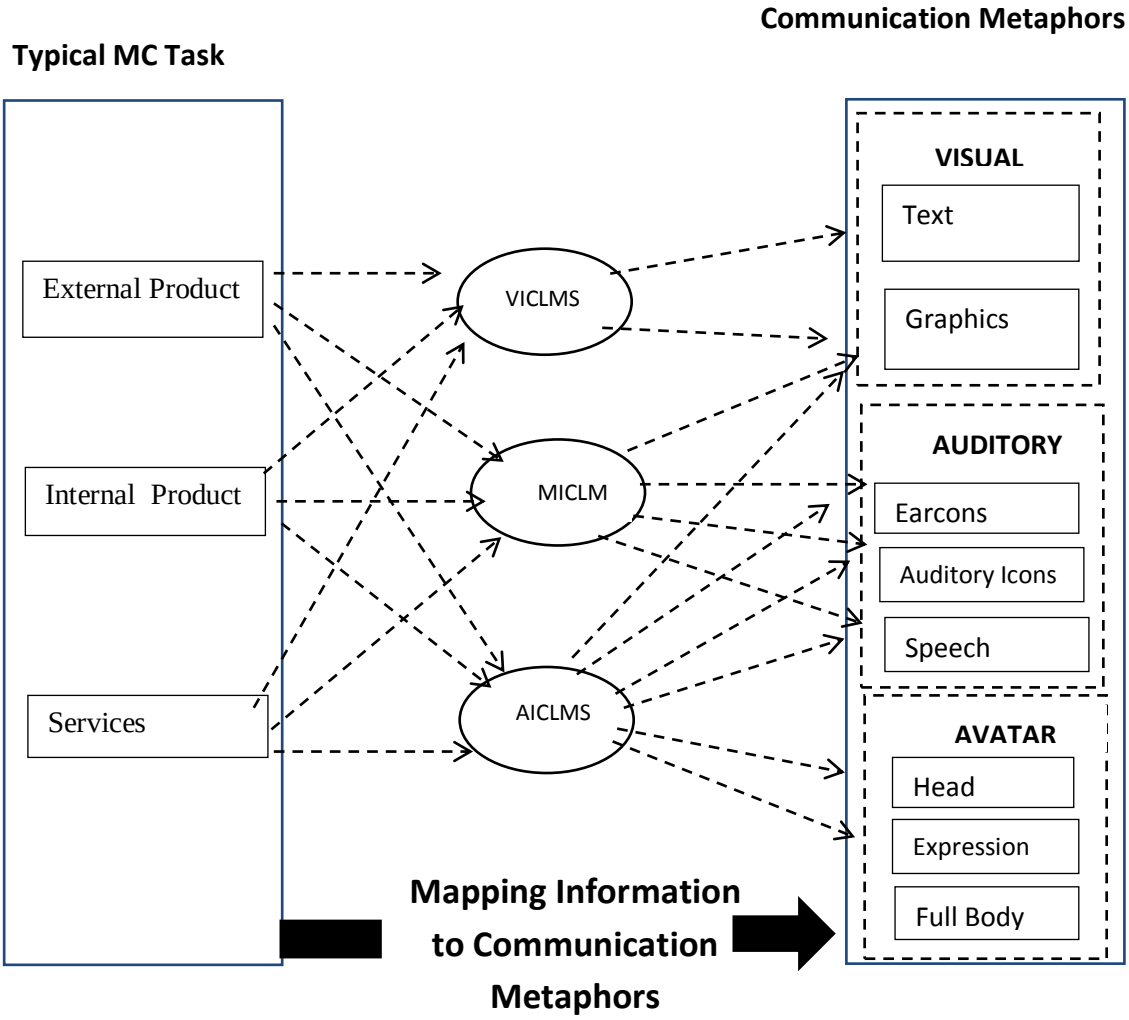

Figure 5.1: Allocating metaphors to a typical MC task.

5.2.5 Combining Metaphors

The synergistic outcome of combining metaphors in a multimodal fashion to either communicate the same information or different parts of a message is an element that designers should explore. The communication of different parts of a message using different metaphors will increase the speed of interaction. As users became more familiar with the way that information was presented, this speed would increase even further. When metaphors are combined, the synchronisation of the presentation is important. Figure 5.1 shows an example of allocating metaphors to the information they communicate.

5.3Validation

A two-stage validation of the design that uses these guidelines is proposed. The first stage should be during the design of the multimodal metaphors. This stage will enable interface designers to quickly determine that suitable metaphors are used for the information that needs to be communicated. The second stage should be performed during the testing phase of the software. User trials are essential in identifying any possible problems in user perception and understanding. In this stage, a fine-tuning of the design of the multimodal metaphors in terms of synchronisation and order is expected. The reasons for validation include:

1. The guidelines provide a general guidance to the interface designers. This may result to multimodal designers using an unsuitable metaphor to communicate a particular interface event. In a large multimodal design, this inappropriate use of metaphors is common.
2. Earcons and auditory icons as auditory stimuli are objects in time, and once they are presented during the interaction, the only reference point is in the user's mind.

3. User interpretation of auditory stimuli depends upon the context presented with slightly different user interpretations under different perceptual contexts.
4. There is a need to synchronise the presentation of the multimodal metaphors particularly when an expressive avatar is used.
5. User input (from trials) is essential in complex multimodal designs as users vary in their understanding of the multimodal metaphors. This is particularly the case when more than one piece of information is communicated simultaneously to users. For example, an avatar based spoken message with background earcons and auditory icons.

5.3.1 First-Stage: Design Validation

Once the multimodal design has been completed, the information that is to be communicated to users at any interaction instance must be clearly defined in a task analysis manner. This would help designers to first identify whether the volume of the total information is appropriately distributed and to synchronise the channels or metaphors.

5.3.2 Second-Stage: Tasks and User Trials

This validation stage consists of identifying *typical user tasks* and performing *user evaluation trials.* A set of tasks (typical to the e-commerce interface under development) needs to be identified. These tasks need to range from simple activities to advance. Tasks for MC must progressively include more requirements for the customisation. Evaluators must ensure that users are familiar with the "text-and-graphics" aspect and the overall operation of the interface.

Trials involving the users performing typical tasks need to be performed in the absence of any help. Prior to the trials, designers must ensure that all multimodal metaphors are

presented at the correct interaction instance. During the trials, evaluators need to assess the multimodal information processing of the users. Typical failed outcome scenarios include:

1. Users failed to meaningfully interpret the communicated information.
2. Users interpreted the information in a different way or they seem not sure.
3. Some users understood all information presented but others did not.

All multimodal designs will need some improvement after user trials. A typical multimodal design will involve a few iterations. The user trials and the user feedback would enable designers to take a user view of the design. This is also often the case with visual interface design. In troubleshooting user perceptual issues, review the multimodal design strategy and the allocation of metaphors.

5.4Multimodal Designing Principles

These principles should be taken into account during the design and validation stages. The suggested use of these multimodal metaphors requires synchronisation and the creation of a user perceptual context.

This will ensure that users interpret the earcons and auditory icons correctly at the appropriate instance during the interaction.

5.4.1 Overuse of Communication Metaphors

The inclusion of multimodal metaphors help to improve usability and often improve the volume of information that can be communicated to users at any given interaction instance. However, the inclusion of more multimodal metaphors to improve usability of speed of user interaction is not always true.

A clear justification is needed for the selection and utilization of each multimodal metaphor.

5.4.2 Suitability of Metaphors

Designers must ensure that metaphors are suitable for the information that is communicated. The principal and supplementary communication metaphor must be identified and clearly mapped with the information they communicate in terms of suitability. For example, an audible alarm will be used in a building to notify residents to evacuate the building. A visual metaphor would be an unsuitable metaphor to be used as a fire alarm. In the same way, there is no point in using auditory stimuli on communicating information that can easily be communicated using a traditional visual metaphor and vice versa.

5.4.3 Auditory Stimuli: Objects in Time

Designers must always consider that auditory metaphors are *objects in time*. This means that once an auditory message is played, there is no further reference than the memory of the user. Therefore, auditory communication, unless is constantly repeated, requires a user memory recall.

This user recall is not always accurate. The object in time issue is mitigated by introducing a user controlled repeat facility of the auditory stimuli. Designers must ensure that this facility offers repeat last message, pause and move forwards and backwards.

5.4.4 Interrupting Nature of Earcons and Auditory Icons

Earcons and auditory icons can be used on their own or in combination with other metaphors. In the latter, their use has an interrupting effect that draws user attention immediately. Designers can use this technique to draw attention on important parts of, say, a spoken avatar or to signal the beginning or the end of a transaction in an e-CLMS

context. The excess use of these auditory metaphors may cause user annoyance that may result in dissatisfaction. Therefore these metaphors should be used with caution and relatively sparingly.

5.4.5 Consistency of Metaphors

The produced design must be consistent in the allocation of metaphors. Users will be conditioned to the multimodal stimuli presented from the brief user training introduction session and throughout the interaction. This is particularly the case for earcons. For example, an earcon, of three notes, communicating an event during MC is presented using different timbre (piano and organ) to signal different instantiations of the same event. From that point onwards, users are expecting the same use of timbre in thesame or similar interaction circumstances; and similarly for all other multimodal metaphors.

5.5 Conclusion

The design of multimodal metaphors is a creative design activity. The guidelines, principles and validation suggestions are general guidelines that need to be interpreted within the context of the e-CLMS interface. Expressive avatars will improve the usability of e-CLMS, as everyday untrained users often prefer to watch information presented than to read, say, descriptions of products. Auditory icons or earcons can be used on the background to annotate the spoken messages of the avatar. The choice between earcons and auditory icons is often debatable. A rule of thumb is to search natural environmental sounds that closely match the information that needs to be communicated and examine the use of earcons when an auditory icon cannot be found.

The new multimodal design requires a validation in the specific interfacing circumstances used. Two stages of validation are proposed. This dual approach ensures the removal of obvious errors from the design and the correct user interpretation during

interaction. Although, multimodal designs for e-CLMS can be based in common guidelines and principles, the end products are often different to each other as the needs of different interfacing circumstance of e-commerce are different. Therefore, designers must adopt an iteration evolving multimodal design based initially on the guidelines, but progressively on user feedback.

Chapter 6: Conclusions

6.1 Introduction

The approach taken in this thesis involved the comparison of multimodal metaphors with a typical visual approach that combines text with graphics in terms of usability. An association is also made between user satisfaction and the potential development of user loyalty.

6.2 Overall Conclusion

The approach of combining the avatars with facial expressions, speech, earcons, and auditory icons produced an e-commerce interface with a better usability and user satisfaction, than an interface that does not use these multimodal metaphors to communicate information (i.e. a visual interface with text and graphics).

6.2.1Communicating Complex Information

The multimodal designs evaluated in Chapters 3 and 4 demonstrate the use of multimodal metaphors to communicate fuzzy or large volumes of information. The MICLMS interface communicated large volumes of information during MC. For example, *explanation* information was communicated using speech, earcons and auditory icons (see sections 3.3).

The AICLMS condition combined speech, non-speech and expressive avatars to communicate the same information with better usability results compared to the other conditions (see sections 3.4). The use of multimodal metaphors allowed users to search for and understand the information faster (compared to the text and graphics condition) during moderate and complex MC tasks (see sections 3.10). No difference in user performance was identified in simple tasks.

6.2.2Earcons

The use of earcons should be used once the possible use of auditory icons has been exhausted. The earcons demonstrated to be suitable to communicate information (see section 3.3 and 3.9) either on their own or in combination with other metaphors.

6.2.2 Recorded Speech

The use of recorded speech, combined with an expressive avatar, was useful to read descriptions and highlight important parts with earcons played in the background. The combination of recorded speech with avatars was found to improve usability (see section 3.9 and 3.10).The synergy between improved usability and user satisfaction is pre-requisites for the development of user loyalty towards the system. This is in accordance with other work in the literature [123, 127, 133, 138 and 162].

6.2.3 Expressive Avatars

The AICLMS condition demonstrates an avatar-based *salesperson* paradigm that presents product features in a user efficient and effective manner (see section 3.4). This paradigm was observed to increase user confidence (see section 3.12). The avatar made the interface look and feel socially rich. This appeared to increase the user satisfaction. The VICLMS and MICLMS conditions did not demonstrate similar results (see section 3.10). It was observed that avatars helped users to focus on the information presented and on the MC tasks. This approach builds upon other studies [162 and 165].

6.2.4 Task Complexity

Simple tasks were not affected by the condition applied with an exception to efficiency. This was not the case with moderate and complex tasks (see sections 3.9.2 and 4.10.2). Some efficiency results showed that the multimodal conditions produced a marginal

effect upon simple tasks. However, on overall, the contribution of the multimodal metaphors becomes significant when a task gets more difficult during MC. Significant differences were observed in the effectiveness of product (EPC and IPC) and service customisation.

The experimental results also showed that visual communication only undermined the performance of the users particularly in tasks involving comparison (see section 3.9 and 3.10). These results are in accordance with previous work [55, 133 and 162].

6.2.5 Facial Expressions with Auditory Icons

The combination of facially expressive avatars with auditory icons produced successful results (see section 4.3.1). For instance, the sound of "opening a bottle" enabled the user to focus on the avatar presentation of a product or additional explanation during MC. Similarly, a "door closing" sound communicated the end of the avatar presentation for that topic.

Auditory icons also communicated to users the presentation of important keywords or concepts during MC. This is the equivalent of underline, bold or italics in written text. The use of these multimodal metaphors together improved usability and user satisfaction (see section 4.11 and 4.12). These results build upon other work [138, 139 and 140].

6.2.6 Facial Expressions with Earcons

Earcons were used either in the background of the avatar spoken message or during the short pauses of the spoken message (see section 4.3.1). The combination of facial expressions with earcons improved the task completion and satisfaction of users (see section 4.11 and 4.12). These results build upon previous work [134, 135 and 162].

6.3 Research Contribution

First, the thesis provides a critical appreciation of the literature and links the concepts of usability and user loyalty in an e-commerce interface. The experimental work presented represents an innovative multimodal design approach to communicate information in typical e-commerce tasks.

Hypothesis		**Accepted**	**Rejected**	**Reference**
A. The MICLMS and AICLMS will outperform the VICLMS in				
A1	Time required by users to complete successfully each task (efficiency)	√		Section 3.10
A2	Tasks completed successfully by users (effectiveness)	√		Section 3.9
A3	Less user errors or incorrect sequence of user actions (effectiveness)	√		
A4	Fewer mice clicks to complete a task (effectiveness)	√		
A5	A better user understanding of the tasks	√		Section 3.12
A6	Better user satisfaction	√		
B. The AICLMS will outperform the MICLMS in terms of:				
B1	Time required by users to complete successfully each task (efficiency)	√	√	Section 3.10
B2	Tasks completed successfully by users (effectiveness)	√		Section 3.9
B3	Less user errors or incorrect sequence of user actions (effectiveness)	√	√	
B4	Less mouse clicks to complete a task (effectiveness)	√	√	
B5	A better user understanding of the tasks	√		Section 3.12
B6	Better user satisfaction	√		
C. The AICLMS will outperform the AEICLMS				
C1	User convenience, enjoyment, customisation and ease of use	√	√	Section 4.12
C2	Completion (level 1) more tasks than the AEICLMS	√		Section 4.11
D. The AICLMS will outperform the AAICLMS				
D1	User convenience, enjoyment, customisation and ease of use	√		Section 4.12
D2	Completion (level 1) more tasks than the AEICLMS	√		Section 4.11

Table 6.1: Outcomes of the hypotheses.

6.4 Re-Examining the Overall Hypothesis

The overall hypothesis was that multimodal metaphors would improve the usability, user satisfaction, and potential of users to develop loyalty in e-CLMS. From this basis, sub-hypotheses were produced, as shown in Table 6.1.

6.5 Limitations

The work presented in this thesis has a number of limitations. These limitations are briefly described below and linked to the future work section that follows.

6.5.1 User Sample and Snapshot View

Experiments were performed *in vitro* with small user samples. The findings in this thesis provide a snapshot image of the performance of users with an e-CLMS in controlled conditions in a laboratory.

The sample used was computer literate and familiar with e-commerce interfaces. These experiments therefore do not cater for users who are not familiar with computers or e-commerce interfaces.

6.5.2 Development of User Loyalty and Trust

The development of user loyalty was measured by subjective views of users and by the impact of a better usability. However, user loyalty and trust develops over time and proving it requires regular user evaluation. The experiments in this thesis show the pre-disposition of users to develop loyalty. It also makes an association between usability and user loyalty.

This association is correct but in e-commerce there are other parameters that will contribute positively or negatively to the development of loyalty. In the context of e-commerce, examples include customer services, delivery of product and post-transaction communication with the user.

This research views the development of user loyalty from the angle of MC and effective and efficient completion of a transaction. This is valid from a user interface approach but is only a part of the contributing factors to user loyalty.

6.5.3 Facial Expressions and Body Gestures

The avatars used in the experiments included six facial expressions. No full body avatars with body gestures were used.

However, human interaction involves more than six facial expressions and several body gestures. Given that avatars aim to mimic human interaction, the use of six facial expressions and nobody gestures is a limitation of the experiments.

6.5.4 Guidelines

The guidelines produced (see Chapter 5) are based on the experiments performed and may not be universally applicable in all e-commerce interfaces. These guidelines provide a general direction to the suitability of the multimodal metaphors.

Designers will need to make their own interpretations in their own e-commerce interaction contexts, unless they use the same context under which the multimodal metaphors were used in these experiments.

6.6 Future work

This type of work can be extended in several ways as the topic is important and has received very little attention. The thesis demonstrates a *prima facie*ses for the use of avatar-based metaphors.

In this sense, this thesis demonstrates the validity of the approach in pursuing larger experiments.

6.6.1 Longer-Term Measurements

A longer-term investigation will enable the researchers to measure the transition from a user being satisfied to a user being loyal. It will involve the measurement of user satisfaction regularly over a longer period of time. It will also have to identify the stage at which this conversion occurs. Does it develop linearly or fluctuate? However, the user exposure to the interface is only one aspect in developing user loyalty.

Other non-interface parameters may have to be taken into account e.g. customer care. It is therefore essential that the experiment is performed with a real life e-commerce interface in which customers are tracked and quizzed over time. As users develop experience with the system, does the level of their user satisfaction remain the same? In the experiment of this thesis, users performed MC as requested by the experiment instructions. Does this change though when users are customising products for real, in order to pay and acquire them? This is also linked to user trust. There is a difference measuring trust according to user views and measuring trust *in vivo*.

6.6.2 Full body Avatars

The line of full body avatars may also be another pathway for investigation. This will allow the inclusion of body gestures. However, it raises a number of questions. Will it make a difference in the usability results? Which e-commerce interaction instances will benefit by a full body avatar? Is this preferable by users?

6.6.3 Multimodal Input

The use of eye-trackers and hand gesture recognition increasingly become main stream in user interfaces. These technologies provide a more natural way of interacting in e-commerce interfaces. It will be useful to measure the effect on multimodal output with multimodal input. For example, during MC, the interface will be able to provide

anexplanation at the point of the customisation, and the avatar will present the relevant parts of the product descriptions as the user views the different parts of a product. Will this change the interaction model? Will it have an effect upon usability and user satisfaction?

6.7 Epilogue

This research establishes a *prima facie* case for the use of avatar-based multimodal metaphors in e-CLMS and other types of e-commerce interfaces. It demonstrates an association between multimodal metaphors and improved usability, as well as between user satisfaction and user potential to develop loyalty.

The application of multimodal metaphors was particularly effective in complex and difficult MC tasks. Therefore, multimodal metaphors were more useful when the interaction during MC became more complex. A set of empirically derived guidelines was also produced to assist designers to develop e-CLM interfaces using multimodal metaphors in addition to the traditional texts and graphics approach. A two-stage validation approach is also suggested in order to ensure that the multimodal metaphors are suitable to the context of the e-commerce interface and the information it communicates. The work also has limitations that can be pursued further with new experiments. This, in turn, opens new horizons for future research to investigate further current approaches and employ new techniques to benefit multimodal e-CLMS.

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Appendices

Appendix A-1: Pre-Session Questionnaire (Experimental Platform I, II and III)

Stage 1: Back ground Information

1. Age: (In what group are you)

( ) 18 to 24.

( ) 25 to 30.

( ) 31 to 40.

( ) over 40 years.

2. Gender: (In what gender are you)

( ) Female.

( ) Male.

3. Education: (What level are you)

() Postgraduate (Research).

( ) Postgraduate (Courses).

( ) Undergraduate.

( ) College.

( ) High School.

Stage 2: Internet Experience

1. The internet: (How many hours do you usually use internet per day)

( ) 0 to 3 hours. ( ) 7 to 9 hours.

( ) 4 to 6 hours. ( ) over 10 hours.

2. The internet: (Have you ever purchased items on internet)

( ) Yes. ( ) No.

3. The internet: (How often do you purchase product on internet)

( ) Daily. ( ) Monthly. ( ) Yearly.

( ) Weekly. ( )Biannual.( ) Never.

4. The internet: (What items do you usually buy on internet).

Choose more than one if you would like.

( ) Books. ( ) Clothing.

( ) Computer & Electronics. ( ) Furniture& Home.

( ) Car. ( ) e-ticket. ( ) Other. .....

<u>Stage 3</u>: About Online Product Customisation

1. The customisation: (Have you ever bought a product by using product customisation)

( ) Yes. (go to question 2).

( ) No. (go to question 3).

2. The customisation: (Did you face any problem during product customisation technique)

Choose more than one if you would like.

( ) Not understandable. ( ) Not persuasive.

( )Difficult touse. ( ) Missing face-to-face communication.

3. The customisation: (why you did not use product customisation)

Choose more than one if you would like.

( ) Not intelligible. ( ) Not persuasive.

( ) Distrust. ( ) Missing face-to-face communication.

( ) I do not know.

Appendix A-2: Scenarios of the Six Tasks (Experimental Platform I & II)

<u>Tasks 1</u>. Simple (Personal Computer customisation):

Scenario**:** Assume that you would like to perchese computer from the website. You need to customize your PC. So you have been asked to purchase components of computer hardware that suit your needs.

<u>T1 Requirements</u>

- Working activities (e.g. surf the Internet)
- The Budget is greater than £1000.00.

External Product						
Product Customisation			Product Cost	Recommender System		
No	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Case & lock	2 front USB ports	(<£15)	Recommended		
2	Monitor	Size is 22 inch Widescreen	(≤ £133.80)	Strong Recommended		

Internal Product						
Product Customisation			Product Cost	Recommender System		
No	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Memory	Size is 8GB	(< £60)	Recommended		
2	Graphics Card	Memory Size is 1024MB	(< £54)	Strong Recommended		
3	Memory - 1st Hard Disk	Cache is 32MB	(< £50)	Strong Recommended		

Software						
Product Customisation			Product Cost	Recommender System		
No	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Operating System	Windows 7 professional	(< £130)	Strong Recommended		

Services			
Service Customisation			Product Cost
No	**Service Name**	**Service Type**	**Price**
1	Home Installation	Family surf Control	(>£79) and (< £118)
2	Data Recovery	Protect 1 hard drive	(> £20)

<u>Tasks 2</u>Simple (Personal Computer customisation):

Scenario**:** Assume that you would like to perchese computer from the website. You need to customize your PC. So you have been asked to purchase components of computer hardware that suit your needs.

<u>T2 Requirements</u>

- Working activities (surf the Internet).
- The Budget is great than £1000.00.

External Product						
Product Customisation			Product Cost	Recommender System		
No	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Mouse	USB connector	(≥ £5)	Recommended		
2	Speakers	Speakers are 2 satellites	(≤ £12)	Recommended		

Internal Product						
Product Customisation			Product Cost	Recommender System		
No	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Power Supply	Power supply is 350W	(≤£29)	Non Recommended		
2	Network	Onboard	(<£19)	Recommended		
3	Modem	Non, I will be using broadband	(=£0)	Non Recommended		

Software						
Product Customisation			Product Cost	Recommender System		
No	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Anti-Virus	Protection is covering viruses	(<£13)	Strong Recommended		

Services			
Product Customisation			Product Cost
No	**Service Name**	**Service Type**	**Price**
1	Build Time	Deliver approximately 5 working days	(<59)
2	Warranty	1 month collect	(=0)

<u>Tasks 3</u>. Moderate (Personal Computer customisation):

Scenario**:** Assume that you would like to perchese computer from the website. You need to customize your PC. So you have been asked to purchase components of computer hardware that suit your needs.

T3 Requirements

- Working activities (e.g. Listen to Music)
- The Budget is greater than £1000.00.

External Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Case & lock	Width Computer Case is 190mm	(≥£29) and (<£59)	=====		
2	Monitor	Resolution is 1920 × 1080	(≤£200) and (≤£134)	It is Strong recommended		

Internal Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Motherboard	Max Bus Speed : 1333 MHZ	(<£37) and (<£36)	=====		
2	Graphics Card	Maximum power usage is 56w	(<£54)	=====		
3	Memory - 2st Hard Disk	Cache is 32 MB	(≥£50) and (<£70)	It is recommended		

Software						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Operating system	Windows Vista	(>£109.99) and (< £168)	=====		

Services			
Service Customisation			Product Cost
No	**S. Name**	**Service Type**	**Price**
1	Home Installation	Family surf Control	(≥£79) and (<£119)
2	Data Recovery	Against Failure	(>£20) and (>£29)

Tasks 4. Moderate (Personal Computer customisation):

Scenario**:** Assume that you would like to perchase a computer from the website. You need to customize your PC. So you have been asked to purchase components of computer hardware that suit your needs.

T4 Requirements

- Working activities (e.g. Listen to Music)
- The budget is greater than £1000.00.

External Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Mouse	Laser mouse	(≥£28) and (<£64)	=====		
2	Speakers	Speakers are 2 satellites	(>£9) and (<£40)	=====		

Internal Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	DVD/BLU-RAY Drive	Bluray write speed 12×	(≥£48) and (<£90)	=====		
2	Modem	56k internal	(≥0)	=====		
3	TV Card	Digital TV card	(≥£20) and (<£25)	=====		

Software						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Anti-Virus	Protection is covering viruses	(>£9) and (<£45)	=====		

Services			
Service Customisation			Product Cost
No	**S. Name**	**S. Information**	**Price**
1	Build Time	Deliver approximately 3 working days	(>£3) and (>£29)
2	Warranty	1 year parts, 3 year labour	(>£3) and (<£69)

<u>Task 5</u>. Complex (Personal Computer customisation):

Scenario**:** Assume that you would like to purchase computer from the website. You need to customise your PC. So, you have been asked to purchase components of computer hardware that suit your needs.

<u>T5 Requirements</u>

- Working activities (e.g. Watch Movies)
- The budget is greater than £1500.00.

External Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Monitor	Resolution is 1920 × 1080	======	Recommended		
2	Monitor Cables	Number of cables are 2	======	Non-recommended		
3	Case & Lock	Case height is more than 426	======	Recommended		

Internal Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Processor	Core Frequency is 2.66GH	=====	Non-recommended		
2	Motherboard	Max Bus Speed : 1333 MHZ and Audio output : 5.1 channel surround	(<£36)	=====		
3	Graphics Card	Memory Size is 1024 MB	(≥£53) and (<£83.79)	Recommended		

Software						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Operating system	Microsoft Windows	=====	Strongly-recommended		

Services			
Service Customisation			Product Cost
No	**Service Name**	**Service Type**	**Price**
1	Home Installation	Family surf Control	(>£99) and (<£139)
2	Data Recovery	Against Failure	(≥£60) and (>£29)

<u>Tasks 6</u>. Complex (Personal Computer customisation):

Scenario**:** Assume that you would like to purchase a computer from the website. You need to customize your PC. So, you have been asked to purchase components of computer hardware that suit your needs.

<u>T6 Requirements</u>

- Working activities (e.g. watch movies)
- The budget is greater than £1500.00

External Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Mouse	Custom-colour	======	Recommended		
2	Webcam	Snapshots at up to 10	======	======		
3	Keyboard	Driver free hot keys	(≥£9) and (<£18)	======		

Internal Product						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Power Supply	Power supply is more than 700 W	======	Recommended		
2	Sound Card	======	======	Strongly-recommended		
3	TV Card	Favorite TV as a TV	(>£9) and (≥£26)	======		

Software						
Product Customisation			Product Cost	Recommender System		
No	**P. Name**	**P. Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	Anti-Virus	======	(>£9) and (≤ £50)	Recommended		

Services			
Service Customisation			Product Cost
No	**Service Name**	**Service Type**	**Price**
1	Build Time	======	(>£29) and (≥£59)
2	Warranty	2 years collect, 2 years parts	(>£69)

Appendix A-3: Post-Session Questionnaire (Experimental Platform I & II)

1- Questions for Loyalty and Understandability

To accurate survey, we would like to know your impression concerning the interface quality. Please indicate the extent to which you agree or disagree with the following statements about the E-CLMS interface. Circle the appropriate number using the scale below.

Code	SD	D	A	SA
Description	Strongly Disagree	Disagree	Agree	Strongly Agree
Scale	1	2	3	4

- **Loyalty**

Scale For Measuring Customer Loyalty		**Code**	**Adapted from**
1.	Choose this interface again	CIA	[1, 176]
2.	Recommend interface to others	RIO	[1, 177]
3.	Purchase using the same technique of this interface	PST	[1, 176]
4.	Overall, how loyal are you to this interface	OLI	[1, 176]

- **Understandability**

Scale For Measuring Understandability		**Code**	**Adapted from**
1.	The information provided in the system was clear	CI	[178,150]
2.	It was easy to find the information I needed	FI	[178,150]

3.	The information provided for the system was easy to understand	EU	[178,150]
4.	The information was effective in helping me to complete the tasks and scenarios	HI	[178,150]
5.	The organisation of the information on the screen was clear	OI	[178,150]

2- Questions for Satisfaction

To accurate survey, we would like to know your impression concerning interface quality. Please indicate the extent to which you agree or disagree with the following statements about the E-CLMS interface. Circle the appropriate number using the scale below.

Code	SD	D	N	A	SA
Description	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
Scale	1	2	3	4	5

Scale For Measuring Participants' Satisfaction		**Adapted from**
1.	I needed to learn a lot of things before I could get going with this system.	[150, 179]
2.	I felt very confident using the software.	[150, 179]
3.	I found the system very cumbersome to use.	[150, 179]
4.	I would imagine that most people will learn to use this interface very quickly.	[150, 179]
5.	I think that there is too much inconsistency in this interface.	[150, 179]
6.	I found the various functions in this interface were well integrated.	[150, 179]
7.	I think that I would need the support of technical person to be able to use this interface .	[150, 179]
8.	I thought the interface was easy to use.	[150, 179]
9.	I found the interface unnecessarily complex.	[150, 179]
10.	I think I would like to use this software frequently.	[150, 179]

Appendix B-1: Raw Data of Task Completion Time (Experimental Platform I & II)

Raw Data of Task Completion Time Regarding VICLMS(Experimental Platform I)

TOT >> Time of Task (sec)

	The Six Experimental Tasks						Task Complexity			Task Type			TOT
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	459	413	336	487	512	497	872	823	1009	906	1310	488	2704
P002	391	341	431	395	528	542	732	826	1070	836	1375	417	2628
P003	285	434	525	460	528	441	719	985	969	1042	1230	401	2673
P004	287	374	563	419	579	630	661	982	1209	1230	1190	432	2852
P005	684	305	391	260	650	327	989	651	977	894	1262	461	2617
P006	507	389	704	484	522	362	896	1188	884	962	1347	659	2968
P007	398	405	410	358	433	510	803	768	943	708	1193	613	2514
P008	477	412	339	396	457	558	889	735	1015	976	1227	436	2639
P009	435	241	496	419	637	599	676	915	1236	922	1381	524	2827
P010	415	430	412	440	530	487	845	852	1017	876	1395	443	2714
P011	534	445	539	442	618	560	979	981	1178	1062	1567	509	3138
P012	380	470	475	490	492	572	850	965	1064	1043	1338	498	2879
P013	447	329	464	544	582	602	776	1008	1184	1070	1542	356	2968
P014	450	305	454	440	525	552	755	894	1077	971	1314	441	2726
P015	449	385	384	500	596	527	834	884	1123	1098	1274	469	2841
P016	348	472	483	464	462	535	820	947	997	976	1347	441	2764
P017	454	399	400	572	650	584	853	972	1234	1228	1403	428	3059
P018	352	473	396	487	572	522	825	883	1094	1047	1331	424	2802
P019	410	452	523	453	512	560	862	976	1072	1185	1377	348	2910
P020	404	454	456	453	484	430	858	909	914	901	1320	460	2681
P021	392	306	431	503	497	486	698	934	983	932	1221	462	2615
P022	492	328	422	502	615	506	820	924	1121	1175	1357	333	2865
P023	350	376	482	524	621	483	726	1006	1104	927	1398	511	2836
P024	395	470	440	480	662	574	865	920	1236	1062	1431	528	3021
P025	404	399	447	466	516	444	803	913	960	785	1372	519	2676
Total	10599	9807	11403	11438	13780	12890	20406	22841	26670	24814	33502	11601	69917
Avg	423.96	392.28	456.12	457.52	551.2	515.6	816.24	913.64	1066.8	992.56	1340.1	464	2796.7

Raw Data of Task Completion Time Regarding MICLMS (Experimental Platform I)

TOT >> Time of Task (sec)

	The Six Experimental Tasks						Task Complexity			Task Type			TOT
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	325	322	230	380	447	374	647	610	821	664	1051	363	2078
P002	252	264	314	268	392	405	516	582	797	555	962	378	1895
P003	270	288	312	332	358	367	558	644	725	587	923	417	1927
P004	215	302	431	322	369	448	517	753	817	935	787	365	2087
P005	553	197	304	286	393	306	750	590	699	618	988	433	2039
P006	333	312	431	377	394	309	645	808	703	620	1113	423	2156
P007	263	272	352	259	312	389	535	611	701	512	830	505	1847
P008	311	264	265	336	337	378	575	601	715	665	831	395	1891
P009	304	182	311	281	392	442	486	592	834	648	809	455	1912
P010	269	320	262	331	373	317	589	593	690	565	911	396	1872
P011	294	325	299	322	378	320	619	621	698	591	958	389	1938
P012	260	290	355	250	312	392	550	605	704	443	978	438	1859
P013	267	329	284	364	402	302	596	648	704	770	882	296	1948
P014	270	185	334	260	345	432	455	594	777	731	654	441	1826
P015	269	265	324	260	356	467	534	584	823	678	794	469	1941
P016	276	311	346	381	316	429	587	727	745	671	945	443	2059
P017	363	251	256	309	375	441	614	565	816	688	923	384	1995
P018	263	233	276	247	332	402	496	523	734	546	812	395	1753
P019	230	272	329	247	392	431	502	576	823	705	859	337	1901
P020	224	267	327	333	364	430	491	660	794	601	992	352	1945
P021	261	293	352	367	437	468	554	719	905	534	1169	475	2178
P022	192	268	317	322	375	386	460	639	761	691	850	319	1860
P023	290	256	247	284	381	363	546	531	744	503	742	576	1821
P024	215	290	320	300	409	394	505	620	803	843	750	335	1928
P025	302	339	387	346	396	384	641	733	780	550	1187	417	2154
Total	7071	6897	7965	7764	9337	9776	13968	15729	19113	15914	22700	10196	48810
Avg	325	322	230	380	447	374	647	610	821	664	1051	363	2078

Raw Data of Task Completion Time Regarding AICLMS (Experimental Platform II)

TOT >>Time of Task (sec)

	The Six Experimental Tasks						Task Complexity			Task Type			TOT
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	225	199	243	294	363	337	424	537	700	544	614	503	1661
P002	200	160	242	250	261	345	360	492	606	422	682	354	1458
P003	210	228	312	272	283	307	438	584	590	382	677	553	1612
P004	211	191	264	259	291	325	402	523	616	514	655	372	1541
P005	313	231	286	270	313	357	544	556	670	655	721	394	1770
P006	200	160	229	238	284	352	360	467	636	428	646	389	1463
P007	201	248	271	225	283	294	449	496	577	409	659	454	1522
P008	199	198	212	294	273	273	397	506	546	362	718	369	1449
P009	193	189	221	231	330	264	382	452	594	439	683	306	1428
P010	156	162	203	216	269	312	318	419	581	268	677	373	1318
P011	223	197	238	260	358	352	420	498	710	490	795	343	1628
P012	221	186	240	229	280	292	407	469	572	403	611	434	1448
P013	208	265	222	302	283	307	473	524	590	583	623	381	1587
P014	250	185	283	260	345	312	435	543	657	605	612	418	1635
P015	184	189	314	252	322	400	373	566	722	518	706	437	1661
P016	203	202	276	261	337	343	405	537	680	551	616	455	1622
P017	193	142	204	259	265	383	335	463	648	569	506	371	1446
P018	243	213	276	247	332	317	456	523	649	522	712	394	1628
P019	216	198	253	266	309	311	414	519	620	505	667	381	1553
P020	205	206	240	238	272	260	411	478	532	321	659	441	1421
P021	205	211	276	279	317	348	416	555	665	511	705	420	1636
P022	222	208	317	284	315	386	430	601	701	627	727	378	1732
P023	230	196	247	262	328	337	426	509	665	538	561	501	1600
P024	215	215	234	238	291	283	430	472	574	554	538	384	1476
P025	182	219	267	286	336	324	401	553	660	452	745	417	1614
Total	5308	4998	6370	6472	7640	8121	10306	12842	15761	12172	16515	10222	38909
Avg	212.32	199.92	254.8	258.88	305.6	324.84	412.24	513.68	630.44	486.88	660.6	408.88	1556

Appendix B-2: Raw Data of Counting Mouse Clicks(Experimental Platform I & II)

Raw Data of Counting Mouse Clicks Regarding VICLMS (Experimental Platform I)

CMC >> Mouse Clicks

	The Six Experimental Tasks						Task Complexity			Task Type			CMC
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	36	35	42	45	48	45	71	87	93	89	100	62	251
P002	39	35	35	37	44	46	74	72	81	80	99	57	236
P003	39	36	29	35	44	51	75	64	79	83	92	59	234
P004	20	27	53	39	40	43	47	92	79	80	100	42	222
P005	31	20	34	35	69	34	51	69	104	77	99	47	223
P006	33	39	82	30	50	34	72	112	80	81	121	66	268
P007	34	26	33	45	39	37	60	78	84	68	96	50	214
P008	30	17	36	39	34	38	47	75	73	63	88	43	194
P009	47	33	54	43	53	49	80	97	96	102	105	72	279
P010	30	38	35	36	41	43	68	71	77	74	93	56	223
P011	38	34	45	43	57	55	72	88	100	95	104	73	272
P012	32	42	75	31	35	37	74	106	66	90	106	56	252
P013	16	36	42	37	36	48	52	79	73	72	94	49	215
P014	37	38	43	49	52	55	75	92	101	92	107	75	274
P015	29	25	37	40	35	38	54	77	75	75	81	48	204
P016	30	24	36	38	35	40	54	74	73	64	89	50	203
P017	36	34	39	38	44	46	70	77	82	78	96	63	237
P018	39	32	36	39	46	44	71	75	85	76	96	64	236
P019	37	31	36	35	43	42	68	71	78	79	92	53	224
P020	43	39	46	44	50	53	82	90	94	90	121	64	275
P021	28	34	36	42	45	48	62	78	87	83	90	60	233
P022	36	35	43	43	49	47	71	86	92	91	101	61	253
P023	31	34	38	39	46	44	65	77	85	77	94	61	232
P024	42	43	44	47	51	53	85	91	98	104	105	71	280
P025	43	39	42	54	51	49	82	96	105	104	107	67	278
Total	856	826	1071	1003	1137	1119	1682	2074	2140	2067	2476	1469	6012
Avg	34.24	33.04	42.84	40.12	45.48	44.76	67.28	82.96	85.6	82.68	99.04	58.8	240.5

Raw Data of Counting Mouse Clicks Regarding MICLMS (Experimental Platform I)

CMC >>Mouse Clicks

	The Six Experimental Tasks						Task Complexity			Task Type			CMC
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	21	20	27	30	33	30	41	57	63	59	70	32	161
P002	27	23	23	25	32	34	50	48	57	56	75	33	164
P003	27	27	20	26	36	42	54	46	62	64	74	40	178
P004	20	25	27	29	38	42	45	56	67	64	81	36	181
P005	29	20	32	32	58	32	49	64	90	74	88	41	203
P006	28	25	25	25	31	35	53	50	56	54	78	37	169
P007	27	24	23	24	31	30	51	47	55	52	72	35	159
P008	29	17	32	34	31	33	46	66	65	59	79	38	176
P009	29	17	37	27	32	33	46	64	59	66	71	38	175
P010	24	32	29	30	35	37	56	59	65	62	81	44	187
P011	17	13	24	21	36	34	30	45	57	53	62	30	145
P012	26	17	31	34	28	32	43	65	62	59	79	30	168
P013	22	30	36	33	36	38	52	69	69	71	83	41	195
P014	19	20	25	32	34	37	39	57	66	56	72	39	167
P015	29	25	37	38	32	37	54	75	70	72	81	45	198
P016	30	24	32	38	32	37	54	70	70	61	87	45	193
P017	27	25	30	29	35	37	52	59	64	60	78	45	183
P018	30	23	27	27	35	35	53	54	62	56	77	44	177
P019	27	25	29	27	37	36	52	56	64	66	76	39	181
P020	22	25	31	29	33	33	47	60	62	54	87	32	173
P021	19	25	28	33	36	39	44	61	69	66	72	42	180
P022	24	23	31	32	37	36	47	63	69	67	79	37	183
P023	25	28	32	33	40	38	53	65	73	65	82	49	196
P024	27	28	29	32	36	38	55	61	68	74	75	41	190
P025	26	26	27	27	34	35	52	54	61	65	73	37	175
Total	631	587	724	747	878	890	1218	1471	1625	1555	1932	970	4457
Avg	25.24	23.48	28.96	29.88	35.12	35.6	48.72	58.84	65	62.2	77.28	38.8	178.28

Raw Data of Counting Mouse Clicks Regarding AICLMS (Experimental Platform II)

CMC >>Mouse Clicks

	The Six Experimental Tasks						Task Complexity			Task Type			CMC
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	17	13	20	20	31	30	30	40	51	48	57	26	131
P002	21	16	21	22	31	31	37	43	53	51	63	28	142
P003	18	17	20	22	32	32	35	42	54	53	60	28	141
P004	19	18	25	23	36	34	37	48	59	56	68	31	155
P005	25	14	23	23	37	31	39	46	60	53	67	33	153
P006	23	14	23	23	33	32	37	46	56	51	66	31	148
P007	19	19	21	23	31	31	38	44	54	50	64	30	144
P008	17	13	24	20	31	30	30	44	51	48	61	26	135
P009	18	15	22	20	33	30	33	42	53	50	59	29	138
P010	18	15	21	22	33	31	33	43	55	51	59	30	140
P011	17	13	23	21	34	34	30	44	55	50	62	30	142
P012	19	15	22	23	33	32	34	45	56	52	64	28	144
P013	18	14	21	23	34	32	32	44	57	51	60	31	142
P014	21	17	22	21	36	33	38	43	57	54	64	32	150
P015	25	18	23	22	32	32	43	45	54	49	63	40	152
P016	20	17	27	23	35	34	37	50	58	56	65	35	156
P017	25	18	27	22	41	34	43	49	63	62	69	36	167
P018	18	15	22	21	33	30	33	43	54	53	58	28	139
P019	18	16	25	24	33	30	34	49	57	57	61	28	146
P020	22	17	23	25	34	34	39	48	59	56	64	35	155
P021	17	19	20	27	31	38	36	47	58	56	64	32	152
P022	20	13	23	20	34	30	33	43	54	51	60	29	140
P023	18	14	22	20	31	32	32	42	51	51	58	28	137
P024	18	17	24	22	34	33	35	46	56	51	62	35	148
P025	18	17	21	21	33	31	35	42	54	54	57	30	141
Total	489	394	565	553	836	801	883	1118	1389	1314	1555	769	3638
Avg	19.56	15.76	22.6	22.12	33.44	32.04	35.32	44.72	55.56	52.56	62.2	30.76	145.5

Appendix B-3: Raw Data of Error Rate (Experimental Platform I & II)

Raw Data of Error Rate Regarding VICLMS (Experimental Platform I)

NOE>> Number of Errors

	The Six Experimental Tasks						Task Complexity			Task Type			NOE
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	0	1	3	2	3	4	1	5	7	4	8	1	13
P002	1	0	3	1	4	5	1	4	9	5	7	2	14
P003	0	1	4	3	4	6	1	7	10	6	10	2	18
P004	0	1	2	1	2	4	1	3	6	3	5	2	10
P005	0	2	2	4	3	4	2	6	7	4	8	3	15
P006	1	1	3	1	5	1	2	4	6	3	6	3	12
P007	0	2	4	3	5	3	2	7	8	5	5	7	17
P008	0	2	4	1	5	2	2	5	7	4	6	4	14
P009	1	1	0	2	4	4	2	2	8	3	6	3	12
P010	2	1	2	1	3	5	3	3	8	6	6	2	14
P011	2	0	1	1	3	3	2	2	6	2	7	1	10
P012	0	0	2	2	4	6	0	4	10	3	8	3	14
P013	0	1	2	2	2	4	1	4	6	5	4	2	11
P014	1	1	3	1	1	5	2	4	6	3	6	3	12
P015	1	2	1	2	4	1	3	3	5	1	6	4	11
P016	2	1	2	3	5	4	3	5	9	5	7	5	17
P017	1	2	1	1	3	5	3	2	8	4	5	4	13
P018	1	2	2	2	3	4	3	4	7	4	7	3	14
P019	0	1	2	2	3	4	1	4	7	3	6	3	12
P020	0	1	3	3	4	3	1	6	7	3	8	3	14
P021	0	1	3	1	4	1	1	4	5	3	3	4	10
P022	1	2	3	1	3	4	3	4	7	7	6	1	14
P023	0	0	2	2	5	4	0	4	9	4	6	3	13
P024	2	1	2	3	4	2	3	5	6	3	6	5	14
P025	2	1	2	2	3	3	3	4	6	4	6	3	13
Total	18	28	58	47	89	91	46	105	180	97	158	76	331
Avg	0.72	1.12	2.32	1.88	3.56	3.64	1.84	4.2	7.2	3.88	6.32	3.04	13.24

Raw Data of Error Rate Regarding MICLMS (Experimental Platform I)

NOE>> Number of Errors

	The Six Experimental Tasks						Task Complexity			Task Type			NOE
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	0	0	2	2	3	3	0	4	6	3	5	2	10
P002	0	0	1	1	3	3	0	2	6	2	4	2	8
P003	0	1	2	1	1	2	1	3	3	2	3	2	7
P004	0	1	2	1	1	3	1	3	4	3	3	2	8
P005	1	0	2	3	1	2	1	5	3	3	5	1	9
P006	1	0	1	1	3	1	1	2	4	2	4	1	7
P007	0	0	3	1	3	4	0	4	7	4	4	3	11
P008	0	1	3	1	2	2	1	4	4	4	4	1	9
P009	1	1	0	1	2	3	2	1	5	3	4	1	8
P010	1	0	1	2	3	2	1	3	5	2	5	2	9
P011	2	0	1	1	1	3	2	2	4	1	6	1	8
P012	0	0	1	0	2	3	0	1	5	2	2	2	6
P013	0	1	1	0	2	4	1	1	6	2	4	3	8
P014	0	0	1	1	2	3	0	2	5	3	2	2	7
P015	1	1	1	2	3	1	2	3	4	3	3	3	9
P016	1	2	1	2	2	1	3	3	3	3	5	1	9
P017	0	1	2	0	2	2	1	2	4	2	5	0	7
P018	1	0	2	1	2	3	1	3	5	2	6	1	9
P019	0	0	2	0	3	3	0	2	6	3	3	2	8
P020	0	2	2	1	4	3	2	3	7	3	6	3	12
P021	0	1	2	1	3	2	1	3	5	3	5	1	9
P022	1	1	2	1	2	4	2	3	6	4	6	1	11
P023	0	0	1	2	2	5	0	3	7	4	4	2	10
P024	0	1	2	3	2	2	1	5	4	3	6	1	10
P025	1	1	1	1	2	2	2	2	4	3	2	3	8
Total	11	15	39	30	56	66	26	69	122	69	106	43	217
Avg	0.44	0.6	1.56	1.2	2.24	2.64	1.04	2.76	4.88	2.76	4.24	1.72	8.68

Raw Data of Error Rate Regarding AICLMS (Experimental Platform II)

NOE>> Number of Errors

	The Six Experimental Tasks						Task Complexity			Task Type			NOE
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All
P001	1	0	1	0	0	1	1	1	1	1	2	0	3
P002	0	0	1	1	0	1	0	2	1	1	1	1	3
P003	0	0	1	0	1	1	0	1	2	0	3	0	3
P004	1	2	0	1	0	0	3	1	0	2	1	1	4
P005	0	0	0	0	1	2	0	0	3	0	2	1	3
P006	0	0	1	1	0	1	0	2	1	1	2	0	3
P007	0	0	1	0	1	0	0	1	1	1	1	0	2
P008	1	0	1	1	2	2	1	2	4	2	3	2	7
P009	2	1	0	0	2	1	3	0	3	2	3	1	6
P010	0	0	1	2	0	2	0	3	2	2	2	1	5
P011	1	1	0	0	1	1	2	0	2	1	2	1	4
P012	1	0	1	1	2	3	1	2	5	3	4	1	8
P013	0	0	0	0	1	2	0	0	3	1	2	0	3
P014	0	1	0	2	1	2	1	2	3	2	3	1	6
P015	0	1	1	0	1	1	1	1	2	2	2	0	4
P016	0	0	1	1	2	1	0	2	3	1	3	1	5
P017	1	2	0	0	2	2	3	0	4	3	4	0	7
P018	1	0	2	0	2	1	1	2	3	1	3	2	6
P019	0	1	0	0	1	1	1	0	2	1	1	1	3
P020	0	1	2	2	2	1	1	4	3	2	4	2	8
P021	0	0	1	1	1	2	0	2	3	2	3	0	5
P022	0	0	2	1	2	1	0	3	3	2	2	2	6
P023	0	0	1	1	2	1	0	2	3	2	3	0	5
P024	0	0	0	1	1	2	0	1	3	1	3	0	4
P025	0	1	1	1	1	0	1	2	1	0	3	1	4
Total	9	11	19	17	29	32	20	36	61	36	62	19	117
Avg	0.36	0.44	0.76	0.68	1.16	1.28	0.8	1.44	2.44	1.44	2.48	0.76	4.68

Appendix B-4: Raw Data of Task Completion Status(Experimental Platform I & II)

Raw Data of Task Completion Status Regarding VICLMS (Experimental Platform I)

TCS>> Tasks Completion Status. (0) is uncompleted task and (1) is successfully completed Task

	The Six Experimental Tasks						Task Complexity			Task Type			Total of TCS	
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All	%
P001	1	1	1	0	0	0	2	1	0	2	0	1	3	50
P002	1	1	1	1	0	0	2	2	0	0	2	2	4	67
P003	1	1	0	1	0	1	2	1	1	0	2	2	4	67
P004	1	1	0	1	0	0	2	1	0	0	1	2	3	50
P005	0	1	1	1	0	1	1	2	1	2	1	1	4	67
P006	0	1	0	0	0	1	1	0	1	0	0	2	2	33
P007	1	1	1	1	1	0	2	2	1	2	1	2	5	83
P008	1	1	1	1	1	0	2	2	1	2	1	2	5	83
P009	1	1	0	1	0	0	2	1	0	2	0	1	3	50
P010	1	1	1	1	0	0	2	2	0	2	1	1	4	67
P011	0	1	0	1	0	0	1	1	0	1	0	1	2	33
P012	1	1	1	0	0	0	2	1	0	2	0	1	3	50
P013	1	1	1	0	0	0	2	1	0	2	0	1	3	50
P014	1	1	1	1	0	0	2	2	0	2	1	1	4	67
P015	1	1	1	0	0	0	2	1	0	1	1	1	3	50
P016	1	1	0	1	1	0	2	1	1	2	1	1	4	67
P017	1	1	1	0	0	0	2	1	0	0	1	2	3	50
P018	1	1	1	0	0	0	2	1	0	2	0	1	3	50
P019	1	1	0	1	0	0	2	1	0	2	0	1	3	50
P020	1	1	1	1	0	1	2	2	1	2	1	2	5	83
P021	1	1	1	0	0	0	2	1	0	2	0	1	3	50
P022	0	1	1	0	0	0	1	1	0	1	0	1	2	33
P023	1	1	0	0	0	0	2	0	0	0	0	2	2	33
P024	1	1	1	0	0	0	2	1	0	1	0	2	3	50
P025	1	1	1	1	0	1	2	2	1	2	1	2	5	83
Total	21	25	17	14	3	5	46	31	8	34	15	36	85	57
Avg	84	100	68	56	12	20	92	62	16	68	30	72	57	

Raw Data of Task Completion Status Regarding MICLMS (Experimental Platform I)

TCS>> Tasks Completion Status. (0) is uncompleted task and (1) is successfully completed Task

	The Six Experimental Tasks						Task Complexity			Task Type			Total of TCS	
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All	%
P001	1	1	1	1	0	1	2	2	1	2	2	1	5	83
P002	1	1	1	1	1	0	2	2	1	2	1	2	5	83
P003	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P004	1	1	0	1	1	0	2	1	1	1	2	1	4	67
P005	0	1	1	1	1	1	1	2	2	2	1	2	5	83
P006	1	1	0	1	1	1	2	1	2	1	2	2	5	83
P007	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P008	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P009	1	1	1	1	1	0	2	2	1	2	2	1	5	83
P010	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P011	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P012	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P013	1	1	1	1	0	1	2	2	1	2	2	1	5	83
P014	1	1	1	1	1	0	2	2	1	2	2	1	5	83
P015	1	1	1	1	1	0	2	2	1	2	2	1	5	83
P016	1	1	1	1	1	0	2	2	1	1	2	2	5	83
P017	1	1	1	1	1	0	2	2	1	2	2	1	5	83
P018	1	1	1	1	1	0	2	2	1	1	2	2	5	83
P019	1	1	1	1	1	0	2	2	1	2	1	2	5	83
P020	1	1	1	1	1	0	2	2	1	2	2	1	5	83
P021	1	1	1	1	1	0	2	2	1	2	1	2	5	83
P022	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P023	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P024	1	1	1	1	0	1	2	2	1	2	1	2	5	83
P025	1	1	1	1	1	1	2	2	2	2	2	2	6	100
Total	24	25	23	25	22	14	49	48	36	46	45	42	133	89
Avg	96	100	92	100	88	56	98	96	72	92	90	84	89	

Raw Data of Task Completion Status Regarding AICLMS (Experimental Platform II)

TCS>> Tasks Completion Status. (0) is uncompleted task and (1) is successfully completed Task

	The Six Experimental Tasks						Task Complexity			Task Type			Total of TCS	
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks	Moderate Tasks	Complex Tasks	EPC	IPC	PSC	All	%
P001	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P002	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P003	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P004	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P005	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P006	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P007	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P008	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P009	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P010	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P011	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P012	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P013	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P014	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P015	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P016	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P017	1	1	1	1	1	0	2	2	1	2	1	2	5	83
P018	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P019	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P020	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P021	1	1	1	1	1	0	2	2	1	2	1	2	5	83
P022	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P023	1	1	1	1	1	1	2	2	2	2	2	2	6	100
P024	1	1	1	1	0	1	2	2	1	1	2	2	5	83
P025	1	1	1	1	1	1	2	2	2	2	2	2	6	100
Total	25	25	25	25	24	23	50	50	47	49	48	50	147	98
Avg	100	100	100	100	96	92	100	100	94	98	96	100	98	

Appendix C-1: Scenarios of the Six Tasks (Experimental Platform III)

Tasks 1 and 2.Simple (Personal Computer customisation):

Scenario**:** Assume that you would like to purchase a computer from the website. You need to customise your PC. So, you have been asked to purchase components of computer hardware that suit your needs.

T1 Requirements

- Working activities (e.g. surf the Internet)
- The budget is greater than £1000.00.

Co-creation							
Product Customisation				Product Cost	Recommender System		
No	**Stage**	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	External	Case & lock	2 front USB ports	(<£15)	Recommended		
2	Internal	Memory	Size is 8GB	(<£60)	Recommended		
3	Software	Operating System	Windows 7 professional	(<£130)	Strongly Recommended		
4	Service	Home Installation	Family surf Control	(≥£79)	N/A		

T2 Requirements

- The most actives (surf the Internet) .
- The Budget is greet than (£1000.00).

Co-creation							
Product Customisation				Product Cost	Recommender System		
No	**Stage**	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	External	Mouse	USB connector	(≥ £5)	Recommended		
2	Internal	Power Supply	Power supply is 350W	(≤ £29)	Non Recommended		
3	Software	Anti-Virus	Protection is covering viruses	(< £13)	Strong Recommended		
4	Service	Build Time	Deliver approximately 5	(<£59)	N/A		

Tasks 3 and 4 .Moderate (Personal Computer customisation):

Scenario**:** Assume that you would like to perchese computer from the website . You need to customise your PC. So you have been asked to purchase components of computer hardware that suit your needs.

T3 Requirements

- The most actives (Listen to Music)
- The Budget is greet than (£1000.00).

Co-creation				
Product Customisation				Product Cost
No	**Stage**	**Product Name**	**Product Information**	**Price**
1	External	Monitor	Resolution is 1920 × 1080	(≤ £200) and (≤ £134)
2	Internal	Motherboard	Max Bus Speed : 1333 MHZ	(< £37) and (<£36)
3	Internal	Graphics Card	Maximum power usage is 56w	(< £54)
4	Software	Operating system	Windows Vista	(>£109.99) and (< £168)
5	Service	Data Recovery	Against Failure	(> £20) and (>£ 29)

T4 Requirements

- The most actives (Listen to Music)
- The Budget is greet than (£1000.00).

Co-creation				
Product Customisation				Product Cost
No	**Stage**	**Product Name**	**Product Information**	**Price**
1	External	Speakers	Speakers are 2 satellites	(>£9) and (<£40)
2	Internal	Modem	56k internal	(≥ 0)
3	Internal	TV Card	Digital TV card	(≥ £20) and (< £25)
4	Software	Anti-Virus	Protection is covering viruses	(>£9) and (< £45)
5	Service	Build Time	Deliver approximately 3 working days	(>£3) and (>£29)

Tasks 5 and 6 .Complex (Personal Computer customisation):

Scenario**:** Assume that you would like to perchese computer from the website . You need to customise your PC. So you have been asked to purchase components of computer hardware that suit your needs.

T5 Requirements

- The most actives (Watch Movies)
- The Budget is greet than (£1500.00).

Co-creation							
Product Customisation				Product Cost	Recommender System		
No	**Stage**	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	External	Monitor	Resolution is 1920 × 1080	N/A	Recommended		
2	Internal	Processor	Core Frequency is 2.66GH	N/A	Non-recommended		
3	Internal	Motherboard	Max Bus Speed : 1333 MHZ and Audio output : 5.1 channel surround	(< £36)	N/A		
4	Software	Operating system	Microsoft Windows	N/A	Strong-recommended		
5	Service	Home Installation	Family surf Control	(>£99)and (<£139)	N/A		

T6 Requirements

- The most actives (Watch Movies)
- The Budget is greet than (£1500.00).

Co-creation							
Product Customisation				Product Cost	Recommender System		
No	**Stage**	**Product Name**	**Product Information**	**Price**	**Non-R**	**R**	**Strong-R**
1	External	Webcam	Snapshots at up to 10	N/A	N/A		
2	Internal	Sound Card	N/A	N/A	Strong-recommended		
3	Internal	Modem	N/A	(≥ £ 0)	Strong-recommended		
4	Software	Anti-Virus	N/A	(>£9)and(≤£50)	Recommended		
5	Service	Warranty	2years collect ,2 years parts	(> £ 69)	N/A		

Appendix C-2: Post-Session Questionnaire (Experimental Platform III)

Questions

To accurate survey, we would like to know your attitude concerning interface quality. Please indicate the extent to which you agree or disagree with the following statements about the E-CLMS interface. Circle the appropriate number using the scale below.

Code	SD	D	A	SA
Description	Strongly Disagree	Disagree	Agree	Strongly Agree
Scale	1	2	3	4

1. **Perceived Convenience** (PC)

Statements Of Perceived Convenience		**Code**	**Adapted from**
1.	I can a purchase without much help.	(PWH)	[99, 60]
2.	This website is user friendly.	(UF)	[99, 60]
3.	This website is very convenient.	(VC)	[99, 60]

2. Perceived Enjoyment (PE)

Statements Of Perceived Enjoyment		Code	Adapted from
1.	This is interesting website.	(IW)	[99,181]
2.	This is entertaining website.	(EW)	[99,181]
3.	This is pleasant website.	(PW)	[99,181]
4.	This is very enjoyable website.	(VEW)	[99,181]

3. Perceived Value Of Customisation (PVC)

Statements Of Perceived Value Of Customisation		Code	Adapted from
1.	This website has recommendations that match my needs.	(RMN)	[99,180]
2.	I feel unique customer at this website.	(FUC)	[99,180]
3.	This website has facilities to customise product easily.	(CPE)	[99,180]

4. Perceived Ease of Use (PEU)

Statements Of Perceived Ease of Use		Code	Adapted from
1.	This website is easy to use for product customisation.	(EUPC)	[99,181]
2.	It is easy to find information quickly.	(EFIQ)	[99,181]
3.	This website is clear and understandable.	(CAU)	[99,181]

Appendix D-1: Raw Data of Level of Success for AEICLMS (Experimental Platform III)

LOS>> Level of Success

(0) is N/A, (1) is complete success, (2) is partial success and (3) is complete failure

Co-creation																		
Participants	Level of success per task						Task Complexity									All of LOS		
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks			Moderate Tasks			Complex Tasks					
							L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
P001	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P002	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P003	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P004	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P005	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P006	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P007	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P008	1	1	1	1	1	3	2	0	0	2	0	0	1	0	1	5	0	1
P009	1	1	2	1	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P010	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P011	1	1	1	1	2	2	2	0	0	2	0	0	0	2	0	4	2	0
P012	1	1	1	1	1	2	2	0	0	1	1	0	1	1	0	4	2	0
P013	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P014	1	1	1	1	1	3	2	0	0	2	0	0	1	0	1	5	0	1
P015	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P016	1	1	1	2	2	1	2	0	0	1	1	0	1	1	0	4	2	0
P017	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P018	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P019	1	1	2	1	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P020	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P021	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P022	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P023	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P024	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P025	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P026	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0

P027	1	1	2	1	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P028	1	1	1	1	3	1	2	0	0	2	0	0	1	0	1	5	0	1
P029	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P030	1	1	2	1	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P031	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P032	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P033	1	1	1	1	1	3	2	0	0	2	0	0	1	0	1	5	0	1
P034	1	1	1	1	3	2	2	0	0	2	0	0	0	1	1	4	1	1
P035	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P036	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P037	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P038	1	1	2	1	2	1	2	0	0	1	1	0	1	1	0	4	2	0
P039	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P040	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P041	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P042	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P043	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P044	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P045	1	1	1	1	3	2	2	0	0	2	0	0	0	1	1	4	1	1
P046	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P047	1	1	2	1	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P048	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P049	1	1	1	2	3	2	2	0	0	1	1	0	0	1	1	3	2	1
P050	1	1	1	2	1	3	2	0	0	1	1	0	1	0	1	4	1	1
Total							100	0	0	84	16	0	71	21	8	255	37	8
Avg.	1	1	1.12	1.18	1.34	1.4												
Mod.	1	1	1	1	1	1												

Appendix D-2: Raw Data of Level of Success for AAICLMS (Experimental Platform III)

LOS>> Level of Success

(0) is N/A, (1) is complete success, (2) is partial success and (3) is complete failure

Co-creation																		
Participants	Level of success per task						Task Complexity									All of LOS		
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks			Moderate Tasks			Complex Tasks					
							L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
P001	1	1	2	1	2	2	2	0	0	1	1	0	0	2	0	3	3	0
P002	2	1	1	1	1	2	1	1	0	2	0	0	1	1	0	4	2	0
P003	1	2	1	2	1	1	1	1	0	1	1	0	2	0	0	4	2	0
P004	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P005	1	1	1	2	1	2	2	0	0	1	1	0	1	1	0	4	2	0
P006	2	1	1	1	1	1	1	1	0	2	0	0	2	0	0	5	1	0
P007	1	1	2	1	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P008	1	1	1	1	2	3	2	0	0	2	0	0	0	1	1	4	1	1
P009	2	1	1	1	3	1	1	1	0	2	0	0	1	0	1	4	1	1
P010	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P011	1	1	1	1	1	3	2	0	0	2	0	0	1	0	1	5	0	1
P012	1	1	1	1	2	2	2	0	0	2	0	0	0	2	0	4	2	0
P013	2	1	2	1	1	1	1	1	0	1	1	0	2	0	0	4	2	0
P014	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P015	1	1	1	3	1	1	2	0	0	1	0	1	2	0	0	5	0	1
P016	1	2	3	1	1	1	1	1	0	1	0	1	2	0	0	4	1	1
P017	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P018	1	1	1	1	3	1	2	0	0	2	0	0	1	0	1	5	0	1
P019	1	1	2	3	1	1	2	0	0	0	1	1	2	0	0	4	1	1
P020	1	1	1	2	3	2	2	0	0	1	1	0	0	1	1	3	2	1
P021	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P022	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P023	1	1	2	1	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P024	1	1	2	3	2	1	2	0	0	0	1	1	1	1	0	3	2	1
P025	1	1	1	1	2	3	2	0	0	2	0	0	0	1	1	4	1	1
P026	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P027	2	2	1	2	3	1	0	2	0	1	1	0	1	0	1	2	3	1

P028	1	1	3	1	1	3	2	0	0	1	0	1	1	0	1	4	0	2
P029	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P030	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P031	1	1	1	1	2	2	2	0	0	2	0	0	0	2	0	4	2	0
P032	2	1	1	2	3	1	1	1	0	1	1	0	1	0	1	3	2	1
P033	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P034	1	1	1	3	1	3	2	0	0	1	0	1	1	0	1	4	0	2
P035	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P036	2	1	1	2	1	1	1	1	0	1	1	0	2	0	0	4	2	0
P037	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P038	1	2	1	3	3	1	1	1	0	1	0	1	1	0	1	3	1	2
P039	1	1	2	1	3	3	2	0	0	1	1	0	0	0	2	3	1	2
P040	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P041	1	1	3	1	1	3	2	0	0	1	0	1	1	0	1	4	0	2
P042	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P043	2	1	1	1	1	1	1	1	0	2	0	0	2	0	0	5	1	0
P044	1	1	1	1	1	3	2	0	0	2	0	0	1	0	1	5	0	1
P045	1	1	1	1	2	3	2	0	0	2	0	0	0	1	1	4	1	1
P046	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P047	1	1	1	1	1	3	2	0	0	2	0	0	1	0	1	5	0	1
P048	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P049	1	1	2	1	2	3	2	0	0	1	1	0	0	1	1	3	2	1
P050	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
Total							88	12	0	77	15	8	64	18	18	229	45	26
Avg.	1.16	1.08	1.28	1.34	1.48	1.6												
Mod.	1	1	1	1	1	1												

Appendix D-3: Raw Data of Level of Success for AICLMS (Experimental Platform III)

LOS>> Level of Success

(0) is N/A, (1) is complete success, (2) is partial success and (3) is complete failure

Co-creation																		
Participants	Level of success per task						Task Complexity									All of LOS		
P. Code	T1	T2	T3	T4	T5	T6	Simple Tasks			Moderate Tasks			Complex Tasks					
							L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
P001	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P002	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P003	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P004	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P005	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P006	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P007	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P008	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P009	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P010	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P011	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P012	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P013	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P014	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P015	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P016	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P017	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P018	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P019	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P020	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P021	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P022	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P023	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P024	1	1	1	1	3	1	2	0	0	2	0	0	1	0	1	5	0	1
P025	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P026	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0

P027	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P028	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P029	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P030	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P031	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P032	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P033	1	1	1	2	1	1	2	0	0	1	1	0	2	0	0	5	1	0
P034	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P035	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P036	1	1	1	1	1	3	2	0	0	2	0	0	1	0	1	5	0	1
P037	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P038	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P039	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P040	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P041	1	1	1	1	2	1	2	0	0	2	0	0	1	1	0	5	1	0
P042	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P043	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P044	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P045	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P046	1	1	1	1	1	2	2	0	0	2	0	0	1	1	0	5	1	0
P047	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P048	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P049	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
P050	1	1	1	1	1	1	2	0	0	2	0	0	2	0	0	6	0	0
Total							100	0	0	98	2	0	91	7	2	289	9	2
Avg.	1	1	1	1.04	1.1	1.12												
Mod.	1	1	1	1	1	1												

Appendix E-1: Raw Data of Customers' Desire Factors for AEICLMS (Experiment III)

(1) is Strongly Disagree(SD),(2) is Disagree(D), (3) is Agree(A), (4) is Strongly Agree(SA)

Users	PC			PE				PVC			PEU		
User Code	**PWH**	**UF**	**VC**	**IW**	**EW**	**PW**	**VEW**	**RMN**	**FUC**	**CPE**	**EUPC**	**EFIQ**	**CAU**
P001	3	4	3	3	3	4	4	3	4	4	3	4	4
P002	4	3	3	4	3	3	4	4	4	3	4	4	4
P003	4	4	4	3	4	3	3	4	4	4	3	4	4
P004	3	4	4	4	3	3	4	4	4	4	4	4	4
P005	3	3	3	3	3	3	3	4	3	3	4	4	4
P006	3	4	4	3	3	4	4	4	4	4	4	4	4
P007	4	3	3	4	4	4	4	3	4	4	4	4	4
P008	4	4	4	4	4	4	3	4	4	4	4	4	4
P009	3	4	4	4	4	3	3	3	4	4	3	4	4
P010	3	3	3	4	4	3	3	4	4	4	4	3	4
P011	4	4	4	3	4	4	4	4	4	4	4	4	4
P012	4	3	3	3	4	4	4	3	4	3	4	4	4
P013	3	4	4	3	4	4	4	4	4	4	4	4	4
P014	4	4	4	4	4	4	3	3	4	3	3	4	4
P015	3	4	3	4	4	4	4	4	4	4	4	4	4
P016	4	4	3	3	4	4	3	4	4	4	4	4	4
P017	4	3	4	3	4	3	3	3	4	4	4	4	4
P018	3	4	4	4	4	4	3	4	4	4	3	4	4
P019	3	4	3	4	4	3	3	4	3	4	4	4	4
P020	4	4	4	3	4	4	3	4	4	4	3	3	3
P021	3	3	4	3	4	4	4	3	4	3	4	4	3
P022	4	3	3	4	4	4	4	4	4	4	4	4	4
P023	4	3	4	4	4	4	3	4	3	3	3	4	4
P024	4	4	3	4	3	3	4	4	4	4	4	4	3
P025	4	4	4	3	3	4	3	3	4	4	4	4	4
P026	3	3	3	3	4	4	3	4	4	4	3	4	4
P027	3	3	3	4	3	3	3	4	4	4	4	4	4
P028	4	4	3	4	4	4	3	3	3	4	4	4	3
P029	3	4	3	3	3	4	4	4	4	4	3	3	4
P030	4	3	4	4	4	3	3	4	4	4	4	3	3
P031	3	4	4	3	3	4	3	3	4	4	4	3	4
P032	3	3	4	3	3	3	3	4	4	3	4	4	3
P033	3	3	4	3	3	4	3	4	4	4	4	4	4

P034	4	3	3	3	4	4	3	4	4	4	4	4	4
P035	3	4	4	4	4	4	4	4	4	4	4	4	4
P036	4	4	3	3	3	3	4	4	3	3	4	4	4
P037	3	3	3	3	4	3	3	4	4	4	4	4	4
P038	3	3	4	4	4	3	4	4	4	4	4	4	4
P039	4	4	3	3	3	4	4	4	4	4	4	3	4
P040	4	3	4	3	3	3	3	3	3	3	4	3	3
P041	4	4	3	4	3	3	4	4	4	4	4	4	4
P042	4	4	4	3	4	3	3	4	4	4	4	4	3
P043	4	4	3	4	3	4	4	4	3	4	4	4	4
P044	3	3	3	3	3	4	3	4	4	3	4	4	4
P045	3	4	3	4	4	3	4	4	4	4	4	4	4
P046	3	4	4	4	3	4	4	4	4	4	4	4	4
P047	4	3	4	3	4	4	4	4	3	4	4	4	3
P048	4	4	3	4	3	4	3	4	4	4	4	4	4
P049	4	4	3	4	4	4	3	4	4	3	4	4	4
P050	4	3	3	3	4	4	3	4	3	3	4	4	3
Avg.	3.54	3.58	3.48	3.48	3.6	3.62	3.44	3.78	3.82	3.76	3.82	3.86	3.8
Mod.	4	4	3	3	4	4	3	4	4	4	4	4	4

Appendix E-2: Raw Data of Customers' Desire Factors for AAICLMS (Experiment III)

(1) is Strongly Disagree(SD),(2) is Disagree(D), (3) is Agree(A), (4) is Strongly Agree(SA)

Users	PC			PE				PVC			PEU		
User Code	**PWH**	**UF**	**VC**	**IW**	**EW**	**PW**	**VEW**	**RMN**	**FUC**	**CPE**	**EUPC**	**EFIQ**	**CAU**
P001	3	3	3	3	3	4	3	4	3	3	3	3	3
P002	3	`2	3	2	2	3	3	2	2	2	3	2	3
P003	4	4	4	4	4	4	4	4	4	4	4	4	4
P004	4	4	4	4	4	4	4	4	4	4	4	4	4
P005	4	4	4	4	4	4	4	4	4	4	4	4	4
P006	3	3	2	3	3	3	3	3	2	2	3	2	2
P007	3	3	4	4	4	3	3	3	3	3	3	3	3
P008	3	3	4	3	3	3	3	3	3	3	4	3	3
P009	4	3	3	3	3	3	3	4	3	2	3	4	4
P010	3	2	4	4	3	3	3	2	3	4	3	4	4
P011	3	4	3	4	3	3	3	3	3	3	4	4	4
P012	3	3	2	3	2	3	3	4	2	3	4	3	3
P013	2	2	4	3	4	3	3	4	4	4	4	4	4
P014	4	4	3	4	3	4	3	3	4	4	4	4	4
P015	3	4	3	3	3	4	3	4	3	4	4	4	3
P016	3	4	2	3	4	4	3	2	3	3	3	3	3
P017	4	3	3	3	3	3	4	4	4	4	4	4	4
P018	4	4	4	4	4	3	3	3	4	3	4	4	4
P019	3	2	4	3	3	4	3	4	3	3	4	3	3
P020	4	4	4	4	4	4	3	4	4	4	4	4	4
P021	3	3	3	3	3	3	3	3	2	3	3	2	2
P022	3	3	3	4	4	3	3	4	4	3	3	4	4
P023	3	3	3	3	3	3	3	3	3	3	4	3	3
P024	4	3	3	4	4	3	3	4	3	4	4	3	4
P025	3	3	3	3	3	4	3	4	3	4	4	4	4
P026	3	3	3	3	3	3	4	3	2	2	3	3	3
P027	3	4	3	3	3	3	4	4	4	3	4	4	4
P028	3	3	3	3	4	3	3	4	4	4	4	4	4
P029	2	4	3	3	3	3	4	3	2	3	3	3	3
P030	4	3	4	3	4	4	3	4	4	3	4	4	4
P031	4	3	3	4	3	3	3	3	4	3	4	4	4

P032	4	4	4	4	4	3	4	4	4	4	4	4	4
P033	3	3	3	3	3	3	4	4	3	3	4	3	3
P034	3	4	4	3	4	3	4	4	3	4	4	4	4
P035	3	3	3	4	4	3	4	4	4	4	4	4	4
P036	3	4	3	3	3	4	4	3	3	4	3	4	4
P037	3	3	3	3	4	4	4	4	4	3	4	3	3
P038	3	3	3	3	3	4	4	4	4	3	4	3	3
P039	4	4	4	3	3	4	4	4	3	4	4	4	4
P040	4	4	3	3	3	3	4	4	4	4	4	4	4
P041	3	3	3	4	3	3	4	3	3	4	4	4	3
P042	4	3	3	3	3	3	4	4	4	3	4	4	3
P043	3	3	3	3	4	3	3	4	4	3	4	4	3
P044	4	3	3	3	4	3	3	4	4	3	4	4	4
P045	3	4	4	4	4	4	4	4	4	4	4	4	4
P046	3	4	4	4	4	4	4	4	4	4	4	4	4
P047	4	3	3	3	3	4	4	4	4	3	4	4	4
P048	4	3	3	3	3	3	3	3	4	3	4	4	4
P049	3	4	3	4	3	3	3	4	4	3	4	4	4
P050	3	3	4	3	3	3	3	4	4	3	4	3	3
Avg.	3.32	3.32	3.28	3.34	3.36	3.36	3.42	3.6	3.42	3.34	3.76	3.6	3.56
Mod.	3	3	3	3	3	3	3	4	4	3	4	4	4

Appendix E-2: Raw Data of Customers' Desire Factors for AAICLMS (Experiment III)

(1) is Strongly Disagree(SD),(2) is Disagree(D), (3) is Agree(A), (4) is Strongly Agree(SA)

Participants	PC			PE				PVC			PEU		
P. Code	**PWH**	**UF**	**VC**	**IW**	**EW**	**PW**	**VEW**	**RMN**	**FUC**	**CPE**	**EUPC**	**EFIQ**	**CAU**
P001	3	3	3	3	3	4	3	4	3	3	3	3	3
P002	3	`2	3	2	2	3	3	2	2	2	3	2	3
P003	4	4	4	4	4	4	4	4	4	4	4	4	4
P004	4	4	4	4	4	4	4	4	4	4	4	4	4
P005	4	4	4	4	4	4	4	4	4	4	4	4	4
P006	3	3	2	3	3	3	3	3	2	2	3	2	2
P007	3	3	4	4	4	3	3	3	3	3	3	3	3
P008	3	3	4	3	3	3	3	3	3	3	4	3	3
P009	4	3	3	3	3	3	3	4	3	2	3	4	4
P010	3	2	4	4	3	3	3	2	3	4	3	4	4
P011	3	4	3	4	3	3	3	3	3	3	4	4	4
P012	3	3	2	3	2	3	3	4	2	3	4	3	3
P013	2	2	4	3	4	3	3	4	4	4	4	4	4
P014	4	4	3	4	3	4	3	3	4	4	4	4	4
P015	3	4	3	3	3	4	3	4	3	4	4	4	3
P016	3	4	2	3	4	4	3	2	3	3	3	3	3
P017	4	3	3	3	3	3	4	4	4	4	4	4	4
P018	4	4	4	4	4	3	3	3	4	3	4	4	4
P019	3	2	4	3	3	4	3	4	3	3	4	3	3
P020	4	4	4	4	4	4	3	4	4	4	4	4	4
P021	3	3	3	3	3	3	3	3	2	3	3	2	2
P022	3	3	3	4	4	3	3	4	4	3	3	4	4
P023	3	3	3	3	3	3	3	3	3	3	4	3	3
P024	4	3	3	4	4	3	3	4	3	4	4	3	4
P025	3	3	3	3	3	4	3	4	3	4	4	4	4
P026	3	3	3	3	3	3	4	3	2	2	3	3	3
P027	3	4	3	3	3	3	4	4	4	3	4	4	4
P028	3	3	3	3	4	3	3	4	4	4	4	4	4
P029	2	4	3	3	3	3	4	3	2	3	3	3	3
P030	4	3	4	3	4	4	3	4	4	3	4	4	4

P031	4	3	3	4	3	3	3	3	4	3	4	4	4
P032	4	4	4	4	4	3	4	4	4	4	4	4	4
P033	3	3	3	3	3	3	4	4	3	3	4	3	3
P034	3	4	4	3	4	3	4	4	3	4	4	4	4
P035	3	3	3	4	4	3	4	4	4	4	4	4	4
P036	3	4	3	3	3	4	4	3	3	4	3	4	4
P037	3	3	3	3	4	4	4	4	4	3	4	3	3
P038	3	3	3	3	3	4	4	4	4	3	4	3	3
P039	4	4	4	3	3	4	4	4	3	4	4	4	4
P040	4	4	3	3	3	3	4	4	4	4	4	4	4
P041	3	3	3	4	3	3	4	3	3	4	4	4	3
P042	4	3	3	3	3	3	4	4	4	3	4	4	3
P043	3	3	3	3	4	3	3	4	4	3	4	4	3
P044	4	3	3	3	4	3	3	4	4	3	4	4	4
P045	3	4	4	4	4	4	4	4	4	4	4	4	4
P046	3	4	4	4	4	4	4	4	4	4	4	4	4
P047	4	3	3	3	3	4	4	4	4	3	4	4	4
P048	4	3	3	3	3	3	3	3	4	3	4	4	4
P049	3	4	3	4	3	3	3	4	4	3	4	4	4
P050	3	3	4	3	3	3	3	4	4	3	4	3	3
Avg.	3.3	3.3	3.2	3.3	3.3	3.3	3.4	3.6	3.4	3.3	3.7	3.6	3.5
Mod.	3	3	3	3	3	3	3	4	4	3	4	4	4

Appendix F-1: List of Programs

No	Programs	Version	Description
1	CrazyTalk Pro	6.0	CrazyTalk Pro is program that utilises to design virtual humans with facial expressions. It provides a total animation with regard to lips, eyes, ears and cheeks.
2	visual studio	2010	Visual studio 2010 is program that contains visual basic which used to design the experiments. Because there are tools (e.g. features in graphical UI, object-oriented and supporting audio and video.
3	SPSS	20.0	SPSS is software which used for statistical analysis and all experiments have been relied on this software in order to obtain the results in terms of q-square, t-test and ANOVA.
4	Free Audio Recorder	6.6.2	It is software that used for record speech through a microphone and saving on mp3 file in order to implement in the experiments.
5	Mp3 Sound Cutter	1.1	This is flexible program that used to cut a particular tone or integration two tones.
6	MP3 Converter Pro	4.0	This program is the converter for the audio file and used to convert the files in order to work in an environment of Visual Basic.
7	Visual Music	1.1	This program was produced several timbre synthesiser to create various earcons.