Measuring the success of the interactive mobile information systems at the individual level of use

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Sveučilište u Zagrebu

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MJERENJE USPJEŠNOSTI INTERAKTIVNIH MOBILNIH INFORMACIJSKIH SUSTAVA NA OSOBNOJ RAZINI UPOTREBE

DOKTORSKA DISERTACIJA

Varaždin, 2016.

In loving memory of my father, Vlado.
Thank you for loving me and believing in me.

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ABSTRACT

Information technology is not only crucial for the success of commercial business, but also an important part of individuals' daily activities. There are many technological solutions used to make our life easier. However, not every technological solution is successful. The research into the meaning of success regarding the interactive mobile information systems, benefits both science and industry. This dissertation deals with the improvements to the DeLone and McLean information systems success model and proposes new success dimensions, as well as relationships between these dimensions, in order to explain the success of today's interactive mobile information systems that are used at the individual level (e.g. for entertainment, information seeking, communication, etc.). The main contributions of this thesis are a valid and reliable measuring instrument questionnaire, and a valid and reliable multi-dimensional interactive mobile information systems success model. Both developed artefacts are results of the application of the design science methodology and represent valuable tools that serve both science and practice. Scientists can use these artefacts as a theoretical basis for similar studies, while providers of interactive mobile information systems can use these artefacts to measure the success of their products, in order to find out which features contribute to the perception of benefits as a result of system use in a greater or lesser degree, to detect whether users have the intention of system reuse, and use this information as a strategy for future system improvements.

Keywords: *interactive mobile information system success model, DeLone and McLean IS success model, information system quality, user experience quality, individual benefits, intention to reuse, interactive augmented reality systems*

SAŽETAK

Informacijska tehnologija nije samo ključna za uspjeh komercijalnih poduzeća, već je također važan dio svakodnevnih aktivnosti pojedinaca. Postoji mnogo tehnoloških rješenja koje koristimo kako bi smo si olakšali život. Međutim, nije svako tehnološko rješenje uspješno. Istraživanje što znači uspjeh u slučaju interaktivnih mobilnih informacijskih sustava, predstavlja korist ne samo za znanost već i za industriju. Disertacija se bavi unapređenjem DeLone i McLean modela uspješnosti informacijskih sustava i predlaže nove dimenzije uspješnosti kao i odnose između tih dimenzija kako bi se objasnila uspješnost današnjih interaktivnih mobilnih informacijskih sustava koji se koriste na individualnoj razini (npr. za zabavu, informiranje, komuniciranje itd.). Glavni doprinosi ove disertacije su valjan i pouzdan mjerni instrument upitnik te valjan i pouzdan višedimenzionalni model uspješnosti interaktivnih mobilnih informacijskih sustava. Oba razvijena artefakta nastala su kao rezultat primjene metodologije znanosti o dizajnu (engl. *design science*) te predstavljaju vrijedan alat koji služi znanosti i praksi. Znanstvenici mogu koristiti ove artefakte kao teorijske osnove za slična istraživanja, a pružatelji interaktivnih mobilnih informacijskih sustava primjenom ovih artefakata mogu izmjeriti uspješnost svojih proizvoda, otkriti koje značajke sustava više ili manje utječu na percepciju dobiti kao posljedicu upotrebe sustava, otkriti da li korisnici imaju namjeru nastaviti koristiti sustav, te koristiti ove informacije kao strategije za buduća poboljšanja sustava.

Ključne riječi: *interaktivni mobilni informacijski sustavi, DeLone i McLean model uspješnosti informacijskih sustava, kvaiteta informacijskog sustava, kvaliteta korisničkog iskustva, individualne dobiti, namjera ponovnog korištenja, interaktivni sustavi s proširenom stvarnošću*

PROŠIRENI SAŽETAK

Cjelokupna disertacija je strukturirana u osam poglavlja (uključujući uvod i zaključak). U prvom poglavlju prikazana je motivacija za istraživanje. Drugo poglavlje predstavlja pregled literature o glavnim konceptima disertacije i pozadinu definicije, povijesti i opsega informacijskih sustava, teorijama informacijskih sustava, interaktivnim (mobilnim) sustavima, te pragmatičnim i hedonističkim komponentama za evaluaciju interaktivnih sustava. U ovom poglavlju prikazana su najznačajnija dostupna istraživanja. U trećem poglavlju predstavljena je metodologija istraživanja. Disertacija slijedi metodologiju znanosti o dizajnu. U četvrtom poglavlju prezentirana su istraživačka pitanja i ciljevi istraživanja. Peto poglavlje usredotočeno je na prijedlog novog modela za mjerenje uspješnosti interaktivnih sustava te su predstavljene hipoteze istraživanja. Fokus ovog poglavlja je na prijedlozima kako poboljšati DeLone i McLean model uspješnosti informacijskih sustava. U poglavlju šest prikazan je razvoj mjernog instrumenta upitnika zajedno s konceptualnim modelom. Poglavlje sedam bavi se testiranjem upitnika i evaluacijom predloženog modela uspješnosti. U ovom poglavlju također je prikazan sažetak vrijednosti predloženog modela uspješnosti interaktivnih mobilnih informacijskih sustava. Zaključak rada opisan je u zadnjem poglavlju. U ovom poglavlju predstavljen je sažetak doprinosa, kao i otvorena pitanja, te prijedlozi za buduća istraživanja.

Danas, informacijska tehnologija nije samo ključna za uspjeh komercijalnih poduzeća, već je također važan dio svakodnevnih aktivnosti pojedinaca. Postoji mnogo tehnoloških rješenja koje koristimo kako bi smo si olakšali život. Međutim, nije svako tehnološko rješenje uspješno. Istraživanje što znači uspjeh u slučaju interaktivnih mobilnih informacijskih sustava predstavlja korist ne samo za znanost već i za industriju. Trenutno na IT tržištu postoji rastući broj raznovrsnih prijenosnih uređaja koji su postali poželjni mehanizmi za mnoge pojedince u interakciji s obitelji i prijateljima, za poslovanje i pristup Internetu, društvenim medijima, vijestima i zabavi. Mnoge trgovine mobilnih aplikacija omogućavaju korisnicima da pronađu, kupe, instaliraju programske aplikacije u samo nekoliko klikova. Kako bi ponuditelji ovih usluga uspjeli na izrazito kompetitivnom tržištu (s preko milijun mobilnih aplikacija dostupnih kroz razne trgovine aplikacija), pitanje kvalitete aplikacija (sustava) postaje sve važnije. Tehnike kao što su dodjeljivanje zvjezdica, komentari i broj preuzimanja su korišteni za procjenu uspješnosti aplikacija, za rangiranje aplikacija te preporuku istih.

Ali ako promatramo aplikacije kao jedan dio mobilnog IS-a, jesu li ove tehnike dovoljne kako bi se napravile valjane prosudbe koja je aplikacija uspješna ili nije? Ove uobičajeno korištene tehnike također imaju svojih nedostataka, i na njih se lako može nepropisno utjecati. Npr. korištenje robota koji automatski preuzimaju aplikacije i time guraju aplikaciju prema vrhu rang ljestvice. Ocjene (zvjezdice) se računaju na temelju prosjeka ocjena svih verzija, te nisu vezane uz određenu verziju sustava. Neki programeri također plaćaju korisnike da procjene njihovu aplikaciju. Dalje, komentari koje korisnici ostavljaju često su kratki, neprecizni ili pisani na različitim jezicima. Ne postoji standardni način za pregled/analiziranje aplikacija. U IT industriji trenutno nedostaje odgovarajući alat za mjerenje uspješnosti kada su IT rješenja korištena za osobne i zabavne potrebe.

Korisnici danas imaju visoka očekivanja u vezi tehnoloških rješenja na tržištu. Osim što trebaju ispunjavati utilitarističke potrebe korisnika, korisnici žele proizvode koji zadovoljavaju i njihove hedonističke potrebe. Uspjeh interaktivnih sustava koji se koriste u svakodnevnom životu pojedinaca nije jednodimenzionalan već može značiti više stvari u isto vrijeme. Stoga, uspjeh uključuje korisnikovu cjelokupnu procjenu interaktivnih sustava npr. procjenu kvalitete informacija, performanse i kvalitetu korisničkog iskustva u prirodnom kontekstu upotrebe tih sustava. Pristup mobilnim aplikacijama kao osobnim mobilnim informacijskim sustavima koristi prednosti postojećih organizacijskih teorija u razumijevanju karakteristika koje utječu da pojedini mobilni informacijski sustavi budu više uspješni u odnosu na druge.

Proučavanjem relevantne i dostupne literature iz područja uspješnosti mobilnih informacijskih sustava uočeno je niz nedostataka. Naime, iako se mnogi autori slažu da je koncept uspješnosti multidimenzionalan, ipak nisu postigli usuglašenost oko dimenzija uspješnosti. Postoji veliki broj mjernih čestica, no one su većinom ograničene na mjerenje uspješnosti organizacijskih informacijskih sustava. DeLone i McLean model uspješnosti informacijskih sustava je jedan od najpopularnijih modela uspješnosti organizacijskih informacijskih sustava u literaturi o informacijskim sustavima. Najveći nedostatak ovog modela je da nije prikladna za hedonističke informacijske sustave, kao što su igre, društvene mreže, ili druge vrste informacijskih sustava koji se koriste za zabavu, što su i sami autori istaknuli kao problem (Petter, DeLone, and McLean, 2008). Stoga, se ova disertacija bavi unapređenjem DeLone i McLean modela uspješnosti i predlaže nove dimenzije uspješnosti (tj. konstrukte) kao i odnose između dimenzija uspješnosti kako bi se objasnila uspješnost današnjih interaktivnih mobilnih informacijskih sustava koji se koriste na individualnoj razini. Tri su razloga zašto je odabran DeLone i McLean model uspješnosti kao polazni okvir. Prvi, ovaj model je jedan od najviše korištenih i najviše citiranih modela procjene uspješnosti informacijskog sustava. Drugi, mnogi istraživači su testirali model procjene uspješnosti te su se složili s autorima da je uspješnost informacijskog sustava multidimenzionalan koncept te kako se uz određene modifikacije njihov teorijski koncept može zadovoljavajuće primijeniti za mjerenje uspješnosti informacijskih sustava u različitim kontekstima (e-učenje, e-upravljanje, e/m-poslovanje, e/m-bankarstvo itd.). Treći, ovaj model se pokazao pouzdanim za mjerenje uspješnosti organizacijskih informacijskih sustava prvenstveno na osobnoj razini upotrebe.

Današnji interaktivni sustavi podržavaju visoku razinu mobilnosti i interakcije u kontekstu. Primjeri ovakvih sustava su mobilni sustavi s proširenom stvarnošću za igranje igara ili u turizmu za istraživanje povijesti nekoga grada ili znamenitosti. Za procjenu uspješnosti ovakvih interaktivnih sustava potrebno je koristiti drugačije kriterije vrednovanja. Iako je još uvijek relevantno procijeniti da li su zadovoljeni osnovni elementi upotrebljivosti, učinkovitosti i djelotvornosti su manje važne kada je riječ o hedonističkim interaktivnim sustavima. Pregledom literature uočeno je da, pored utilitarnih vrijednosti kao ishoda korištenja sustava, uspješnost tih sustava na individualnoj razini upotrebe se treba mjeriti i kroz hedonističke vrijednosti kao ishode korištenja sustava. Stoga su u ovoj doktorskoj disertaciji postavljeni sljedeći ciljevi istraživanja: (1) identificirati dimenzije uspješnosti (interaktivnih) mobilnih informacijskih sustava na individualnoj razini upotrebe; (2) razviti instrument za mjerenje uspješnosti (interaktivnih) mobilnih informacijskih sustava na individualnoj razini upotrebe; (3) razviti i validirati model uspješnosti (interaktivnih) mobilnih informacijskih sustava na individualnoj razini upotrebe u konkretnom okruženju.

Osim ciljeva istraživanja, predstavljene su sljedeće istraživačke hipoteze:

H1: Razvijeni mjerni instrument za mjerenje uspješnosti mobilnih informacijskih sustava iz perspektive vrijednosti krajnjeg korisnika biti će valjan i pouzdan.

H2: Razvijeni model mjerenja uspješnosti informacijskih sustava osigurati će više eksplanatorne moći nego postojeći DeLone i McLean model uspješnosti informacijskih sustava kada je upotreba mobilnog informacijskog sustava na osobnoj razini.

Disertacija slijedi korake metodologije znanosti o dizajniranju (engl. *design science research* DSR). DSR metodologija objašnjava kako artefakti koji su rezultat istraživanja, npr. konstrukti (konceptualni vokabular domene), modeli (skupa propozicija ili izjava koje izražavaju odnos između konstrukata), metode (skupa koraka koje se koriste za izvođenje zadataka), instance (predstavljaju operacionalizaciju konstrukata, modela i metoda) ili bolje teorije (izgradnja artefakta kao analogija eksperimentalnim prirodnim znanostima), predstavljaju valjani znanstveni doprinos. Iako postoje mnoga tumačenja i verzije metodologije DSR, u ovom radu korišten je pristup od pet koraka od autora Vaishnavi i Kuechler (2004, 2007). Prema ovom pristupu, prvi korak DSR-a predstavlja prezentaciju problema istraživanja (opisano u poglavlju četiri), u drugom koraku predložena su moguća rješenja problema (opisano u petom poglavlju), treći korak je razvoj predloženog rješenja (opisano u šestom poglavlju), četvrti korak je evaluacija predloženog rješenja (opisano u sedmom poglavlju), a zadnji korak je zaključak rezultata istraživanja (opisano u poglavlju sedam, te u poglavlju osam).

Glavni rezultat disertacije, na temelju metodologije znanosti o dizajniranju je model uspješnosti interaktivnih mobilni informacijskih sustava (IMISS model) koji podržava mjerenje uspješnosti interaktivnih hedonističkih sustava na individualnoj razini upotrebe. Ovaj model je formiran na temelju DeLone i McLean modela uspješnosti informacijskih sustava. Promjene koje su u napravljene u DeLone i McLean modelu su sljedeće: (1) *kvaliteta usluge* je izdvojena iz modela jer je postigla relativno malu potporu u drugim sličnim istraživanjima te zbog stava samih autora da je možda uvođenje ove dimenzije bilo nepotrebno jer kvaliteta usluge danas predstavlja kvalitetu informacijskog sustava, tj. sam informacijski sustav je usluga; (2) uvodi se nova dimenzija uspješnosti *kvaliteta korisničkog iskustva* koja mijenja postojeću dimenziju *korištenje* i opisuje iskustvo korištenja sustava; (3) kako se interaktivni sustavi ne koriste se samo za obavljanje nekog zadatka već i za zabavu, potrebno je uvesti određene promjene u dimenziju uspješnosti *individualne dobiti* kako bi se obuhvatile i hedonističke vrijednosti koje korisnik dobiva upotrebom sustava; (4) dalje, kako bi se provjerila lojalnost korisnika prema informacijskom sustavu uvodi se nova dimenzija *namjera ponovnog korištenja* kao zadnja zavisna dimenzija uspješnosti.

IMISS model, na svojoj meta-razini, predstavlja spoj četiri dimenzije: *kvaliteta informacijskog sustava*, *kvaliteta korisničkog iskustva*, *dobiti na osobnoj razini* te *namjera ponovnog korištenja*. Dimenzija *kvaliteta informacijskog sustava* predstavlja kvalitetu informacija koju sustav osigurava te kvalitetu rada samog sustava. *Kvaliteta korisničkog iskustva* predstavlja mjeru do koje su ispunjena očekivanja korisnika za pozitivnom interakcijom sa sustavom. *Individualne dobiti* opisuju direktne hedonističke i pragamtičke dobiti koje korisnici dobivaju upotrebom sustava. *Namjera ponovnog korištenja* se odnosi na pozitivan stav korisnika prema sustavu koji dovodi do ponovne upotrebe sustava. IMISS model je formiran kao višedimenzionalan model točnije kao model treće razine. Na prvoj razini IMISS model nalaze se atributi (svojstva) uspješnosti, na drugoj razini nalaze se pod-dimenzije uspješnosti, a na trećoj razini nalaze su glavne dimenzije uspješnosti. Atributi predstavljaju skup čestica koje mjere ista svojstva. Pod-dimenzije predstavljaju skup više atributa koje opisuju istu karakteristiku. Pod-dimenzije IMISS modela su kvaliteta informacija, kvaliteta sustava, kvaliteta pragmatičkog iskustva, kvaliteta hedonističkog iskustva, percepcija pragmatičkih dobiti i percepcija hedonističkih dobiti. Dok glavne dimenzije uspješnosti na višoj razini predstavljaju skup više pod-dimenzija.

Za potrebe validacije definiranog konceptualnog modela uspješnosti interaktivnih mobilnih informacijskih sustava i potvrđivanja postavljenih veza između latentnih varijabli (dimenzija uspješnosti) kreiran je mjerni instrument upitnik. Kako bi se razvio mjerni instrument s dobrim psihometrijskim karakteristikama, slijeđen je pristup istraživača Moore i Benbasat (1991). Prvo je kreiran skup čestica upitnika koje predstavljaju manifestne varijable modela. U početnoj fazi za IMISS model izdvojene su 93 čestice i 23 atributa. Evaluacija sadržajne valjanosti izdvojenih atributa i čestica provedena je izračunom omjera sadržajne valjanosti na temelju preporuka autora Lawshe (Lawshe 1975), gdje je skupina stručnjaka (N = 9) iz područja interakcija čovjeka i računala te područja informacijskih sustava procijenila svaku česticu, atribut i dimenziju uspješnosti. Čestice i atributi koji su dobili nisku potporu od stručnjaka su izbačene iz daljnje analize. Te je na kraju izostavljeno iz daljnje analize ukupno 46 čestica.

Nadalje, kako bi se procijenila valjanost konstrukta, koristila se tehnika sortiranja karata, gdje su stručnjaci (N = 6) iz područja informacijskih sustava te područja interakcije čovjeka i računala razvrstali atribute prema pripadajućim dimenzijama. Za atribute koji su uzastopce sortirani u određenu kategoriju (dimenziju), postignuta je konvergentna valjanost atributa s određenim konstruktom, te diskriminacijska valjanost prema drugima konstruktima. Za procjenu pouzdanosti postupaka sortiranja korištene su dvije mjerne metode: Conger Kappa koeficijent (koeficijent slaganja između više od dva stručnjaka), i omjer pogodaka. Atributi za koje stručnjaci nisu postigli sporazum kroz svaki krug sortiranja su isključeni iz upitnika. Ukupno su provedena dva kruga sortiranja. Prilikom sortiranja isključen je atribut *učinkovitost* zbog neslaganja među ekspertima pod koju dimenziju bi ovaj atribut zajedno sa svojim česticama trebao ići. Nakon toga uslijedilo je testiranje pouzdanosti čestica u upitniku. Sve čestice upitnika su formulirane kao izjave na koje su se ispitanici mogli pozicionirati na skali od 1 do 5, gdje 1 znači *u potpunosti se ne slažem* a 5 *u potpunosti se slažem* s navedenom izjavom. Pouzdanost upitnika testirana je na uspješnom i dobro prihvaćenom interaktivnom sustavu mobilnoj igri s proširenom stvarnošću *Ingress*. Igrači ove igre su pozvani putem Google+ grupa da sudjeluju u istraživanju i ispune anketu o uspješnosti sustava *Ingress*. Prikupljanje podataka u pilot istraživanju trajalo je od početka do kraja trećeg mjeseca 2015. godine. U pilot istraživanju sudjelovalo je 43 igrača. Za testiranje pouzdanost upitnika korišten je koeficijent *Cronbach's Alpha*. *Cronbach's Alpha* je indikator pouzdanosti mjerenja te predstavlja prosječnu korelaciju (povezanost) pitanja koja mjere istu osobinu. Preporučena vrijednost *Crobach's Alpha* koeficijenta u pilot istraživanju bi trebala biti iznad 0.65, dok je u glavnom istraživanju preporuka da ovaj koeficijent bude iznad 0.70. Nakon analize prikupljenih podataka samo skala čestica atributa *pristupačnost* nije ostvarila zadovoljavajuću razinu koeficijenta te je stoga isključena iz daljnje analize. Kako su sve ostale mjerne skale ostvarile zadovoljavajuću razinu pouzdanosti, zaključeno je da je osigurana podrška za prvu hipotezu na temelju podataka iz pilot istraživanja.

Provedba glavnog dijela istraživanja izvršena je na dva mobilna sustava s proširenom stvarnošću kao primjerima hedonističkih interaktivnih sustava koji zahtijevaju visoku razinu mobilnosti i visoku razinu interaktivnosti u kontekstu, ponovno na mobilnoj igri *Ingress*, i na mobilnom turističkom vodiču *VarazdinAR* (mobilna aplikacija razvijena od strane pristupnice). Poziv za sudjelovanje postavljen je na Google+ grupama gdje se okupljaju igrači igre *Ingress*. Prikupljanje podataka za potrebe glavnog istraživanju trajalo je od početka četvrtog mjeseca 2015. godine do sredine sedmog mjeseca 2015. godine. Prikupljeno je 112 valjanih odgovora na anketu uspješnosti mobilne igre *Ingress*. U slučaju *VarazdinAR* sustava, postupak provedbe je bio drugačiji. Letci s opisom aplikacije i s QR kodom s web adresom aplikacije bili su postavljeni u turistički centar grada Varaždina i na info pult hotela Turist. Ali, zbog malog odaziva turista da sudjeluju u istraživanju, u istraživanje su uključeni i studenti Fakulteta organizacije i informatike, Sveučilišta u Zagrebu da isprobaju aplikaciju i ispune anketni upitnik o uspješnosti *VarazdinAR* sustava. U konačnici je bilo valjano 102 odgovora na anketu uspješnosti *VarazdinAR* sustava.

Kako bi se pokazala valjanost modela te ispitala povezanost između dimenzija (konstrukata) predloženog modela, primijenjena je metoda parcijalnih najmanjih kvadrata (engl. *Partial Least Squares Structural Equation Modeling PLS-SEM*). Procjena modela provedena je u dva koraka, najprije analiza vanjskog modela, a potom analiza unutarnjeg modela. Postupak vrednovanja se razlikovao ovisno o tome da li je vanjski model formativan ili reflektivan. Analiza reflektivnih mjernih modela uključivala je procjenu unutarnje konzistencije (kompozitne) pouzdanosti i pouzdanosti čestica, konvergentne valjanosti i diskriminacijske valjanosti. Analiza formativnih mjernih modela uključivala je procjenu konvergentne valjanosti, procjenu mogućih problema kolinearnosti među česticama, te testiranje značajnosti i relevantnosti vanjskih vrijednosti. IMISS model je formiran kao višedimenzionalan model, gdje su na prvoj razini sve latentne varijable reflektivne. Na drugoj i trećoj razini sve latentne varijable su formativne osim zadnje zavisne latentne varijable *namjera ponovnog korištenja*. S obzirom na vrstu latentne varijable primijenjene su odgovarajuće mjere analize. Kod analize reflektivnih latentnih varijabli na prvoj razini, procjena unutarnje konzistencije (kompozitne) pouzdanosti mjernih skala (atributa) u oba slučaja je bila zadovoljavajuće razine tj. iznad preporučenih 0.70. U slučaju mobilne igre *Ingress* najveća vrijednost kompozitne pouzdanosti bila je za atribut *privlačnost* koja je imala vrijednost 0.9448. Najmanju vrijednost je imao atribut *prilagodljivost* koji je imao vrijednost 0.7464. U slučaju turističkog vodiča *VarazdinAR* najveća vrijednost kompozitne pouzdanosti bila je za atribut *vrijeme odgovora* koji je imao vrijednost 0.9381. Najmanju vrijednost pouzdanosti imao je atribut *razumljivost* koji je iznosio 0.7677. Kako bi se provjerila konvergentna valjanost mjera, izračunata je vrijednost prosječne ekstrahirane varijance i pouzdanost čestica. Pouzdanost čestica bi prema preporukama trebala biti blizu ili iznad 0.708. U oba slučaja pouzdanost većine čestica je bila iznad preporučene razine. Jedna čestica u slučaju turističkog vodiča *VarazdinAR* je imala vrijednost 0.6768 što je ispod preporučene razine. No kako je ta ista čestica u slučaju mobilne igre *Ingress* imala zadovoljavajuću razinu te kako postoji dovoljno teorijske potpore za zadržavanjem te čestice, čestica je zadržana unutar IMISS modela. Vrijednost prosječne ekstrahirane varijance prema preporukama treba biti iznad 0.50, što znači da konstrukt objašnjava više od 50% varijance pridruženih manifestnih varijabli, te da se manji dio objašnjene varijance odnosi na varijancu pogrješke. Rezultati su pokazali da su u oba slučaja ove vrijednosti iznad preporučene razine. Diskriminacijska valjanost je provjerena izračunom kriterija *Fornell-Larcker* i pomoću vrijednosti unakrsnih opterećenja. *Fornell-Larcker* kriterij govori da konstrukt treba dijeliti više varijance sa svojim pridruženim manifestnim varijablama nego s preostalim konstruktima. Što su rezultati za oba sustava i potvrdili. Drugi kriterij, vrijednost standardiziranog faktorskog opterećenja pojedine manifestne varijable s temeljnim konstruktom treba biti veći od svih vrijednosti unakrsnih opterećenja sa preostalim konstruktima vanjskog reflektivnog modela. Što je također potvrđeno za oba sustava. Na temelju analize rezultata reflektivnog modela može se zaključiti kako postoji dovoljna razina statističke potpore da se prihvati prva hipoteza.

U slučaju formativnih modela koji se nalaze na drugoj i trećoj razini IMISS modela procjena konvergentne valjanosti je provedena u fazi izrade upitnika kada su eksperti domene trebali sortirati atribute pod odgovarajuće predefinirane dimenzije uspjeha. Nakon toga je slijedila provjera mogućih problema (multi)kolinearnosti. Kolinearnost je pokazatelj redundancije u vanjskom formativnom modelu. Kako bi se provjerila moguća postojanost kolinearnosti izračunava se koeficijent tolerancije i koeficijent inflacije varijance (*VIF*). Na drugoj i trećoj razini sve mjerene varijable su imale vrijednosti tolerancije iznad 0.20 i vrijednost *VIF* ispod 5 u oba slučaja što znači da kolinearnost nije prisutna kod IMISS modela. Za vrjednovanje pouzdanosti formativnih latentnih konstrukata provodi se testiranje značajnosti relativnog i apsolutnog doprinosa mjernih varijabli konceptualnoj strukturi latentnog konstrukta. Relativan doprinos mjerne varijable predstavlja težinsku vrijednost tj. njen standardizirani koeficijent parcijalne regresije, a vrijednost faktorskog opterećenja predstavlja apsolutan doprinos tj. dvosmjernu korelaciju između mjerne varijable i temeljnog latentnog konstrukta. Značajnost ovih mjera se testira primjenom *bootstrapping* procedure. Nekoliko veza između mjernih varijabli i konstrukata imaju ne značajne težinske vrijednosti. U tom slučaju prema Haier i sur. (J. F. J. Hair et al. 2013) trebaju se provjeriti značajnosti faktorskog opterećenja. Mjerne varijable koje imaju ne značajne težinske vrijednosti, ali značajna faktorska opterećenja su apsolutno važna, ali ne i relativno važna. Međutim, formativni pokazatelji se nikada ne odbacuju samo na temelju statističkih rezultata. Ukoliko postoji osnova za mjernim varijablama na osnovu prijašnjih istraživanja i na temelju teorija, mjerne varijable bi trebale biti zadržane u modelu (J. F. J. Hair et al. 2013, str. 127-130,158), što je bio slučaj kod nekoliko mjernih varijabli IMISS modela.

Nakon analize mjernog modela na prvoj, drugoj i trećoj razini uslijedila je analiza unutarnjeg modela odnosno strukturnog modela. Analiza strukturnog modela uključivala je provjeru postojanja kolinearnosti, izračun koeficijent determinacije, veličinu i značaj koeficijenata puta, prediktivni značaj i veličinu učinka. Rezultati su pokazali da ne postoji kolinearnost kod IMISS modela u oba slučaja (koeficijent tolerancije > 0.20 i koeficijent inflacije varijance < 5). Validacijom strukturnog dijela modela potvrđena je signifikantnost svih postavljenih veza u IMISS modelu u oba slučaja. Analizom rezultata utvrđena je pozitivna veza između dimenzije *kvaliteta informacijskog sustava* i dimenzije *kvaliteta korisničkog iskustva*, te se pri tome utvrdilo da dimenzija *kvaliteta informacijskog sustava* objašnjava 35,60% varijance dimenzija *kvaliteta korisničkog iskustva* mobilne igre *Ingress*, te 49,80% varijance dimenzije *kvaliteta korisničkog iskustva* mobilnog sustava *VarazdinAR*. Dalje, potvrđene su pozitivne veze između dimenzije *kvaliteta informacijskog sustava* kao i dimenzije *kvaliteta korisničkog iskustva* s dimenzijom *individualne dobiti*. Ove veze objašnjavaju 58,80% varijance dimenzije *individualne dobiti* u slučaju mobilne igre *Ingress* te 60,50% varijance u slučaju mobilnog sustava *VarazdinAR*. Također je potvrđena pozitivna veza između dimenzije *individualne dobiti* i dimenzije *namjera ponovnog korištenja*, pri tome se utvrdilo da dimenzija *individualne dobiti* objašnjava 24,70% varijance dimenzije *namjera ponovnog korištenja* mobilne igre *Ingress*, te 40,40% varijance dimenzije *namjera ponovnog korištenja* mobilnog sustava *VarazdinAR*. Rezultati su pokazali da u slučaju hedonističkog sustava namijenjenog igranju dimenzija *kvaliteta korisničkog iskustva* ima veći utjecaj na dimenziju *individualne dobiti* od dimenzije *kvalitete informacijskog sustava*. Dok u slučaju mobilnog sustava namijenjenog istraživanju informacija kao što je turistički vodič, dimenzija *kvalitete informacijskog sustava* ima veći utjecaj na dimenziju *individualne dobiti* od dimenzije *kvaliteta korisničkog iskustva*. Rezultati su pokazali da IMISS model također ima prediktivne mogućnosti.

Krajnji cilj u društvenim znanostima je pronaći modele koji su dobri u objašnjavanju podataka, modele s visokim R^2 i modele koji su skromni, tj. modele koji imaju mali broj egzogenih konstrukata. Kako bi se pokazale prednosti predloženog IMISS modela naspram DeLone i McLean modela uspješnosti informacijskih sustava u slučaju interaktivnih mobilnih informacijskih sustava korištenih na osobnoj razini i za osobne potrebe, na istom skupu podataka analizirana su ova dva modela. Rezultati su pokazali da ažurirani DeLone i McLean model uspješnosti IS objašnjava 22.00% varijance endogene varijable *individualne dobiti* u slučaju mobilne igre *Ingress*, a 33.10% varijance endogene varijable *individualne dobiti* mobilnog vodiča *VarazdinAR*. Kako bi usporedba dva modela bila pravedna, korištena je prilagođena mjera koeficijenta determinacije R^2 (R^2adj) za novi IMISS modela. Prilagođena mjera R^2 (R^2adj) novog IMISS modela objašnjava 58.04% varijance endogene varijable *individualne dobiti* u slučaju mobilne igre *Ingress*, a 59.77% varijance endogene varijable *individualne dobiti* mobilnog vodiča *VarazdinAR*. Usporedbom eksplanatorne moći (R^2 vrijednosti) ova dva modela, može se zaključiti da novi IMISS model ima više eksplanatorne moći u objašnjavanju i predviđanju dimenzije *individualne dobiti* (dobiti na osobnoj razini) nego ažurirani DeLone i McLean IS model uspješnosti. IMISS model kroz dimenziju *kvalitete korisničkog iskustva* nudi bolje razumijevanje veza između *kvalitete informacijskih sustava* i percipiranih *individualnih dobiti*. Na temelju rezultata ove usporedbe osigurana je osnova za prihvaćanje druge hipoteze istraživanja.

Ukratko, ključni znanstveni doprinosi ove disertacije su: (1) analiza i sistematizacija relevantne znanstvene literature o informacijskim sustavima i literature o interakciji čovjeka i računala; (2) identifikacija dimenzija uspješnosti interaktivnih mobilnih informacijskih sustava; (3) uvođenje dimenzije kvalitete korisničkog iskustva u model uspješnosti informacijskog sustava; (4) uključivanje hedonističkih ishoda pored utilitarnih u dimenziju dobiti na osobnoj razini; (5) razvoj pouzdanog i valjanog instrumenta (upitnika) za mjerenje uspješnosti na individualnoj razini upotrebe i (6) razvoj pouzdanog i valjanog višedimenzionalnog modela uspješnosti interaktivnih mobilnih informacijskih sustava. Razvijeni instrument uspješnosti, zajedno s modelom uspješnosti, predstavlja vrijedan alat koji služi znanosti i praksi. Znanstvenici mogu koristiti ovaj model i mjerene čestice kao teorijske osnove za slična istraživanja ili za procjenu uspješnosti drugih nadolazećih osobnih interaktivnih sustava, kao što su fitness i zdravstveni sustavi, sustavi za pametne vožnje i navigaciju, itd. Disertacija osim vrijednih znanstvenih doprinosa, ima nekoliko praktičnih doprinosa za industriju. Koristeći novi razvijeni model, pružatelji mobilnih informacijskih sustava imaju mogućnost da na praktičan način procjene uspješnosti svojih proizvoda u fazi korištenja, te time mogu dobiti uvid u odrednice uspješnosti svojih proizvoda. Na temelju informacija o uspješnosti, pružatelji informacijskih sustava mogu uvidjeti trenutne prednosti i nedostatke razvijenog sustava te mogu planirati i prilagoditi strategiju budućeg razvoja kako bi osigurali adekvatnije rješenje za korisnike. Primjenom ovog modela kao standardiziranog mjernog modela uspješnosti mogu se identificirati razine i razlozi uspješnosti sličnih rješenja mobilnih informacijskih sustava. Pružatelji usluga mogu koristiti ove informacije kao dokaz kvalitete proizvoda koje nude svojim korisnicima, a korisnici s druge strane mogu odabrati sustave na temelju rezultata analize uspješnosti sustava. Svi postavljeni ciljevi istraživanja su ostvareni.

Ključne riječi: *interaktivni mobilni informacijski sustavi, DeLone i McLean model uspješnosti informacijskih sustava, kvaiteta informacijskog sustava, kvaliteta korisničkog iskustva, individualne dobiti, namjera ponovnog korištenja, interaktivni sustavi s proširenom stvarnošću*

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1. INTRODUCTION

The current IT market provides variety of ways to access information, from personal computers to different portable devices, e.g. smartphones, smart watches, smart goggles, smart bracelets, etc. The technology is becoming more mobile and, ubiquitous, and the mediums are becoming richer and more interactive. Information systems are not used just in office/work contexts anymore, but have also pervaded every aspect of our personal and social life. Information systems have become a highly interactive, interconnected and important part of our everyday life even when we are on the move (anytime and anywhere). The rapid technology advances are changing the ways in which we interact with technology (van Wassenhove, Grant, and Poeppel 2005). PCs are only one of the many ways we access information resources and services today. The boundaries between office and home contexts of use have become blurred and we continue to carry computers in our pockets, in our car, and even in our clothes long after working hours (Yoo 2010). We use information technology to find the *information* we are interested in (news e.g. Internet portal – *Cnet.com*, word translation – *Google translate* etc.), to make *transactions* (orders and payments for goods *Amazon.com*), for *communication* (with family and friends – *Facebook*) or to *entertain* ourselves (playing *Angry birds*).

With the advancements in technology, the consumers' awareness is also changing. Today's market is driven by the consumers, and marketers have to offer more than just basic functionalities in order to attract and keep consumers (Ortbach et al. 2013). Many researchers advocate that the main route to reach long-lasting competitive advantages on the market is to place stronger focus on the consumer, i.e. to expand the consumer centric approach (Gentile, Spiller, and Noci 2007). Companies have become aware that designing products and services is not enough, whereas designing for consumer experiences is the next level of competition (Väänänen-vainio-mattila, Roto, and Hassenzahl 2008). Consumers do not seek just the utilitarian value of consumption anymore (functional and instrumental benefits), but also seek the hedonic value of consumption (emotional, experiential, and enjoyment-related benefits) (Chitturi, Raghunathan, and Mahajan 2008).

There aren't many IS/IT studies that take into account the fact that the majority of our everyday activities have become digitally mediated and that we now use technology to fulfil our personal and social goals. The IS/IT industry is currently lacking an appropriate success evaluation tool that will explain and report the success of these modern interactive mobile information systems which are used voluntarily and at the individual level. More than twenty years ago, American information system management professors William H. DeLone and Ephraim R. Mclean proposed the information system success model in order to support the success measurement of organizational information systems. Since then, many researchers have tested, extended and challenged this model in various organizational contexts (e/m-banking, e/m-commerce, e-government, e-learning etc.). This model still continues to provide an adequate explanation for understanding individual and organizational benefits of utilitarian information systems. However, as information systems have evolved and become highly interactive, mobile, and used not just in work related contexts but for personal and leisure purposes as well (more than ever before), this model may not have sufficient explanatory power to explain or predict the success of modern interactive mobile information systems that are used in everyday life of individuals. Therefore, the main goal of this study is to expand and reconceptualise the updated DeLone and McLean IS success model in order to measure the success of interactive mobile information systems at the individual level of use. More precisely, this study will suggest improvements of the DeLone and McLean IS success model by integrating the *user experience quality* construct as an intermediate success dimension between the *information system quality* dimension and the *individual benefits* dimension (individual impacts).

The thesis is organized as follows. Chapter 2 provides overview of basic concepts such as information technology, information systems, interactive systems, information systems evaluation and user experience. A description of how these fields evolved over time is provided and the current state of the art is presented. Chapter 3 presents the methodology of the thesis. The research steps in this thesis have been carried out by following the design science research methodology. In Chapter 4 the main research problem of the thesis is presented along with the objectives of the study. In the next section (Chapter 5) the solution of the presented problem is proposed and the hypotheses of the study are stated. Chapter 6 deals with the development of the measuring instrument questionnaire and the development of the conceptual model. Chapter 7 deals with the evaluation of the measuring instrument and the evaluation of the conceptual model. Two mobile augmented reality systems are employed for this purposes. The summary of contributions and the limitations of the study are presented in last section.

2. LITERATURE REVIEW

21st century brought many changes in how and when we use technology. Majority of our today's activities has become digitally mediated. There are thousands even millions of personal information systems aimed to improve the quality of our everyday life activities. The literature review of relevant work on the view and progress of information systems is presented in following subchapters.

2.1 Information Technology and Information Systems

People usually do not distinguish the terms *information technology* (IT) and *information systems* (IS). However, there is an important difference between these two terms. According to Kroenke (Kroenke 2011) information technology refers to the products, methods, inventions, and standards that are used for the purpose of producing information. Information technology present technological solutions that enable users to produce, transmit and manipulate the information (Watson 2007). Technology can basically be paper and pen, but with its development we now use information technology products such as hardware, software and telecommunication equipment to capture, process, store and distribute information (Watson 2007), (Kroenke 2011).

Information system is a broader concept. A person cannot buy an information system, just information technology (Kroenke 2011). Information system (IS) exist even without information technology (IT). Information systems include information technology but they are not purely concerned with technology. Instead, they are more oriented towards the end use of information technology (van Twist 2014). People in general use output of IS i.e. *information* to make better decisions, in both professional and private contexts. People are the key component of information systems. IS is what emerges from usage and adaptation of IT by people (Paul 2007). People's use of information technology in specific ways forms an information system. Every system needs *people* in order to be useful (STEGĂROIU and STEGĂROIU 2014). Petter et al. (2012) define information systems as systems that communicate processed data into a relevant form for *users* who need the information to make decisions or take action (Petter, DeLone, and McLean 2012). "*These users may be using the information to make a decision to improve an organization, to take action to positively impact society, or for entertainment"* (Petter, DeLone, and McLean 2012). When raw facts, dates and figures are shaped into a form that is meaningful and useful to *people (users)* then we talk about *information* (Laudon and Traver 2011). For example, if we have data sets containing latitudes and longitudes of illegal acts of a city in last five years (bicycle thefts, robberies, speeding, etc.), analysing the data the city managers can get meaningful information about the critical areas in the city and plan adequate strategies of police patrol or where they need to invest in new traffic lights implementation, street illumination, etc. Computers and related software programs present the technical foundation, i.e. the tools and materials of modern information systems (Laudon and Traver 2011).

In order to consider something an information system, three main activities should be involved (Laudon and Traver 2011): *input*, *processing* and *output*. *Input* captures or collects raw data. *Processing* converts this raw input data into a meaningful form i.e. *information*. Then *output* transfers the processed information to the people who will use it. These activities are present in every IS from most complex to the most simple ones. Kroenke (Kroenke 2011) states that today in information sciences, the term *information system* implies "*an assembly of hardware, software, data, procedures, and people that produces information*" (Figure 1). These five components are present in every information system, e.g. in the contacts application of an iPhone device, or in an enterprise resource planning system (Kroenke 2011).

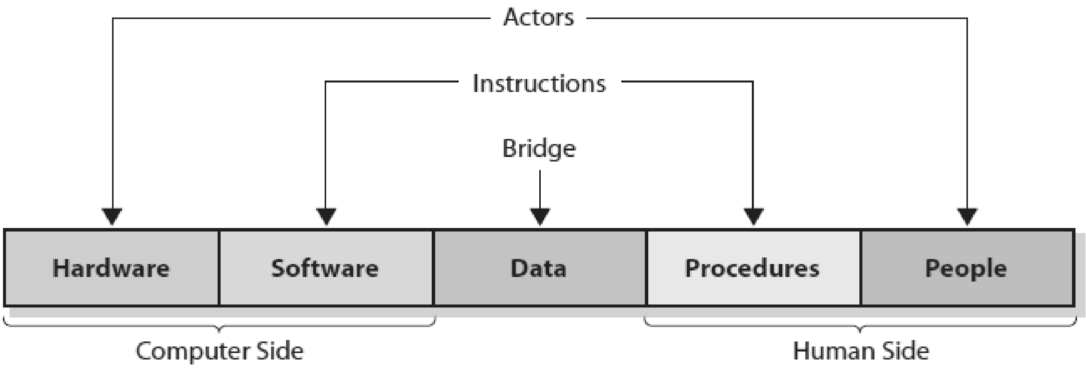


Figure 1 Five components of an information system
Source: (Kroenke 2011, p. 10)

Information systems are not just sum of parts i.e. technology, information and people but a synergetic whole that is results of symbiosis of these parts (Baskerville 2013). Information system as a discipline connects *computer science* (discipline studying hardware, software design and algorithmic process) with the study of *how* to achieve the delivery and *what* value IT delivers to the end users in their contexts of use.

2.2 *Information Systems Then and Now*

Petter et al. (2012) conducted a literature review of the past IS studies and organized information system research and evaluation into five eras (Petter, DeLone, and McLean 2012): (1) data processing era (1950-1960), (2) management reporting and decision support era (1960-1980), (3) strategic and personal computing era (1980s-1990s), (4) enterprise system and networking era (1990s-2000s) and (5) customer-focused era (2000 onwards). A short description of each era based on their extensive report is presented in the following sub-chapters.

2.2.1 Data Processing Era

The *Data Processing Era* was present from 1950s till 1960s. Then computers were mainly used as sophisticated calculators in military and in financial industry. Information systems were used to complete certain tasks and to automate processes. Implementation of IS at that time did not affect management, instead it affected a small number of highly trained computer knowledgeable individuals who were prepared to use IS for specific jobs. At this time measurement of information systems success were mainly oriented on technical qualities of the systems such as speed and accuracy.

2.2.2 Management Reporting and Decision Support Era

The *Management Reporting and Decision Support Era* characterises period from 1960s till 1980s. Computing technology was mainly used for monitoring processes, controlling production and for work automatization. The output of the information systems from this era ware structured information that were used for making routine decisions. More people than in previous era become affected by the information system use. Managers could use information system reports to make better decisions. During this era the researchers realized that human factor, besides technical qualities, is also important when evaluating the information system success. Other measures of success that the researchers used were the use of the system itself and the effects it had on cost reduction.

2.2.3 Strategic and Personal Computing Era

The *Strategic and Personal Computing Era* characterises the period form 1980s till 1990s. The organizations have become aware that usage of information systems by more employees could increase the value for the company. Computers were moved from the back-offices to the front-offices. During this era both individuals and organizational impacts became important. The researchers were divided in their opinion about the best way to measure the information system success. One way to measure IS success was by focusing on goal achievement specified by managers and the other was oriented towards the fulfilment of the users' needs such as communication facilitation, improvements in job satisfaction, etc. Practice was more oriented towards the operational performance (system availability, user problem reports, IS operations costs) and development performance (project management, on-time completion, user acceptance, post implementation audits). During this era, technology acceptance model proposed by Davis (1989) was also used to see how individuals perceive IS and the way they accept some IS more readily than others. DeLone and McLean summarized the findings from previous eras and proposed IS success measurement framework which consists of six dimensions (explained in Chapter 2.8.).

2.2.4 Enterprise System and Networking Era

The *Enterprise System and Networking Era* characterises the period from 1990s till 2000s. Within this era different types of systems (transaction processing systems, decision support systems, and management information systems) that originally worked in isolation became more sophisticated as *enterprise systems* which connected these disparate information systems across departments and organizations. Networks and client-server computing changed how individuals and organizations accessed information from IS. Data cloud ceased to be isolated in a single machine or with a single individual. Instead it started to be shared among applications and managers in order to improve collaboration among individuals, groups and organizations. Most popular systems within this era are *enterprise resource planning* (ERP) systems. In order to evaluate the success of these systems, some researchers used DeLone and McLean IS success model while others used the Kaplan and Norton's Balanced Scorecard approach or other similar organization focused approach. In this era, practitioners were more oriented towards the evaluation of the process of system developments i.e. project quality. They wanted to find out whether the project is on the time and within the budget and meets functionalities rather than focusing on the benefits provided by the finished product, i.e. to measure the value the system provides to the organization.

2.2.5 Customer-Focused Era

The *Customer-Focused Era* started beginning of 2000s and it is still present. Customers interact with information systems directly (order products, track shipments, and receive customer service) even without making any direct contact with employees of a firm.

Information systems are used not only by managers and employees of a firm but also by customers and suppliers. Information systems offer personalized experiences to IS users based on their preferences, interests and roles. A major change is that IS success can be now studied in two directions: systems for work that affect employees and systems for pleasure that affects customers. In this era, IS success measurement is more complex, and systems must create value (success) for the customers (users) and the company (i.e. IS providers) simultaneously. The value should be measured from the customer perspective and from the organization perspective. Information systems become more personal and customized, therefore the measures of IS success should also be adopted to meet and capture these changes. Prior the web sites and mobile devices were primarily used in a business context, but now they have become more consumer-friendly and available to all users (Middleton, Scheepers, and Tuunainen 2014). The prime purposes of information systems is no longer just utilitarian, but systems have enjoyment for the users as their purpose as well (Petter, DeLone, and McLean 2012). Methods that have been used for IT/IS evaluation (IT/IS success) are all still relevant in the customer-focused era; but the context and metrics related to these factors have changed over time (Petter, DeLone, and McLean 2012).

2.3 *Information Systems by Scope*

Information systems were primarily implemented and organized within organization. Therefore many categorizations of IS are related to the workflows of organization. However, with emergence of PCs and portable device (e.g. laptops, smartphones and tablets) that are adopted by individuals for their own personal usage the scope of IS have been broaden. Within next few sub-chapters the different classifications of IS are presented.

2.3.1 Organizational IS

In their early stages, computers were mainly used within businesses. At that time classification of information systems was based on the hierarchical/pyramidal management structure of the organization they support. One of the pioneers of such classification was the Anthony's Triangle (Figure 2) which includes three types of information systems according to three organizational levels (J. K.-K. Ho 2015): (1) operational level – *transaction processing systems*; management level – *management information systems* and strategic level – *decision support systems*.

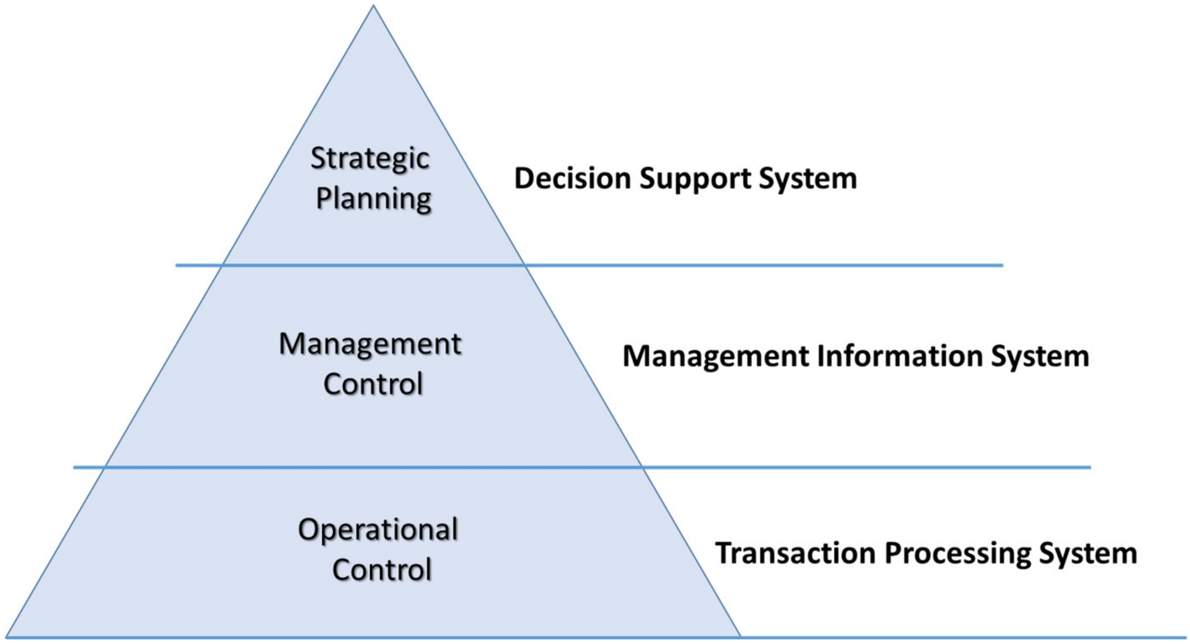


Figure 2 Classification of Organizational Information Systems based on Anthony's Triangle
Source: Adopted from (J. K.-K. Ho 2015)

Although the pyramidal/hierarchical view of IS use in organization is still useful, a large number of new information systems emerged, in which some do not fit perfectly into the original organizational IS idea (Correia et al. 2013). Laudon and Traver (2011) extend this classification by adding at the *executive support systems and systems for business intelligence*. In continuance, descriptions of the previously mentioned systems will be provided.

(1) *Transaction Processing Systems TPS* – These systems are used by operational managers in order to keep track of the elementary activities and transactions of the organization (e.g. sales, receipts, cash deposits, flow of materials in a factory etc.). At this level, tasks, resources, and goals are predefined and highly structured.

(2) *Management Information Systems MIS* – These systems help middle management in process of monitoring and controlling the business and predicting future performance. The transaction data from *Transaction Processing Systems* are compressed and usually presented in reports that are produced on a regular basis. *Management Information Systems* generally are not flexible and have little analytical capability, and use simple routines, such as summaries and comparisons.

(3) *Decision-Support Systems (DSS)* – These systems support managers in non-routine decision making processes. Here, the focus is on problems that are unique and rapidly changing, and there are no predefined procedures for achieving the solution. Besides information from *Transaction Processing Systems* and *Management Information Systems* they use information from other external sources and use a different decision models to analyse the data. All management roles need systems that can help them with *monitoring*, *controlling*, *analysing*, and *decision-making*.

(4) *Executive support systems (ESS)* – These systems help senior management in decision-making process. Most of the time managers have to address non-routine decisions which requires thoughtful evaluation, judgment, and insight before making a conclusion. As input they use data from *Decision-Support Systems* and *Management Information Systems*, and other external sources. The outputs of these systems are graphs and data from many sources. Such systems include *business intelligence analytics* for analysing trends, making forecasts, or performing data mining at greater levels of detail.

In order to get all of the different kinds of organizational systems to work together companies use *Enterprise Systems* (Laudon and Traver 2011). These enterprise systems integrate a related set of organizational functions and business processes to enhance the performance of the organization as a whole. They help businesses to be more flexible and productive by connecting processes from different departments and focusing on the efficient management of resources and customer service. Laudon and Traver (Laudon and Traver 2011) define following four main enterprise systems:

(1) *Enterprise resource planning* (ERP) systems – These systems integrate business processes from different organizational departments (manufacturing and production, finance and accounting, sales and marketing, and human resources) into one single software system. Here information is not fragmented across different systems but is instead stored in a single comprehensive data repository, where it can be used by many different departments of the organization.

(2) Supply Chain Management Systems (SCM) - These systems help suppliers, purchasing firms, distributors, and logistics companies to share information about orders, production, inventory levels, and delivery of products in order to better manage these information flows. The ultimate aim of these systems is to improve efficiency of companies by enabling managers to better organize and schedule sourcing, production, and distribution of products and as well of lowering the costs of moving and making products.

(3) *Customer Relationship Management Systems* (CRM) – These systems help managers to manage their relationships with their customers. They provide the right information to departments that deal with sales and marketing, and offer a service to optimize revenue, customer satisfaction, and customer retention. Companies with the information from these systems can more easily identify, attract, and retain the most profitable customers, and provide better service to existing customers, and consequently increase sales (Laudon and Traver 2011).

(4) *Knowledge Management Systems* (KMS) – Most of the time, company's knowledge is unique and difficult to imitate so these type of systems help organizations collect relevant knowledge and experience, organize it according to the importance and make it available to all relevant stakeholders whenever they need it.

Kroenke (2011) used a different approach to group organizational IS. According to him organizational IS can be grouped in four groups (Kroenke 2011): *personal IS*, *workgroup IS*, *enterprise IS* and *interenterprise IS*.

(1) *Personal (individual) IS* are type of information system which are used by a single individual. These type of systems have only one user and their procedures are simple and usually not documented or formalized in any way.

(2) *Workgroup IS* is an information system that is used to support communication and collaboration of a group of people for a particular purpose. They are formed to facilitate commons activities that involve more people (teams, departments, committees etc.) that are either locally or globally situated.

(3) *Enterprise IS* are information systems that support business processes and workflow of an organization. They typically have hundreds to thousands of users. These type of systems are very complex and in order to use the system users undergo formal procedure training (e.g. SAP ERP). The system procedures are formalized and extensively documented.

(4) *Interenterprise IS* are information systems that support business transactions and communication between two or more independent organizations. These type of systems typically involve thousands of users. In order to perform some activity (e.g. purchasing) they require cooperation among different, usually independently owned, organizations (Kroenke 2011).

Today many organizations transfer their operations to the Internet and perform their main processes via world-wide digital network. We very often encounter terms such as *e-business*, *e-commerce* and *e-government*. *E-business* is a term used to describe businesses that use the Internet and digital technology to support the organizational internal management, coordination with suppliers and other business partners. *E-commerce* is a part of e-business and deals with buying and selling of goods and services via the Internet, and includes all related supporting activities such as marketing, customer support, delivery, payment, etc. Governments now also implement Internet technology to support the communication between citizens and relevant governmental departments. *E-government* empowers citizens by giving them easier access to information and the ability to communicate and network electronically with other citizens.

Over 100 million business professionals use systems such as Google Apps, Google Sites, Microsoft's Windows SharePoint Services, and IBM's Lotus Connections to support blogs, project management, online meetings, personal profiles, social bookmarks, and online communities (Laudon and Traver 2011). Successful managers' have to keep up with technological advances, and adopt online collaboration and social networking systems in order to improve communication, collaboration, coordination and knowledge sharing. Web-based services enable employees to interact with clients using blogs, wikis, e-mail, and instant messaging services. Source of business value shifted from offering products to offering solutions, and even offering experiences simultaneously shifting from internal sources to networks of suppliers and towards collaborations with customers (Laudon and Traver 2011).

2.3.2 Geographic IS

Geographic IS (GIS) is a system that works with geographic information, i.e. positional data related to the Earth's surface, and enables us to understand the world around us by seeing where things are, or should be. They integrate hardware, software, and visualization of all forms of geographical information relevant to the user of the system. United States Geological Survey defines GIS as "a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information (that is data identified according to their locations)" (United States Geological Survey 2007). GIS have been studied and used since 1960's. They have long tradition and multiple applications in the industry, science and education.

Peuquet and Marble define GIS through four subsystems (Peuquet and Marble 2003): (1) *data input subsystem* collects and/or processes spatial data derived from existing maps, remote sensors, etc.; (2) *data storage and retrieval subsystem* organizes the spatial data in order to make them retrievable by the user for subsequent analysis, as well as to permit rapid and accurate updates and corrections of the spatial database; (3) *data manipulation and analysis subsystem* performs a variety of tasks such as changing the form of the data through user-defined aggregation rules or producing estimates of parameters and constraints for various space-time optimization or simulation models; (4) *data reporting subsystem* is capable of displaying all or a part of the original database as well as manipulated data and the output from spatial models in tabular or map form.

GIS technology utilizes two basic types of data to create information and to facilitate analysis: (1) *spatial data* which describe the absolute and relative location of geographic features, refer to the real-world geographic objects of interest, such as streets, buildings, lakes, and countries, and their respective locations; (2) *attribute data* which describe quantitative and/or qualitative characteristics of spatial features, such as a name, number of stories, depth, or population. Spatial data can be stored and presented on a map in one of the three basic types: *vector*, *raster*, *image* (Peuquet and Marble 2003). The key geographic concepts in GIS according to the Campbell and Shin (Campbell and Shin 2012) are: (1) *location* – the position of an object on the surface of the Earth and is commonly expressed in terms of latitude and longitude; (2) *direction* – the position of something relative to something else usually along a line; (3) *distance* – the degree or amount of separation between locations which is measured in nominal or absolute terms in various units; (4) space – a generic term that is used to denote the general geographic area of interest; (5) navigation – destination-oriented movement through space.

In order to consider something as true GIS the system, it should be capable of storing, editing, processing, and presenting geographic data and information as maps. Some of the big players in GIS are Environmental Systems Research Institute Inc. (http://www.esri.com), with product ArcGIS, and company PitneyBowes (http://www.pbinsight.com), which distributes MapInfo GIS. There is also an open-source GIS initiative GRASS (http://grass.itc.it) which is freely distributed and maintained by the open-source community. Today we have maps on the Internet, on handheld devices, car navigation systems, mobile phones etc. The maps offered by companies like Google, Yahoo!, and Microsoft, are not considered as true GIS platforms, rather as small scaled personal GIS. These maps are highly interactive, colourful, searchable and dynamic, and help individuals to better orient themselves on the Earth's surface by using Global Positioning System (GPS) technology. GPS is based on a constellation of twenty-four satellites that are orbiting the Earth and constantly transmitting time signals. Originally it was developed by the United States Department of Defence for military purposes, but today there are a wide range of commercial, personal and scientific uses of GPS. In order to determine a position of an earth-based GPS units receive signals from at least three satellites from the constellation and use this information to triangulate a location (Campbell and Shin 2012).

A new trend is *geospatial web* or *geoweb* which refers to the integration of the content available on the Internet (e.g., text, photographs, video, and music) with geographic information, such as location. This is called geotagging (Campbell and Shin 2012). Examples of geotagging are map mashups, i.e. web-based applications that combine data and information from one source and map it on an online map service (e.g. restaurants and their position in the city).

2.3.3 Health IS

Hospitals have has hospital information systems from the beginning of their existence. With improvements of information processing tools such as information technology software and hardware, hospitals have looked for new ways how to enhance their performance using these tools. The term *health IS* today generally encompasses computer based information systems used in healthcare settings (Yusof et al. 2008). World Health Organization defined *health IS* (HIS) as information systems that collect different data from health sectors and other relevant departments, analyse the data to ensures their quality, relevance and timeliness, and convert the data into information for health-related decision-making staff (World Health Organization 2008). HIS are used in healthcare organizations in order to support data processing related to the management of the organization (e.g. scheduling, billing, inventory control, statistics calculations etc.) and patient care (e.g. electronic patient record, history data, monitoring data and providing preliminary diagnoses) in order to improve the healthcare service they provide.

HIS can range from simple systems, such as *transaction processing systems*, to very complex systems, such as *clinical decision support systems*. Yusof et al. (Yusof et al. 2008) conducted literature review and classified different types of IS used within health organizations:

(1) *Patient centred information systems* – they mainly contain medical records, appointment scheduling, treatment management and department reporting.

(2) *Administrative information systems* – they record the main business processes and routine transactions of the organization such as patient admission, discharge and transfer, bill processing, reporting and other management activities.

(3) *Clinical information systems* – they offer specialized services of clinical departments such as collection of specific data for patient care, research, management, planning and maintenance of national data repositories.

(4) *Radiology information systems* – they support the acquisition and analysis of radiological images as well as administrative functions of radiology department

(5) *Laboratory information systems* – they perform data validation, administration, electronic transmission and computer storage.

(6) *Pharmacy information systems* – they keep patients' medication records, check prescriptions, and provide drug prescriptions and administration to physicians and nurses.

(7) *Telemedicine* - facilitates exchange between primary care physicians and specialists as well as patients from disperse locations via electronic communications and IT.

(8) *Clinical decision support systems* – they support clinical decision making by alerting, reminding, critiquing, interpreting, predicting, diagnosing, assisting and suggesting.

(9) *Hospital information system* – they support healthcare activities at the operational, tactical and strategic levels.

HIS offer numerous possibilities such as standardization and understandability of clinical information, improvement of information sharing between healthcare professionals, ownership and traceability of information, cost reduction, duplication elimination etc. They are becoming an essential part of planning and decision-making process of every health delivery service.

2.3.4 Hedonic IS

As information systems use have spread outside the organizational boundaries, in IS literature it can be found additional classification of IS on the *hedonic* and the *utilitarian* systems. *Hedonic* IS, are mainly developed for pleasure and enjoyment (e.g. game systems), whereas *utilitarian* IS are developed in order to improve individual and/or organizational performance (e.g. office system). Utilitarian systems provide functional, instrumental value to users, and they aim is to improve individual, group, and organizational productivity (Sun and Zhang 2006). Hedonic systems, on the contrary provide self-fulfilling values to users, and are employed for pleasure and relaxation (Sun and Zhang 2006). The value of a hedonic system is a function of the degree to which the user experiences fun when using the system (Heijden 2004). Mainly these type of system are used in homes or for leisure environments, whereas utilitarian systems are mostly employed in workplace settings, and for utility related purposes (Brown and Venkatesh 2005). Instrumental objective is key driver of utilitarian system usage, such as task performance improvement, while hedonic systems doesn't have this at all as purpose. The interaction with the system can be purpose by itself (e.g. playing games, instant messaging etc.) (Heijden 2004). However, there are also the systems that fulfil both of the purposes hedonic and utilitarian. Systems can have both utilitarian and hedonic aspects, but to different degrees depending on what tasks they are used for (Sun and Zhang 2006). One of such examples is Internet. Users can use Internet to perform various tasks such as searching for a job (*utilitarian*) or simply surf the net for fun (*hedonic*).

The idea about classification of information systems on hedonic and utilitarian came from consumer behaviour literature that distinguishes between utilitarian and hedonic products

(Hirschman and Holbrook 1982). One of the first mentions of the term *hedonic information systems* were in work of Heijden (Heijden 2004). Many studies have found that *perceived usefulness* is the stronger determinant of using utilitarian systems, but this aspect has been less important than *perceived enjoyment* in predicting hedonic system usage (Heijden 2004) (Sun and Zhang 2006), (J. Wu and Du 2012). The main goal of these research streams was that developers of IS should employ inclusion of the hedonic aspects such as multimedia interactive content, aesthetically appealing visual layouts etc. in order to prolong the use or encourage repeated system use.

2.3.5 Individual IS

Individual or *personal IS* is a form of information system. They supply specific information to a single user depending on his/her context of use, situation, taste or needs. They can be used in organizational and outside organizational context for individual/personal goals achievement. Personal information systems in organizational settings are used by employees to improve their work productivity. The key feature of these personal IS is that single individual is responsible for defining the requirements, designing the framework of the system and using it (Kumar 2009). First notation of the term personal IS (PIS) was in bibliographic environment where it was used to describe the process where an individual use technology to collect, annotate, and store bibliographic information according to his own (idiosyncratic) needs and preference (Burton 1981). Moon, in similar context defined personal information systems as a systems for supporting the acquisition, storage and retrieval of information by individuals (Moon 1988). This view was later bordered by Silberschatz and Zdonik where they say that "personal information system [is one that] provides information tailored to an individual and delivered directly to that individual via a portable, personal information device (PID) such as a personal digital assistant, handheld PC, or a laptop" (Silberschatz and Zdonik 1996). PIS are designed to offer an information to specific needs of the consumer whether explicitly stated by them or inferred by the system depending on the information gathered overtime (Nicely and Sankaranarayanan 2013). The main characteristics of personal information systems are that have only one user, procedures are simple and probably not documented or formalized in any way (Kroenke 2011). Mostly they include using computers with software applications such as word processing, electronic spreadsheets, graphics and presentation applications, organizing applications, e-mail applications etc. The greater use of these systems for personal activities started beginning of 1990s with mass availability of

Windows 3.x and Windows 9.X operating systems with different utility applications for personal uses and with Internet Explorer application for web browsing. Today, more and more individuals using portable computers such as laptops, smartphones, tablets etc. with different software applications in order to fulfil their professional or personal goals.

Baskerville (Baskerville 2011b) used term *individual information systems* instead of the term *personal information system*, in order to not confuse it with IS that deals with personal data. He used information systems theory as a platform for design theorizing of the individual information systems and defined individual information systems as “an activity system in which individual persons, according to idiosyncratic needs and preferences, perform processes and activities using information, technology, and other resources to produce informational products and/or services for themselves or others” (Baskerville 2011b). The activity system presents any human activity that is supported with technology. Or in other words, an individual information systems serve individuals with information for their personal leisure and/or business needs, and perhaps extend to the individual’s home and family (Baskerville 2011b). Today we use simple and more complex IIS or switch between them based on our needs and context of use. The contact manager on a smartphone device (e.g. iPhone) or in on an email account is an example of a simple personal/individual information system (Kroenke 2011). Whereas the use of multiple desktop machines and laptops, smart phones, printers, scanners, and fax machines networked at home into a local area network (LAN) is an example of more complex IIS (Figure 3). The individual usage of IT devices has evolved into more complex framework beyond the boundaries of personal computing alone. This IIS has become a purposefully accumulated set of services that support definite information requirements. Baskerville presupposes that IIS may be an extremely large, undiscovered, arena for future IS research (Baskerville 2011b).

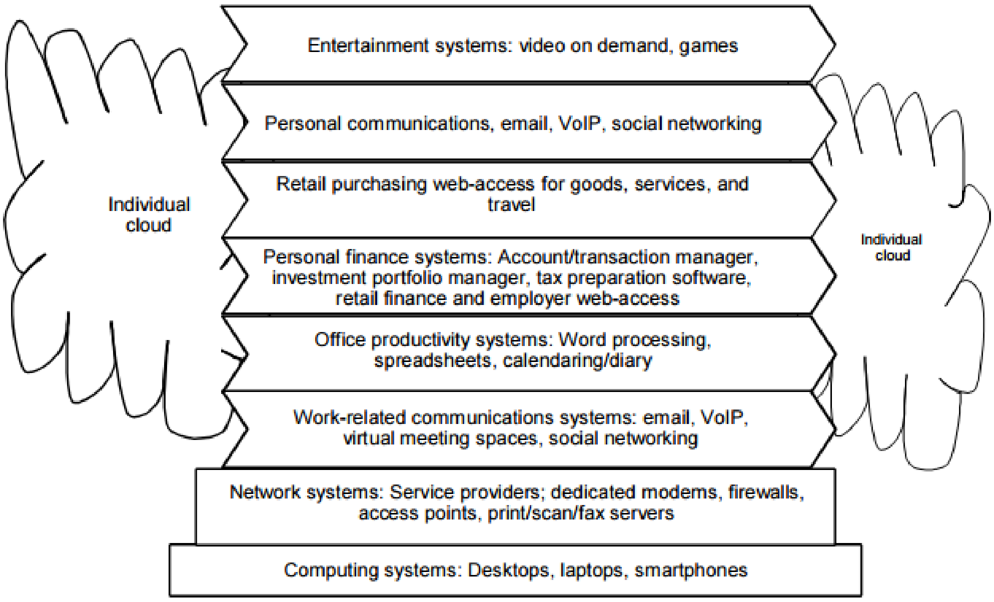


Figure 3 Example of Individual Information System Architecture
Source: (Baskerville 2011a)

2.3.6 User Generated IS

Traditionally the information systems were created by skilled technical professionals. However, today ordinary users are integrating different technological solutions in order to create new value for themselves. IS users are no longer just consumers, but as well contributors and creators. In IS literature one more type of IS can be found, so called *user-generated information systems* (UGIS). UGIS are systems where users are "proactively integrating data and services to create their own novel and personal information systems" (DesAutels 2011). Social media is example of user generated information system which integrates social networking sites, Web 2.0 tools and other technologies to provide unique value to the user (Wolf, Sims, and Yang 2015). Consumers are able to access applications and to enter their data and parameters to adapt the information service to their own contexts.

DesAutels (DesAutels 2011) reported one simple example of UGIS: "*Bob's phone beeps; a reminder flashes on the screen. He pauses the TV show he's watching on his Notebook. It's time to pick up Bella, his girlfriend, from the airport. Heading out to the car, Bob checks Bella's flight status from his phone. It's on time - great! Next, he jumps over to the Google Map app and checks traffic: it's bumper to bumper on the highway - not great! With the Navigon GPS app, he dynamically routes around the traffic jam. Having arrived earlier than expected at the airport, Bob heads over to a short-term parking lot where he fills time by watching the TV episode he paused earlier, utilizing the Netflix app. A text message arrives;*

Bella is just getting off the plane. Argh! He was supposed to make dinner reservations: it is Bella's birthday. No problem; a quick check on the Yelp app highlights a good place nearby. Reservations are simple, using the OpenTable app. With that restaurant address in the GPS app, Bob picks up Bella as she exits the terminal and whisks her off to a romantic dinner. In the course of an hour, Bob has saved his relationship by creating a complex logistics and entertainment information system, adding elements as needed to meet changing requirements. And, he did it all with no formal technical background." (DesAutels 2011).

According to DesAuthels (2011) *user-generated information system* can be defined "as set of component services, integrated by the user into a novel configuration such that the resulting information service is (1) qualitatively different from its components and (2) offers unique value to the user over and above the value of its inputs" (DesAutels 2011). In order to successfully enable UGIS these components need to be open, interconnected, and interoperable.

2.3.7 Mobile IS

Computer based IS are no longer limited to fixed, stationary settings. The IS are evolving as technology and application areas for IS evolve (Andersson and Henningsson 2010). Mobile computing extends the IS use regardless of user location and enables new ways of performing personal or professional activities. It covers devices, from mobile phones, to small laptop computers, palmtops, personal digital assistants (PDAs), e-book readers and tangible and wearable computing (Benyon 2010). The terms "*mobile*" and "*mobility*" come from the Latin word *mōbilis*, which generally means *to move* (Basole 2004). Pernici defined mobile information systems as "information systems in which access to information resources and services is gained through end-user terminals that are easily movable in space, operable no matter what the location, and, typically, provided with wireless connection*"* (Pernici 2006). Similar definition can be found in the work of (Krogstie et al. 2004), (Michael Er and Kay 2005), (Nicely and Sankaranarayanan 2013). Key aspects of mobile IS are *anytime* and *anywhere* use. Anytime refers to access whenever the user needs a certain service or information, whereas anywhere describes the opportunity to access the IS without restrictions to a certain location (Andersson and Henningsson 2010). The advantage of mobile IS is their ability to provide new value-added services due their mobility and flexibility with respect to the context of use (Pernici 2006). The concept of *mobility* is usually studied from *social* and *technical* perspective (Basole 2004). The first one is oriented towards issues of movement of people, objects, and work in terms of place, space, and time, and the second is focused on analysing the design, use, and functionality of IT. Mobile devices enable mobile IS by providing users with powerful, multifunctional computing capacity wherever they want (Middleton, Scheepers, and Tuunainen 2014). Mobile information systems may support different degrees of mobility (Pernici 2006): (1) *fixed* – where user always accesses the system from the same location and device; here mobility is not present; (2) *nomadic* – where users can access the system from different places, using different devices. Here during the interaction, the location does not vary; (3) *mobile* – where users move during their interaction with the mobile information system.

According to Kim and Ammeter (Kim and Ammeter 2014) personal information system within mobile context is an information system that is equipped with mobility, accessibility, personalization, and localizability to support the communication, information, transaction, and entertainment tasks of an adopter. They have proposed three key elements of personal mobile information systems (Kim and Ammeter 2014): user, personalization engine and task. *User* is the subject that is using the personal information system in his/her daily life. *Personalization engine* is an artefact that has an understanding of the user. It has features of the mobility, accessibility, personalization, and localizability. *Task* is a goal-directed activity performed by a user. They have categorized different kind of activities user performs in four groups: communication, information, transaction, and entertainment.

The advantage of mobile information systems is their ability to provide new value-added services owing to their mobility and flexibility with respect to the context of use (Pernici 2006). Kakihara and Sorensen (Kakihara and Sorensen 2002) suggest expanding the concept of mobility by looking at three interrelated dimensions of human interaction; *spatial*, *temporal* and *contextual* mobility (Table 1). Spatial mobility is primarily oriented towards users, i.e. people moving in space, having access to information and services. However, it can also relate to all sort of things in the environment. Temporal mobility represents the consequences of spatial mobility, as in speeding up and saving time. It explain how freedom from linear "clock" time, enabled by mobile ICT is affected by social and cultural dimensions of time that determine how and when it is acceptable to interact with others. This leads to a complex social environment where monochronicity (where people only focus on one activity at a certain time) and polychronicity (where people deal with several things at the same time) of interaction among humans are intertwined and renegotiating with each other. Spatial mobility mainly concerns questions of "where", and temporal mobility answers to questions of "when". In context human action is inherently situated and it frames and is framed by his or her performance of the action recursively. Such context is critical for capturing the nature of interaction. Contextuality in which the action occurs is of equal importance in organizing human interaction besides to spatiality and temporality. Aspects such as "in what way", "in what particular circumstance", and "towards which actor(s)" the action is performed constitute the critical disposition of interaction just as the aspects "where" and "when" (Kakihara and Sorensen 2002).

Table 1 Three Dimensions of Mobility and Extended Perspectives

Dimensions of mobility	Aspects of interaction	Extended perspectives
Spatiality	Where	*Geographical movement of not just human but objects, symbols, images, voice, etc.*
Temporality	When	- *Clock time vs. Social time* - *Objective vs. Subjective* - *Monochronicity vs. Polychronicity*
Contextuality	- In what way - In what circumstance - Towards which actor(s)	- *Multi modality of interaction* - *Unobtrusive vs. Obtrusive* - *Ephemeral vs. Persistent* - *Weakly & strongly tied social networks*

Source: (Kakihara and Sorensen 2002)

Krogstie (Krogstie et al. 2004) extends the view of contexts in following: (1) *spatio-temporal context* – it is related to the aspects of time and space, and contains attributes like time, location, direction, speed, track, and place; (2) *environment context* – captures the entities that surround the user, e.g. things, services, temperature, light, humidity, and noise; (3) *personal context* – describes the user state, such as physiological context (information like pulse, blood pressure, and weight) and the mental contexts (mood, expertise, anger, and stress); (4) *task context* – describes what the user is doing with explicit goals or the tasks and task structures; (5) *social context* – describes the social aspects of the user context, and it may, contain information about friends, neighbours, co-workers and relatives and (6) *information context* – is the part of the global and personal information space that is available at the time.

Mobile IS different from traditional information systems in following characteristics (Krogstie et al. 2004):

(1) *User orientation and personalisation* – As mobile IS are usually targeted to a wider user group, user interfaces need to be very simple. Input and output facilities are restricted, there is no keyboard, or it limited, screen-size is small etc., or interaction is based on new modalities such as touch screen, speech recognition etc. Mobile devices need support for individualisation i.e. adaptation for example of user interface to the user's preferences in order for the system to be more usable to the user.

(2) *Technological aspects* – Mobile devices still have limited processors and memory capacity in comparison with today's PCs. Therefore, the first step in design applications form mobile devices should be performance considerations. Second, it needs to support a multi-channel/device approach where the same functionality and information resources are made available across a large range of processing devices. Mobile IS with small interaction devices imply a number of hardware and software limitations that must be taken into account when developing systems and services as well to ensure the accessibility and usability of those systems (Pernici 2006).

(3) *Methodology for development and operations* – Mobile IS developers should strive to use lightweight design techniques and early prototyping approach, and follow some of the development methodologies and user-interface guidelines and standard.

(4) *Security and Other Quality Aspects* – Mobile IS pose new challenges to information systems security. System should offer appropriate level of dependability i.e. to deliver service that can justifiably be trusted.

The mobile technology is not without problems. First and far most important challenges regarding mobile technology are design constraints i.e. the limited screen space, or no screen at all. Other significant technological features include the battery life, limitations on storage, memory and communication ability (Benyon 2010).

More and more business systems are moving from PCs and desktop machines to mobile devices in order to improve the efficiency of their business or to offer more personalized service to their clients (Laudon and Traver 2011). Andersson and Henningsson (Andersson and Henningsson 2010), present the AUDE framework of four entities that are often used in information system development (Figure 4): (1) *application* – a service offering functionality to the user, (2) *user* – a physical individual or another system; (3) *device* – a stationary computer, laptop or a handheld computer; and (4) *environment* – the setting surrounding the user, application and platform. Framework is also valid in mobile context. Application can be mobile in terms of moving between different devices or platforms (portability). Device can have possibility to be carried around. User can be mobile and can use the same resource at different places. User can use technology in stationary setting or in mobile setting (environment), depending on the context.

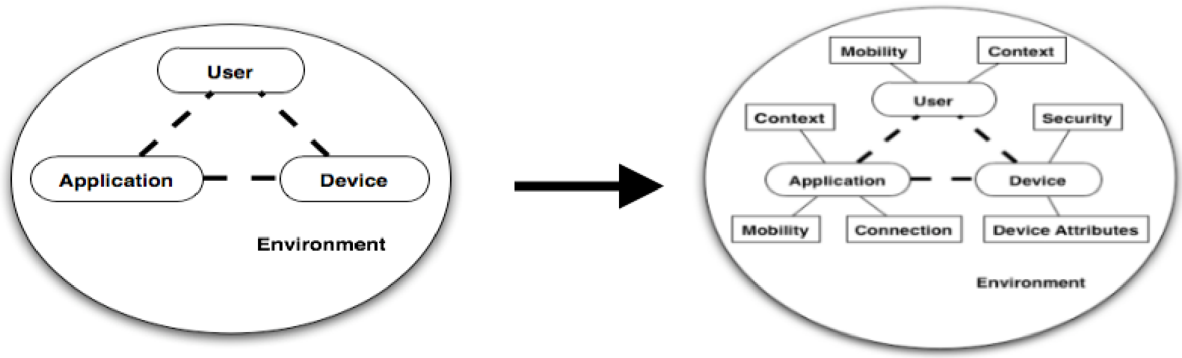


Figure 4 Four Prominent Entities Often Used Implicit in Information System Development
Source: Adapted from (Andersson and Henningsson 2010)

Smartphones and tablet PCs are exemplars of personal mobile information systems that offer users Internet access, telephony, entertainment, and productivity support all in single highly portable devices. Application stores, such as Apple App Store, Google Play, and Windows Phone Store, enable users to find, buy, and install software applications with just a few clicks for their multifunctional devices. On theses application market users can find numerous of non-work related applications aimed to help them in performing different kind of activities like: organizing tasks/files, management of learning process, for communication and files sharing, for finance management (purchasing and payment), for leisure and entertainment-related contexts (travelling and gaming), for navigation purposes etc. The statistics show that the number of apps available for download in July this year already reached up 1.6 million for Android users, and on Apple's App Store 1.5 million[1], and further prognosis expect that the number of consumers who use smartphones across the world will reach 2.16 billion in 2016[2].

2.3.8 Ubiquitous IS

Technological progress brought many advanced technological solutions such as the powerful microprocessors and embedded sensors, where information becomes instantaneous, universal

[1] The Statistics Portal, *Number of apps available in leading app stores as of July 2015*, Available: http://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ [Accessed: 10-Aug-2015].

[2] The Statistics Portal, *Number of smartphone users* worldwide from 2012 to 2018*, Available: http://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/, [Accessed: 10-Aug-2015].

and ubiquitous (Dupuy-Chessa 2009). Information and communication devices are becoming embedded in walls, ceilings, furniture and ornaments, they are worn as jewellery or woven into clothing, etc. (Benyon 2010). Term "*ubiquitous*" comes from Latin word "*ubique*" that is used to explain something that exist everywhere (Sørensen and IFIP Working Group (last) 2005). Research of ubiquity information access have roots in seminal article by Mark Weiser "The computer for the 21st Century" (Weiser 1999). In literature, these research streams can be found under the terms (Kowatsch and Maass 2013): *ambient intelligence* (Keegan, O'Hare, and O'Grady 2008), *experiential computing* (Yoo 2010), *internet of things* (Floerkemeier et al. 2008), *nomadic computing* (Lyytinen and Yoo 2002b), *pervasive computing* (Hassanien et al. 2010), *smart products* (Thiesse and Kohler 2008) or *ubiquitous computing* (Lyytinen and Yoo 2002a). All mentioned research streams can be placed under the one umbrella term *ubiquitous information systems* (Vodanovich, Sundaram, and Myers 2010). *Ubiquitous IS* (UIS) provide means for supporting single actors and groups in real-world contexts by services over ubiquitous computing technologies (Lyytinen and Yoo 2002a), (Vodanovich, Sundaram, and Myers 2010). They consist of *artefacts* that can dynamically change their configurations according to contextual changes and user behaviour (Maass and Varshney 2012).

Vodanovich et al. proposed (Vodanovich, Sundaram, and Myers 2010) different dimensions on IS (Figure 5) based on the: (1) *context*: work versus home, (2) *activity*: professional versus personal, (3) *user*: digital immigrant versus digital native and (4) *technology*: traditional versus ubiquitous. UIS no longer support just professional activities such as managing customer requests, issuing invoices or writing business emails, but as well communication with friends, family, reserving hotel room, ordering clothes online etc. UIS extends the traditional view on IS as office system towards the use of IS in home or outdoors for personal leisure and fun activities (traveling, shopping etc.). Users are no longer just people who adopted the technology as result of changing environment (digital immigrants) but as well the people how grew up with digital technology from young age (digital natives). Ubiquitous technologies covers hardware such as tabs, pads, boards, dust, skins, and clay that are interconnected and interwoven into the very fabric of our lives through ubiquitous networks (Vodanovich, Sundaram, and Myers 2010).

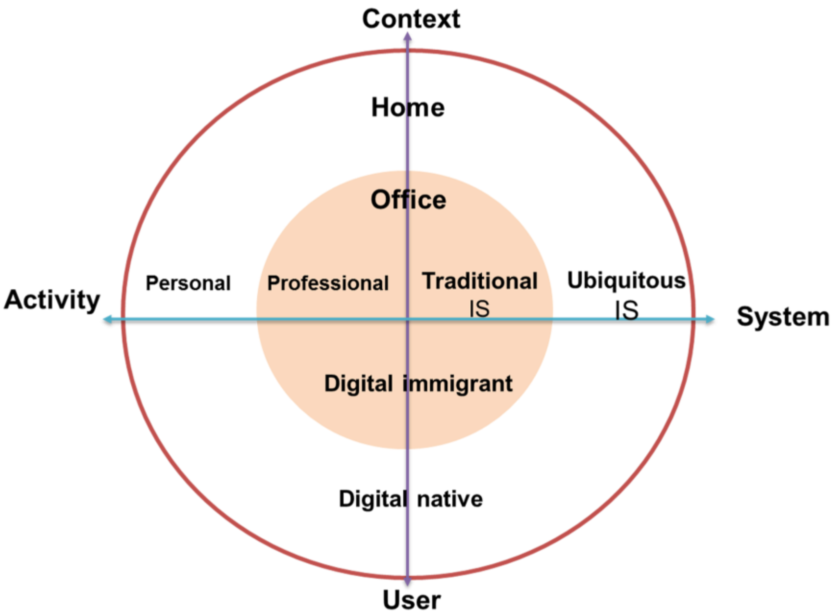


Figure 5 Dimensions of Information Systems Design
Source: Adapted from (Vodanovich, Sundaram, and Myers 2010)

Ubiquitous technology is becoming invisibly embedded in everyday environments and artefacts. Input devices are replaced by natural language interfaces that observe the users and interpret spoken words, gestures or mimes as potential commands and adopt information to the user context. Ubiquitous computing enables new use behaviours, supporting individual in his/her multiple roles in a personal, professional, national or broader global societal context (Figure 6) (Middleton, Scheepers, and Tuunainen 2014).

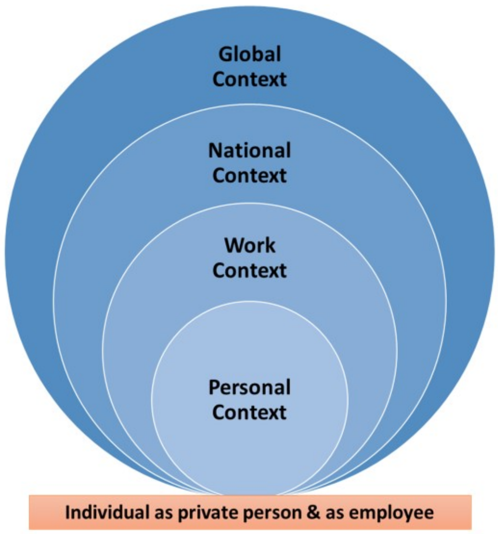


Figure 6 The Multiple Contexts of Use of (Mobile) Computing Technology
Source: Adapted from (Middleton, Scheepers, and Tuunainen 2014)

2.4 Information Technology and Information System Artefacts

The idea of introducing *IT artefacts* was a result of advanced technological solutions that become available for usage not only to companies but also to the individuals in their everyday lives. IT artefacts are defined as "bundles of material and cultural properties packaged in some socially recognizable form such as hardware and/or software" (Orlikowski and Iacono 2001). The authors (Orlikowski and Iacono 2001) argue that the main characteristics of IT artefacts are that they are not static neither fixed nor independent, and "are always embedded in some time, place, discourse and community". Similarly, Benbasat and Zmud (2003) defined IT artefacts as "the application of IT to enable or support some task(s) embedded within a structure(s) that itself is embedded within a context(s)" (Benbasat and Zmud 2003). Authors in (Orlikowski and Iacono 2001) called to take term *IT artefact* seriously within IS studies in order to better understand and contribute to the world that has become "increasingly interdependent with ubiquitous, emergent, and dynamic technologies". Sein et al. (2011) further considers this idea about integrating term IT artefact within IS studies and introduced a new term *ensemble artefact* as a part of outcomes of the action design research (Sein et al. 2011). Silver and Markus further developed the idea of IT artefacts within the term *sociotechnical artefact* in order to emphasize the importance of the social aspects in IT artefact i.e. to explain how individuals, organizations, and society employ IT and what are the consequences of IT use (Silver and Markus 2013). Further, A. Lee, Thomas, and Baskerville (A. Lee, Thomas, and Baskerville 2013) use the term *IS artefact* to denote that *artefact* is not just a sum of parts but a combination and interaction of three artefacts, *information artefact*, *technology artefact* and *social artefact,* who serve to solve a problem or achieve a goal for individuals, groups, organizations, societies, or other social units (A. Lee, Thomas, and Baskerville 2013). Information artefact presents "an instantiation of information, where the instantiation occurs through a human act either directly (as could happen through a person's verbal or written statement of a fact) or indirectly (as could happen through a person's running of a computer program to produce a quarterly report)" (A. Lee, Thomas, and Baskerville 2013). Technology artefact presents "something that is human-invented, human-discovered, or human-developed and that has worked well enough to be considered valid to cope with the problems both external and internal to the artefact's user or beneficiary" (A. Lee, Thomas, and Baskerville 2013). Social artefact presents "an artefact that consists of, or incorporates, relationships or interactions between or among individuals through which an individual attempts to solve one of his or her problems, achieve one of his or her goals, or serve one of his or her purposes" (A. Lee, Thomas, and Baskerville 2013). Alter (2015) argued about usage of *IT/IS artefact* terms within IS studies. He recommends to use these terms with great caution and whenever possible, replace it with simpler terms that are immediately understandable, such as *information systems* (Alter 2015), which in their essence they exactly are that.

2.5 Interactive IS

Today we have so many interactive products that we are using in our everyday life: smartphones, tablets, computers, ATMs, ticket machines, iPods, GPS navigation devices, game consoles etc. All these products are combination of hardware and software components. They have special algorithms integrated within them that enable the processing of the entered or "self-gathered" data via various sensors. When these products are used by user in order to achieve his professional or personal goals they are part of the information system. One of the early definitions of *interactive information systems* were in work of Orman (Orman 1985). He defined interactive information systems as "human-machine systems designed to collect, store, retrieve, process and present large quantities of information interactively". Interactive information systems enable the interaction, a dialog between the user and the device in order to support the user in his/hers context of use. Later many authors dropped the word information from the concept and just used the shorter term *interactive systems*. But in the essence they still talked about the systems whose main function is information processing for the user of the system.

Carr stated generally that any system that accepts input from the user and provide information as output to the user is an interactive system (Carr 2005). Similarly, International Standard Organization ISO 9241-210:2010 defined the interactive systems as "combination of hardware, software and/or services that receives input from, and communicates output to, users". Benyon used the term interactive systems to explain components, devices, products and software systems deal with the transmission, display, storage or transformation of information which people can perceive and that can respond dynamically to people's actions (Benyon 2010). Interactive systems can be viewed from the user perspective, and the system perspective (Carr 2005). To the user the interactive system is a tool for accomplishing tasks, something that receives input, and displays output. To the interactive system the user is a source of asynchronous input, an indirect target for output through various devices (display, speaker, lights, etc.). Interactive systems involve a significant degree of user interaction (Kotonya and Sommerville 1998). Physically people interact with systems through media for interaction such as keyboard, voice recognition, video input, touch screen, mouse, motion sensors, etc. (Kotonya and Sommerville 1998). Systems that use multiple ways of communication with the system (modalities of interaction) are also in literature known as multimodal systems. Roberto, states that interactive systems are becoming growing reality worldwide and that people use them “through different devices, for different purposes, in quite different contexts, and with unforeseen and far-reaching consequences” (Roberto Pereira 2013). Interactive technology has fundamentally changed the way we work and play (Goh and Karimi 2014), and has become an integral part of our everyday life activities (Yoo 2010).

Interactive systems are no longer expected to be used in stationary and predefined places. Interaction is no longer solely a property of the device but rather of the usage context (Dix et al. 2000). Interactive mobile IS usually have more flexibility from the stationary systems and can allow users to manipulate data to meet their needs in the specific mobile context of use (e.g. navigation option from current user location how to reach some point of cultural event in the foreign city). They have an awareness of the surrounding space of the user and use this information as a resource for the interaction. The view of context can be observed through the user’s physical relation to space (Botha, Van Greunen, and Herselman 2010). The view of this relationship is presented with matrix (Figure 7). User and device can move from one type of interaction to another (Botha, Van Greunen, and Herselman 2010).

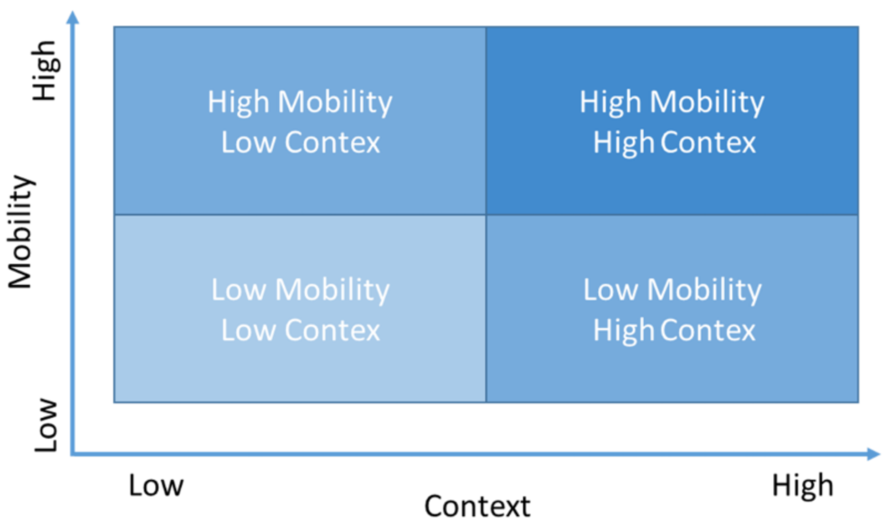


Figure 7 Mobility and Context
Source: Adapted from (Botha, Van Greunen, and Herselman 2010)

Low mobility interactions present static use of mobile technology. Here mobility of the device or the user is not essential for the interactions and the mobile technology is primarily being used as a result of other factors (low cost, convenience and restricted connectivity). *High mobility interactions* present interactions in which the mobility of the technology or user is an essential element to the activity. In *low context* scenario, context doesn't actively interact with user or device. Whereas in *high context* scenarios, context information are directly feed into the interactions. This context is either the context of the user or the physical context of the interaction (e.g. marks, browsing history, preferences, points that have been visited etc.).
Low context - low mobility interactions characterizes broadcasting of information to a selected group of users or individuals. Some examples of this category are use of SMS as an advertisement in commerce, the use of SMS to inform parents of school activities etc. *Low context - high mobility interactions* characterizes that the user and device are mobile but the context does not feed any information into the interaction. Some examples of this category are characterised by activities on the move, learning in a train, watching mobile TV on the bus etc. *High context - low mobility interactions* characterizes by stationary personalized context. Some examples would be the stationary access to a personalised virtual profile in a lecture room or class that is linked to the specific user's context within the learning experience. *High context - high mobility interactions* characterizes user and device on the move and information of the context feed into the interaction. Examples of this category are pervasive learning environments, GPS based games, and tourism systems (data collection of current position in order to provide adequate context relevant information to the user) etc.

2.5.1 Augmented Reality IS

Augmented reality systems are currently the most promising interactive systems, and they are very popular in the defence industry, construction industry, architecture, medicine, marketing, gaming industry, navigation, education and tourism. Augmented reality supplements the real world with virtual objects and they appear to coexist in the same space as the real world (Zhou, Sabino, and Rodrigues 2011). Devices that support augmented reality became much smaller and more accessible compared to the beginnings of 1960s when they were mainly used in the laboratory (van Krevelen and Poelman 2010). Augmented reality is not an alternative to the real world but an added value that extends users' experience of the real world in a personalized way (Fritz, Susperregui, and Linaza 2005). Augmented reality integrates various aspects of ubiquitous computing enabling users the real time interactions with networked devices and enhances the way in which information is accessed and presented

(Olsson et al. 2012). This technology has potential to enhances our perception enabling us to see, hear and feel environment in enriched way (van Krevelen and Poelman 2010).

First example of AR product was developed in 1960s by Ivan Sutherland and his students at Harvard University and the University of Utah (van Krevelen and Poelman 2010). He used the developed technology to present 3D graphics. In 1985 Warren Robinett and his colleagues at the University of North Carolina built an improved see-through display using LCD displays in colour, half-silvered mirrors, and magnifying lenses. As part of the US Air Force Super Cockpit project, Tom Furness developed a high-resolution heads-up overlay display for fighter pilots, supported by 3D sound (Karimi and Hammad 2004). 1990s brought significant changes in computing. Devices started becoming more powerful, small enough to be carried and to support registered computer-generated graphical overlays in a dynamic mobile environment. In 1997 the Columbia Touring Machine was an early prototype of an outdoor mobile augmented reality system (MARS) that presented 3D graphical tour guide information to campus visitors, registered with the buildings and artefacts the visitor sees (Karimi and Hammad 2004). Billinghurst, Weghorst, and Iii (Billinghurst, Weghorst, and Iii 1998) worked on AR conferencing system and found out that users collaborate better on a task in a face-to-face AR setting than in a fully immersive Virtual Environment. They continued researching application of AR conferencing and proposed a method for tracking fiducial markers and a calibration method for optical see-through HMD based on marker tracking (Kato and Billinghurst 1999).

Among first mentions of the term *augmented reality* was in the work of authors Caudell and Mizell (Caudell and Mizell 1992). They worked at Boeing on the design and prototyping the implementation of a heads-up, see-through, head-mounted display (HUDset). The intention was to allow a computer-produced diagram to be superimposed and stabilized on a specific position on a real-world object in order to *augment* the visual field of the user with information necessary for the performance of the current task. Azuma summarized previous research on augmented reality and defined AR as supplements to the reality where it appears to the user that the virtual and real objects coexisted in the same space (Ronald Azuma 1997). In order to avoid limiting AR to specific technologies, following three characteristics of augmented reality systems are defined (Ronald Azuma 1997), (R. Azuma et al. 2001): (1) *blend real and virtual objects in a real environment*; (2) *are interactive in real time*; (3) *align real and virtual objects with each other (registered in 3D)*. Milgram and Kishino (Milgram and Kishino 1994) defined augmented reality as a term to refer any case in which an otherwise real environment is *augmented* by means of virtual (computer graphic) objects. The focus of their research was on factors which distinguish different mixed reality display systems from each other. For them, augmented reality is just one part of general mixed reality in the *reality-virtuality continuum* (Figure 8).

Figure 8 The Reality-Virtuality Continuum
Source: (Milgram and Kishino 1994)

This environment of mixed reality is where the real world and virtual world objects are presented together within a single display anywhere between the extreme ends of the continuum (MILGRAM and KISHINO 1994). Although augmented reality has potential to supplement the physical environment with information perceptible by all human senses, visual and auditory overlays are currently the most commonly applied augmentations (Karimi and Hammad 2004). There are two basic choices how to accomplish the combining of real and virtual and these are *optical* and *video technologies* (Ronald Azuma 1997). *Optical see-through Head-Mounted Displays* (HMDs) work by placing optical combiners in front of the user's eyes. Combiners are partially trans-missive, and the user can look directly through them to see the real world. Further, these combiners are also partially reflective, so that the user sees virtual images bounced off the combiners from head-mounted monitors. The optical combiners usually reduce the amount of light that the user sees from the real world.

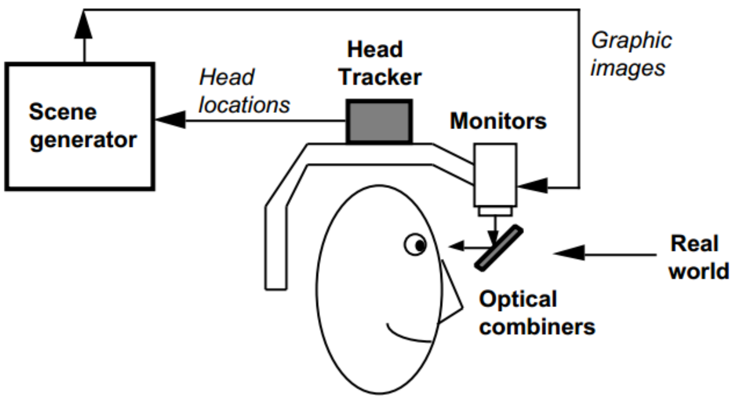


Figure 9 Optical See-Through HMD Conceptual Diagram
Source: (Ronald Azuma 1997)

Video see-through HMDs give a closed view with one or two video cameras integrated on HMD, or monitors. Video from these cameras is combined with graphic images created by the scene generator, blending the real and virtual, and the results are sent to the user's eyes.

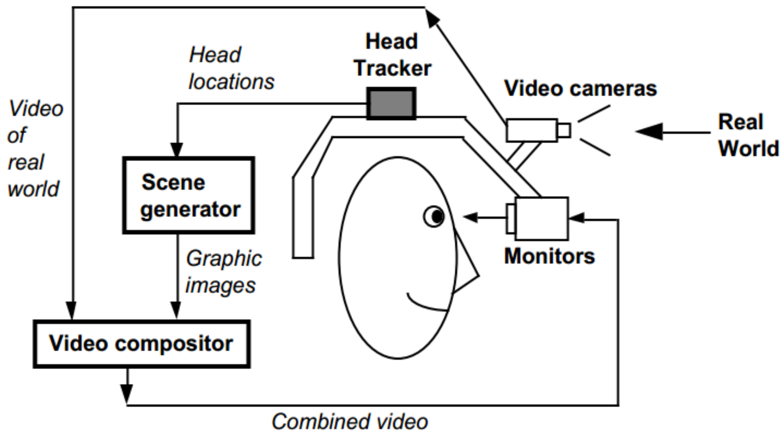


Figure 10 Video See-Through HMD Conceptual Diagram
Source: (Ronald Azuma 1997)

Achieving optical blending is simpler and cheaper than video blending (Ronald Azuma 1997). Optical approach deals only with one video stream (e.g. graphic images), and the real world is presented directly through the combiners. To achieve video blending, one must deal with separate video streams for real and virtual images. Time delays are much greater than in optical approach. 1990s brought significant changes in computing. Azuma et al. (R. Azuma et al. 2001) state that mobile augmented reality is one of the fastest growing research areas, due to the emergence and widespread uptake of powerful smartphone devices that can easily support augmented reality features. Modern mobile smartphone devices and tablets have integrated fast processor with powerful graphics hardware, a large touch screen, and embedded sensors, integrated camera, GPS, Wi-Fi, compass, accelerometer, therefore making them ideal for both indoor and outdoor augmentation. AR systems enable image, object, and shape recognition in which virtual objects (in the form of video, 3D, 2D, text etc.) will be superimposed over it. We can differentiate several types of tracking (Amin and Govilkar 2015): (1) *fiducial marker based tracking* - black and white squares which enable high contrast compared to background environment and can thus be quickly recognized, (2) *hybrid based tracking* - combines two or more data sources such as GPS, compass, accelerometer to calculate actual position and orientation, (3) *model based tracking* – based on the edge detection uses the geometrical representation of 3D objects, (4) *natural feature tracking* – usage of real world features as markers.

Although the use of augmented reality technology has significantly increased in recent years, this technology is still in the development stage and its potential has not yet been fully realized. Researchers have already performed studies in which they confirm that both perceived usefulness, perceived easy to use and enjoyment have a positive impact on the intention to use mobile augmented reality applications within cultural heritage context (Haugstvedt and Krogstie 2012) and education (Yusoff, Zaman, and Ahmad 2011). A large proportion of published research in AR has focused on the acceptance and development of AR technology and improvement of AR solutions. However, only few studies have analysed user experience and the benefits the user gets from using these systems. Predictions for the next period promise not only the application and usefulness of augmented reality in industrial and organizational contexts but also that it will become an integral part of everyday life of ordinary people (users). It will drastically change the way of life, and it is only a question of time before augmented reality becomes today's Internet. All 360 degrees around us will carry augmented reality information and simply by targeting and positioning our views we will be able to operate the system. The forecast of Juniper Research predicts that mobile augmented reality revenues will exceed $1BN annually by 2015 and AR app number of users will approach 200 million by 2018 (W. Holden 2014). Having in mind all mentioned, we can conclude that augmented reality field is currently beneficial and worth researching.

2.5.2 Multimodal IS

Multimodal interfaces are becoming more and more important due the advances in hardware and software technology. Nigay and Coutaz, described multimodality as "the capacity of the system to communicate with a user along different types of communication channels and to extract and convey meaning automatically" (Nigay and Coutaz 1993). Chatty described multimodal interaction systems as systems that have multiple input devices (multi-sensor interaction) and offer multiple interpretations of input issued through a single device (Chatty 1994). Multimodal systems can combine visual information with voice, gestures and other modalities (handwriting, touch, gaze, etc.) in order to enable more natural dialogue between humans and the systems. User of multimodal system can choose the modality that best suit the context of use (situation) or their preferences. The idea about multimodal interfaces within human/computer interaction field emerged 30 years ago with Richard Bolt's "*Put-that-there*" application (Bolt 1980). This application linked both spoken commands and pointing gestures using an armrest-mounted touchpad in order to move and change shapes displayed on a screen in front of the user. Emergence of multimodal interfaces based on the recognition of human speech, gaze, gesture, and other natural behaviour is just the beginning of the progression towards computational interfaces with human-like sensory perception (Oviatt 2003).

The difference between multimedia and multimodal systems is that multimodal systems interpret the inputs and give them meaning, while multimedia systems just accept different inputs without giving them a meaning. Multimodal system recognizes inputs from different modalities combining them according to the constraints whether temporal or context (Caschera, Ferri, and Grifoni 2007). This field of multimodality covers a broad spectrum of research fields, from cognitive psychology (studies how human brain processes information and interacts through various modalities) to software engineering (studies and develops software architectures and multimodal processing techniques) including human/machine interaction (studies how humans use multimodal interfaces) (Dumas, Lalanne, and Oviatt 2009). Technical input modalities of systems are designed in such a way that they correspond to human senses (Sebe 2009): camera – sight; haptic sensor – touch; microphone – hearing; olfactory – smell; and research streams are in progress to develop technical alternative for the sense of taste. Users can benefit from the application of integrated multiple input/output modes because multimodal systems have a potential to be used and mastered easily. Multimodal human-computer interaction, in which the computer accepts input from multiple channels or modalities, is more flexible, natural, and powerful than unimodal interaction with input from a single modality (Ferri, Grifoni, and Paolozzi 2007). Reeves et al. (Reeves et al. 2004) define several guidelines for multimodal user interface design where multimodal systems should be flexible and need to fit the broad range of users and contexts of use (e.g. speech input could be useful in a car, but keyboard or pen input in a noisy environment); privacy and security issues should be assured (e.g. voice modality should not be used to transfer private or personal information when user is in a public contexts); according to user preferences and capabilities modalities should be adjusted (e.g. aggregating audio and visual outputs for the users so they can co-process the information more easily); multimodal systems should be designed to adapt easily to different contexts, user profiles and application needs. There is also one major advantage of multimodal interface design, for both users and systems, and that is error prevention and handling of information. Specific guidelines include integrating complementary modalities to improve system robustness, and giving users better control over modality selection so they can avoid errors.

Multimodal interfaces proved to be not so efficient as was expected as they speed up task completion only by 10% (Oviatt 1997). But on the other hand, multimodal systems have offered many advantages (Sebe 2009), (Dumas, Lalanne, and Oviatt 2009): they can help in error prevention, enable more robust interface, add alternative ways of communication appropriate for different situations and environments, enable flexible personalization based on user and context, etc. Users can process information faster and better when it is presented in multiple modalities (van Wassenhove, Grant, and Poeppel 2005). Multimodal systems have potentials to improve accessibility (Vitense, Jacko, and Emery 2002). Hearing-impaired users will rely more on visual aspect, while visual impaired users may rely on the voice modality. Scientists are now focusing on the research and development of the technology that will be able to automatically analyse facial expressions i.e. sad, angry, happy etc. The ultimate goal is to create a more natural way of communication with computer as a tool or to the computer as a dialog partner. There are also efforts in development of *Multimodal Interaction Framework* for the web by World Wide Web Consortium (W3C).

2.5.3 Interactive Mobile IS Framework

Technological advancements facilitate the implementation of different forms of mobile interactive systems in our everyday life context. In this study the author will not be using the term *IT artefact* or *IS artefact.* Instead the simpler term *interactive mobile information system (IMIS)* will be used as it comprises the meaning of the term *information artefact* (i.e. software application) installed on a *technology artefact* (i.e. smart interactive mobile devices e.g. smartphones, tablets, smart watches) and used by a *social artefact* i.e. a person in order to solve his/her problem or to achieve his/hers personal goal. The main feature of interactive mobile information systems (IMIS) is that they are characterized by *high mobility* and *high context interactions*, i.e. the users and device are mobile and the data from the environment are fed in to the interaction in order to provide adequate information to the user to his/her context of use (e.g. gaming, tourism, fitness).

In basics *IMIS* is an ensemble of all necessary hardware and software components that supports the collection, storage, retrieval, processing and presentation of the information dynamically for the user's activity in his/hers mobile context of use. The author developed the IMIS framework based on the AUDE framework by (Andersson and Henningsson 2010), personal information system framework by (Kim and Ammeter 2014), ubiquitous IS framework by (Vodanovich, Sundaram, and Myers 2010), IS artefact by (A. Lee, Thomas, and Baskerville 2013) and interactive systems framework by Benyon (Benyon 2010). The five components of the IMIS framework are: *user*, *application, device*, *activity* and the *mobile context*. This framework is presented on the Figure 11.

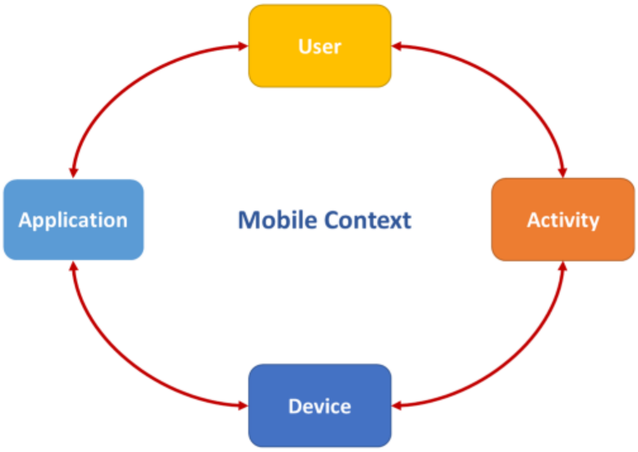


Figure 11 The framework of the Interactive Mobile IS
Source: made by the author

User is a physical individual that uses the system. *Device* presents ensemble of different hardware components such as *input devices, screen*, *memory*, *processor, and sensors* compound in one whole (mobile) product e.g. cell phone, tablet, watch etc., whereas as *application* is software component that support the processing of the data and enables communication between user and device. Application and device are interactive because they can respond dynamically to user's context and actions. *Activity* presents the function being performed by user in the (mobile) context. Activity can be professional, personal or both. In general four groups of activity can be identified: *information*, *communication*, *transaction* and *entertainment*. *Context* is the whole situation, background relevant to some happening. It is the environment in which the interaction takes place. Context can be stationary or mobile. Stationary context means that user uses the system in the location-dependent environment. Whereas mobile means that user can use the system anywhere. Within this study under the mobile context it is meant situations where the mobility of the technology and user is an essential for the activity e.g. city tour guides.

2.5.4 Interactive Mobile IS Case Studies

2.5.4.1 Ingress Mobile Augmented Reality Game

Ingress is interactive mobile augmented reality location-based game. The game is created by Niantic Labs, a start-up within Google. It was first developed only for Android devices but later they spread on iOS too. Players with this game can choose the side they want to play for.

There are two main sides the *Enlightenment* (the green team) and the *Resistance* (the blue team). Players of each side go around the city and collect *keys*, *weapons* and *upgrades*, and capturing *portals* that have been “placed” at cultural significant locations (e.g. landmarks, monuments, public art etc.) for their “*faction*”. The goal of the game is to establish *faction portals* and linked them to create virtual triangular *control fields* over geographical areas. Ingress is played around the world in the U.S., Europe, East Asia, India and the Middle East. This is example of the mature and successful hedonic information systems, entertainment oriented with high mobility and high context interactions.

Figure 12 Augmented reality game Ingress

When game is started the map of the surrounding area shows up on the screen. On the map player can see portals, Exotic Matter (XM), links, control fields, and items that have been dropped from a player's inventory (Wikipedia: Ingress 2015). In order to interact with the object, players must be physically near objects. Player hacks nearby portal to acquire in-game items. Then the players are rewarded with AP (Access Points) for actions within the game. When player has enough accumulated AP beyond certain thresholds, he get higher access levels, i.e. access to stronger items and capabilities. The access levels are numbered from 1 to

16, with 16 being the highest. Players can participate in the mission actions. That is a user-created set of places to visit and interact with in specified ways. By completing the missions player can win the virtual medals (for more information please read: (Wikipedia: Ingress 2015). In order to play the game user has have strong Wi-Fi or cellular data connection as well as GPS sensors.

2.5.4.2 VarazdinAR Mobile Augmented Reality City Tour Guide

VarazdinAR is mobile augmented reality city tour guide system developed for tourists of city Varazdin, Croatia by the author of this thesis. The project was outcome of bilateral cooperation agreement between *Faculty of Organization and Informatics*, *University of Zagreb* and *Evolaris next level GmbH*, *Graz, Austria*. The project started in April, 2012 and now it is in its finishing phase. The idea of the project was research potential benefits of augmented reality system use in tourism, as well as development of concrete AR system for city Varaždin in order to present and promote AR in Croatia. This is the example of hedonic system, orientated to information seeking purposes of the individuals (tourist) that supports high mobility and high context interactions.

VarazdinAR system is currently available for iPhone/iPad systems, and enables presentation of the context relevant information based on user location. The city tour guide system is developed based on Metaio SDK augmented reality framework. The system is organized in four modules: *(1) AR view of points of interest; (2) Map view of points of interest; (3) Door view; (4) Magic book view.* Main screen is shown on Figure 13. The first module is the display points of interest (POI) through the real world view. Based on the current location of tourists annotations are enriched with the distance and direction of particular POI (Figure 14a). Tourist information can be filtered by distance and by groups: *landmarks*, *restaurants*, *bars*, *accommodation*. The second module displays points of interest on the Apple maps. Tourists can easily see where you are currently located on the map and what surrounds them (Figure 14b). Points on the map can be filtered according to the groups: *landmarks*, *restaurants*, *bars*, *hostels.*

Figure 13 Main Screen of the VarazdinAR System

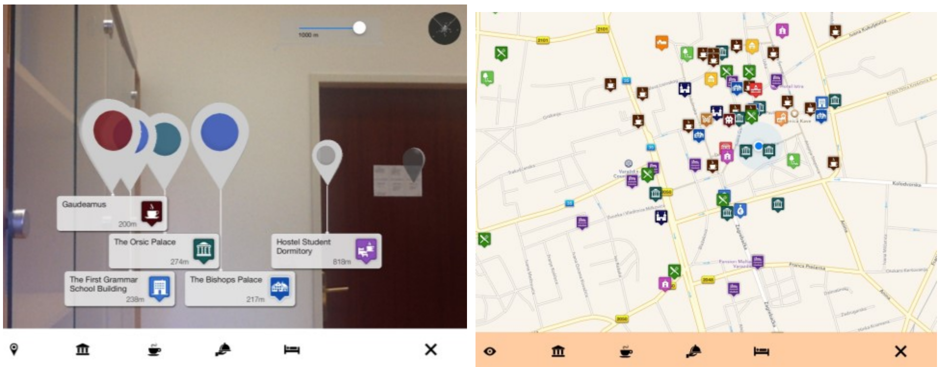


Figure 14 a) Augmented Reality Points of Interest View; b) Map Points of Interest View

Selecting an individual pin tourist can see more information about the point of interest, how to get to it and link to the official website of POI. If this is a historically relevant points of interest, two additional possibilities are enabled to start module of recognizing and tracking the door of historical buildings and module of recognizing and tracking the content of the official *2015 Varazdin tourism brochure*. These are the third and the fourth module (Figure 15 a, b) of *VarazdinAR* system.

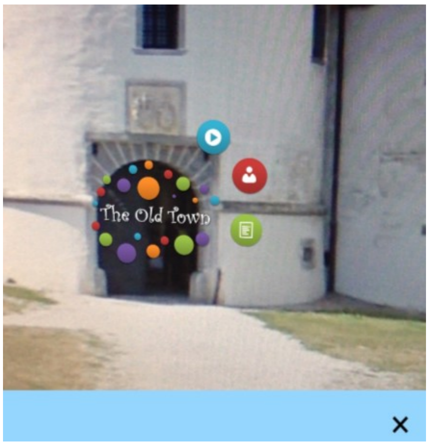


Figure 15 a) Augmented Reality Landmark Door View; b) Augmented Reality Magic Book View

All modules are connected to each other and enable the tourists for example, looking at a brochure of the city of Varazdin decided what the building he/she want to visit, with the ability to inform in advance about the landmark or if it is more convenient to inform him/herself on the spot (Figure 15b). The process of displaying the content augmented reality includes the following, first the camera shows the actual environment, then the system captures video images and creates a pattern, the pattern is compared with a sample from the database, and if the system finds similarity, displays and positions the content depending on the sample (marker). In order to use the system smart device should be connected to city Varazdin free Wi-Fi or use the sim card's 3G internet access. The additional advantage from the existing systems is enabling audio files for each POI, so the tourist doesn't need to look through the display all the time. For the next version of the system, the following functionalities are considered to be integrated: *communication possibilities (to establish direct contact via phone call or e-mail wit service providers e.g. renting a room)*, *feedback (to see or to post feedback or ratings to each POI)*, *push-notifications (to enable notifications when tourists is close to the POI he wants to visit)*, *m-commerce possibilities (to book or to pay via mobile system)* and *tour generation possibilities (based on the preferences and time span suggest and adapt tours)*.

2.6 Privacy Issues in the Interaction Context

As a result of more and more issues that arise from *ubiquitous technology* and *large–scale networked data* use, *privacy rights* have been recognized as a market imperative and a precondition for gaining trust of consumers. By developing IT solutions, the developers/providers have a great responsibility to incorporate privacy protection into the early stages of product design, instead of struggling with gaps later on (Schaar 2010). Concept

Privacy by Design originates from joint report *Privacy-enhancing technologies* by the Information and Privacy Commissioner of Ontario, Canada, the Dutch Data Protection Authority and the Netherlands Organisation for Applied Scientific Research in 1995. The idea of this concept is to stress the importance of consumer privacy rights in product/service consumption by providing guidelines on how to implement privacy aspects in every stage of product/service development. This concept is broader than security. *Privacy by Design* “includes the idea that systems should be designed and constructed in a way to avoid or minimize the amount of personal data processed” (Schaar 2010).

In order to ensure better protection of product/service consumers, seven principles have been derived which should become an integral part of organization’s ecosystem. The seven foundational principles are (Cavoukian 2011):

(1) *Proactive not Reactive, Preventative not Remedial*. This means that we should not wait for privacy risks to occur to react but rather we should take all necessary preconditions to prevent them from occurring. Privacy practices should be adopted proactively, early and consistently.

(2) *Privacy as the Default Setting.* This means that privacy setting should be integrated into the system by default and that there should be no action required from the user to protect his/hers privacy.

(3) *Privacy Embedded into Design.* This means that privacy should be embedded into the design and architecture of the system and should not exist as some additional functionality. It should be an essential component of the core functionality being delivered.

(4) *Full Functionality – Positive-Sum, not Zero-Sum*. This means that both *privacy* and *security* should be ensured to users without one excluding the other. Integrating privacy should not impair functionality of product/service, business practice but should embrace them in an innovative positive-sum manner.

(5) *End-to-End Security - Full Lifecycle Protection.* This means that for the whole life cycle of the data in question strong security/privacy measures should be ensured without gaps in either protection or accountability. “*Without strong security, there can be no privacy*” (Cavoukian 2011).

(6) *Visibility and Transparency - Keep it Open*. This means that all stakeholders involved in business practice or technology use should operate according to the stated promises and objectives, subject to independent verification.

(7) *Respect for User Privacy - Keep it User-Centric*. This means that developers, designers and others should keep interests of the individual as guidelines by offering such measures as strong privacy defaults, appropriate notice, and empowering user-friendly options.

Principles of *privacy by design* refer to all types of personal information. However, special attention should be given to sensitive data such as medical information and financial data. These principles are not so easy transformable into practice. They are often critiqued as not clear and not specific enough and that they leave many open questions regarding their implementation in engineering systems (van Rest et al. 2014). Therefore, in practice, the most common privacy legislation used includes the following: *notice, choice and consent, proximity and locality, anonymity and pseudonymity, security, and access and recourse* (Langheinrich 2001). Privacy within information systems refers to the ability of the system to keep user identity confidential during the system use. Information system should ensure the protection of various types of data that are collected weather the user knows or does not know about them. The trust the users have in the system (or the provider of the system) in order to accomplish their goals securely and to maintain the privacy of their personal information will impact their level of satisfaction and their intention to use the system again (Warrington, et al. 2000). Implementation of mobile technology, requires a detailed understanding on which types of tasks, functional areas, and users will benefit from it and how to provide appropriate level of security and privacy.

2.7 Information System Evaluation

Information systems evaluation has been researched since 1970s. In the last four decades many IS theories (paradigms) have been developed. There are more than eighty different theories today that explain usage, adoption, or values IS provides for its users (Larsen et al. 2015). Some of the major metrics and theories are presented in the following subchapters.

2.7.1 Economic Theories

Over the years, many methods have been proposed that evaluate the cost and benefits of IS investment (Gunasekaran, Ngai, and McGaughey 2006). Many businesses invest large amounts of money and time in implementation of organizational information systems. They primarily expect an increase in economical effectiveness of their businesses. Managers tried to prove the profitability of these investments by using economical financial measures e.g. *Return of Investments* (ROI), *Net Present Value* (NPV), *Internal Rate of Return* (IRR) or *payback period*. These measure have been effective for measuring the value of simple IS, such as transaction processing and office automation systems. However, these measures are not effective in case of the more complex systems (Martinsons, Davison, and Tse 1999). IS researchers have placed more focus on the evaluation whether the IS projects should be funded, or do the projects meet time, scope, and functionality requirements, rather than on evaluating whether the system provides the intended benefits (Petter, DeLone, and McLean 2012). Evaluation process isn't always the same. For example, if we measure the value of IS investments in public sector then we need to have more intangible measures, but if we measure IS value in the manufacturing sector we need to have more tangible measures than intangible measures (Gunasekaran, Ngai, and McGaughey 2006). The same applies if we want to measure the success of entertaining system, in this case the success is more evaluated by using intangible measures.

2.7.2 Information System Adoption Theories

Predicting the adoption and use of information technology got a great deal of attention in IS literature. Technology that was easily adopted by users was considered as successful. Thus these theories were mainly used as basis for the development of other theories because acceptance is the precondition for technology use and its success. Most important theories in this field are presented in the following subchapters.

2.7.2.1 Diffusion of Innovations Theory

Diffusion of Innovation (DOI), was developed by professor of communication studies Everett Rogers in 1962, based on previous sociological and anthropologists work on diffusion (Rogers 2010). According to him, innovation is communicated/diffused through certain channels over time among the participants in a social system. He presented the theory that strives to explain how, why, and at what rate new innovations i.e. ideas and technology will be adopted by members of a given culture. Some innovations/ideas spread more quickly than others. Theory predicts that opinion and judgment of people to adopt some innovation is influenced by media as well through interpersonal contacts and opinions of the leaders. In order to reach self-sustainability, an innovation must reach a point at which it reaches critical mass. Rogers believes that there are five categories of people, based on their propensity to adopt a specific innovation: *innovators*, *early adopters*, *early majorities*, *late majorities* and *laggards*. These categories follow a standard deviation-curve (Figure 16), where very small amount of *innovators* (around 2,5%) adopt an innovation immediately, which is then followed by 13,5% of *early adopters* who agree to give it a risk and try/use/accept an innovation. *Early majority* (34% of the population) sees the benefits and wants them, and *late majority* (34%) accepts an innovation only because of the fear they will not "fit" into the society. After some time finally the *laggards*, who make up for 16%, accept it as well. *Innovators* are of visionaries and risk takers. Much of their time and energy is spent on experimenting and developing new ideas and artefacts and enthusiastically talking about them. It is believed that there is no change program without their energy and commitment. *Early adopters* look for new ways how to improve quality of life or businesses and are very keen to adopt something in order to have advantage over their peers and get social prestige. *Early majorities* adopt something if there is proof for efficiency. They will not waste their time and money if something is not obviously valuable. They are slow adopters and feel comfortable with moderately adopting new ideas. *Late majority* are conservative pragmatists who hate taking risks. They only do something because of the fear of not fitting in, and opinions of laggards. *Laggards* are people who see a high risk in adopting a particular product or behaviour and they have strong fear towards change.

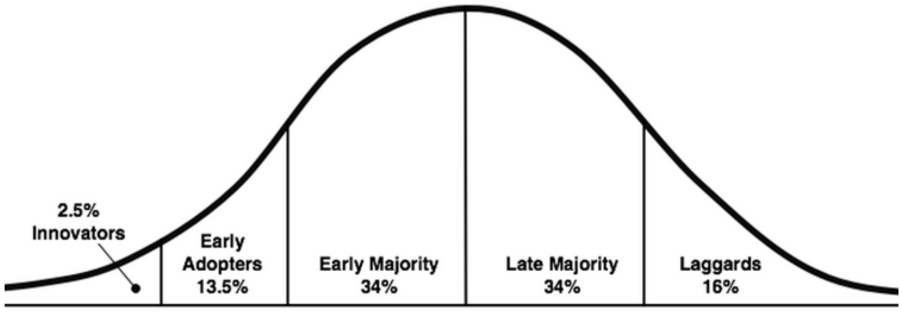


Figure 16 Diffusion of Innovation Theory
Source: (Rogers 2010)

There are five main characteristics that influence adoption of an innovation by adopters: *relative advantage* – the degree to which an innovation is seen as better than current practice; *compatibility* – the degree to which an innovation is consistent with the values, experiences, and needs of the adopters; *complexity* - how difficult the innovation is to understand and/or learn to use; *triability* – how much effort and risk is needed in order to explore and experiment with an innovation before making an adoption decision, and *observability* - the extent to which the results of an innovation are easily seen and understood. *The Diffusion of Innovations Theory* is primarily concerned with innovation characteristics that may drive individual's adoption decision, and the qualities that make an innovation spread. It has served as the basis for the development of a variety of technological models that have been applied to monitor the acceptance of IT/IS.

2.7.2.2 Theory of Reasoned Action

Theory of Reasoned Action (TRA) was developed by Fishbein and Azjen (Fishbein and Ajzen 1975; Ajzen and Fishbein 1980). This theory provides a framework for identifying and measuring the underlying reasons for a person's intent to or not to behave in a certain way. The three main components of TRA are: *behavioural intention* (individual's relative strength of intention to perform a behaviour), *attitude* (individual's beliefs about the consequences of performing the behaviour multiplied by evaluation of these consequences), and *subjective norm* (combination of perceived expectations from relevant people along with intentions to comply with these expectations). An individual's attitude, combined with subjective norms, forms individual's behavioural intention. The importance or the weight of attitudes and norms is not equal in predicting behaviour, therefore a weight is associated with each of these factors in order to more precisely predict a behaviour. Within IT adoption context, TRA postulates that actual technology use is influenced by the individual's behavioural usage intention, which depends on the individual's attitude towards the use of the technology as well as the subjective norms of using the technology predominant in the user's social environment (Röcker 2010). TRA suggests that all other factors that can influence behaviour are indirect (external variables) influencing the attitude or subjective norms. These variables can be for example, the characteristics of the tasks, interface, implementation development type, political influences, organizational structure, etc. (Davis, Bagozzi, and Warshaw 1989) The downside of TRA is that is too general and does not specify the beliefs that are operative for a particular behaviour (Davis, Bagozzi, and Warshaw 1989). Another downside is that it deals with action prediction, rather than outcomes of behaviour (Yousafzai, Foxall, and Pallister 2010).

2.7.2.3 Theory of Planned Behaviour

Theory of Planned Behaviour (TPB) is developed by Ajzen (Ajzen 1991) as an extension of *Theory of Reasoned Action* with construct *perceived behavioural control* that presents individual's perception of control over performing a given behaviour (Yousafzai, Foxall, and Pallister 2010). It was added as third antecedent of intention to the TRA model and covers skills, resources, and opportunities, and their perceived importance in order to achieve an outcome. Ajzen claimed that TRA was insufficient when people believe they have little control over their decisions (Ajzen 1991). TPB holds that attitudes, subjective norms, and perceived behavioural control are direct determinants of intentions, which in turn influences behaviour.

2.7.2.4 Technology Acceptance Model

Davis et al. (Davis, Bagozzi, and Warshaw 1989) developed *Technology Acceptance Model* to explain why some IS are more readily accepted than others. They derived this theory based on the *theory of reasonable action* and on the *theory of planned behaviour*. The researchers investigated the factors that influence on users to accept and make use of technology. Their premises were that the *attitude* of a user toward the system will influence whether the user will accept or reject the system and that beliefs such as *perceived usefulness* and *perceived ease of use* are directly correlated to the *acceptance* of a given technology (Davis, Bagozzi, and Warshaw 1989). Many researchers have tested and extended the model formation. For example, Davis and Venkatesh (Davis and Venkatesh 1996) hypothesised that only two beliefs are sufficient to explain user's behaviour and excluded attitude from the theoretical model. Later these authors suggested second generation of the *Technology Acceptance Model, TAM 2 model*, where they have identified several variables that influence the perceived usefulness such as *subjective norm* (from which experience and voluntariness are included as moderating factors), *image*, *job relevance*, *output quality*, *result demonstrability* (Venkatesh and Davis 2000). Further, Venkatesh et al. (Venkatesh et al. 2003) conducted an extensive analysis of acceptance literature published since the original formation of the model and as outcome presented *Unified Theory of Acceptance and Use of Technology model* (UTAUT). This new model integrated and expanded previous technology acceptance and use models with *performance expectancy*, *effort expectancy*, *social influence* and *facilitating conditions* as direct determinants of user acceptance and usage behaviour, in which gender, age, experience, and voluntariness of use were posited to moderate the impact of the four key constructs. Later, *TAM 3 model* (Venkatesh and Bala 2008) was also introduced. TAM model and its extensions have become highly popular in IS literature and there are numerous acceptance studies of different IT solutions by its users: of digital libraries (Hong et al. 2002), of intelligence and security technology (Jen-Hwa Hu, Lin, and Chen 2005), of health care systems (R. J. Holden and Karsh 2010), e-learning systems (Sung Youl Park 2009), Web 2.0 technology (Dong-Hee Shin and Won-Young Kim 2008) etc.

There are several extensive literature reviews and critical analysis about the technology acceptance model and it's successors (Y. Lee, Kozar, and Larsen 2003), (Legris, Ingham, and Collerette 2003), (King and He 2006), (Schepers and Wetzels 2007), (Chuttur 2009), (Turner et al. 2010), (Marangunić and Granić 2014). Acceptance theories assume that people are rational and plan their actions and evaluate the *usefulness* and *easy of use* of the technology, then develop the *intention to use* it and then *actually use it.* However, people are not so rational and they do have some intention to use a product even if they had not had the opportunity to try it before as it was the case with queues of people waiting in line to buy the first iPhone even though they had never seen or tried this technology before. Researchers have developed multiple competing models of the acceptance model, each with a different set of acceptance determinants. Original TAM was mainly extended by introducing factors from related models, or by introducing additional or alternative belief factors, or by examining antecedents and moderators of *perceived usefulness* and *perceived ease of use* (Wixom and Todd 2005), (Marangunić and Granić 2014). Benbasat and Barki argue that TAM and its extensions have become ironically more and more similar to the theories they were originally based on (TRA and TPB) (Benbasat and Barki 2007). Researcher are still not harmonious regarding the models' theoretical assumptions and their practical effectiveness (Chuttur 2009).

2.7.3 Information System Success Theories

The way in which the success of IS is evaluated has changed over time along with changes in the context, and purpose of IS use. Some researchers used TAM model to explain successful, however *acceptance is not equivalent to success*, although acceptance of an information system is a necessary precondition for success (Petter, DeLone, and McLean 2008). TAM is usually applied in early phase of product use, i.e. weather the user will accept for usage particular technological solution. Beliefs and attitudes measured by TAM are oriented towards the behaviour of using a technology, and not towards the beliefs and attitudes about the object itself i.e. quality of information system (Wixom and Todd 2005). Therefore the model provide limited guidance in how to plan or design a technology to be more acceptable because they do not take into account the system characteristics which is crucial in today's competitive IT environment (e.g. *information currency*, *flexibility of the system*, etc.).

The contribution of IS on individual or organizational performance is difficult to measure directly. Benefits or impacts of IS could happen in later phases as outcome of IS use. Murphy and Simon (Murphy and Simon 2002) report that the benefits from IS can be hard to measure because some benefits can be intangible. Due the complex, interdependent, and multidimensional nature of IS the measures of IS success are usually *ill-defined* in practice (Sedera, Eden, and McLean 2013). Objective of IS research streams were to simplify multidimensionality of information system success concept in order to understand it and to be able to measure it (Gable, Sedera, and Chan 2008). Three very popular success theories in IS literature are task-technology fit (TTF), balanced-score card (BSC) and DeLone and McLean IS success model. All these models have mainly been applied and validated for the utilitarian information systems.

2.7.3.1 Task-Technology Fit Model

Task-Technology Fit Model (TTF) assumes that users will chose the technology which is most appropriate for their activity (Goodhue and Thompson 1995)(Goodhue 1998). They will only use technology if it provides functionality fit to the users' activity. The better the fit, the higher the impact of the performance. TTF is a part of a chain between information technology and performance impacts (Zhang and Galletta 2015). It's composed of four constructs: task characteristics, technology functionality, fit between task characteristics and technology functionality, and technology utilization as the outcome variable. In order to influence an individual's performance the technology must be utilized and there must be a good fit with the tasks the technology supports. Otherwise the technology will not improve performance. The TTF model has been used in a variety of different task domains such as s group support systems, knowledge management systems, healthcare environment, e-commerce, mobile IS etc. However, there is little support for these model within hedonic system usage.

2.7.3.2 Balanced Scorecard Approach

The Balanced Scorecard (BSC) approach has been developed by Kaplan and Norton in 1992 in order to allow managers to evaluate corporate performance by including both financial and non-financial measures (Kaplan and Norton 1992). They have argued that traditional financial accounting measures are too narrow and incomplete and that a reliance on such data prevents the creation of future business value (Martinsons, Davison, and Tse 1999). Therefore they proposed three additional perspectives, *customer satisfaction*, *internal business processes*, and ability for *learning* and *growth,* as complements to the *financial perspective.* The idea is to enable clarification, communication and to actively manage corporate strategy. For each perspective a set of measures, key performance indicators, needs to be defined in order to reflect how well the strategy is implemented within the organization. BSC is usually represented with strategy map to form a visual presentation of strategy and objectives within perspectives. Each objective is presented with lagging and leading indicators. Lagging indicators represent the results of measurements, while leading indicators present the future trends that will affect the future results. BSC has been very popular in industry practice.

Initially, using the Balanced Scorecard method ICT was treated as a shared corporate resource. This way of measuring proved to be inadequate, and soon it was suggested the development of IT Balanced Scorecard in order to measure the value of investments in IT of organization (Keyes 2005). The generic IT BSC (Van Grembergen and De Haes 2005), (Martinsons, Davison, and Tse 1999), is composed of following four perspectives: *user orientation* - represents the user evaluation of IT; *operational excellence* - represents the IT processes employed to develop and deliver the applications; *future orientation* - represents the human and technology resources needed by IT to deliver its services over time; *business* *contribution* - captures the business value created from the IT investments. These perspectives need to be translated into metrics and measures that assess current situation in the company. The main value of IT BSC is the cause and effect relationship between performance drivers and outcome measures. This cause and effect relationship needs to be defined through the whole BSC. The assessments are than repeated periodically in order to see the improvements and to better align established goals towards the strategy of organization.

However, BSC approach is not without problems. Academic literature argues that there is no significant theoretical background for framework formulation (Nørreklit 2003). Many studies report fail in implementation mostly because of the difficulties in determining what indicators to choose, difficulties in identifying cause and effect relationships, ensuring the continuance and completeness in implementation in order to achieve the full value (Kaufmann and Becker 2006). IT BSC formation and practice is oriented towards the objective assessment in the organizational setting. It doesn't take into the consideration that IS of today are as well used outside the organizations and for individual purposes such as entertainment. Therefore in its current form IT BSC cannot be applied for the success measurement of these modern interactive personal IS.

2.8 DeLone & McLean IS Success Model

In information system literature most popular and most cited model to measure success of information systems is *DeLone and McLean Information System Success Model* (D&M Success Model). These researchers conducted literature review of over a hundred empirical and conceptual studies on managing information system success in order to synthesize previous research to bring more understanding to the IS success concept and to provide guidance to future researchers (DeLone and McLean 1992). They developed their initial taxonomy using established theories adapted for IS (e.g. *Shannon and Weaver communication theory* and *information influence theory of Mason*) (DeLone and McLean 1992). They assumed that utilization and user attitudes about the technology (information systems) will lead to individual and organizational performance impacts. They proposed a multidimensional model consisting of six major dimensions: *information quality*, *system quality*, *system use*, *user satisfaction*, *impact on the individual user*, *impact on the organizational use*. They suggested that these dimensions of IS success should be interrelated rather than independent and suggested the temporal and causal interdependencies between these dimensions.

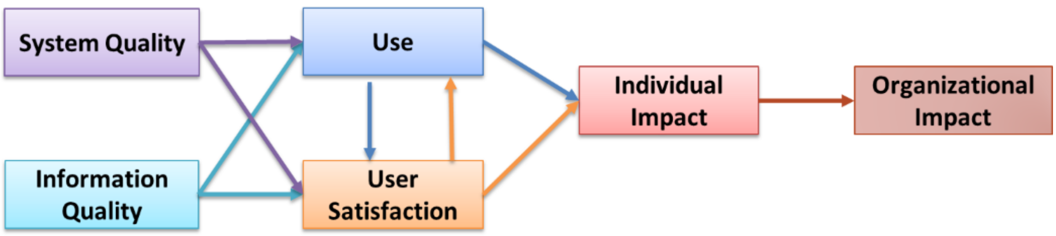


Figure 17 The Original DeLone and McLean IS Success Model
Source: (DeLone and McLean 1992)

Their conclusions are that (DeLone and McLean 1992) (DeLone and McLean 2003): (1) the multidimensional and interdependent nature of IS success should be considered with careful attention in order to measure the possible interactions among the dimensions so the effects of various independent dimensions with one or more of these dependent success dimensions can be isolated; (2) choice of selecting success dimensions and measures should be decided based on the objectives and context of the research; however, whenever it is possible, tested and proven measures should be applied; (3) although the IS success concept is multidimensional, researchers need to make attempt to reduce the number of measures to measure IS success so that research results can be more easily compared and validated the findings; (4) the proposed success model should be further validated and developed before it could be used as a basis for the IS success measures selection.

Because IS success was and still is an interesting topic, many researchers have accepted the authors' call for further model validation and adaptations in their contexts of use. Researchers have critiqued, challenged or extended the D&M model. Model formation and the relationships between dimensions have received relatively mixed empirical support in IS literature to date. Ten years later, having in mind received feedback from research community, the authors updated the model for *e-commerce contexts* and suggested an extension of the model with the *service quality* dimension (DeLone and McLean 2003). Because of the difficulties the researchers had in measuring *use*, they concluded that it may sometimes be more appropriate instead of measuring the behaviour, i.e. *IS use,* to measure the attitude, i.e. *intention to use*. They stated that increased *user satisfaction* leads to higher *intention to use*, which then again affects *use*. Therefore, they added *intention to use* to the new version of the IS success model. Further, they grouped *impact on the individual level* and *impact on the organizational level* into one dimension named *net benefits* (i.e. consequences of use) (DeLone and McLean 2003). "This new variable, "net benefits," immediately raises three issues that must be taken into account: what qualifies as a "benefit"? for whom? and at what level of analysis?" (Delone and Mclean 2004). This change stemmed from the need to adopt appropriate variables when measuring information system success in different contexts. Short description of the dimensions of DeLone and McLean IS success model is presented in Table 2.

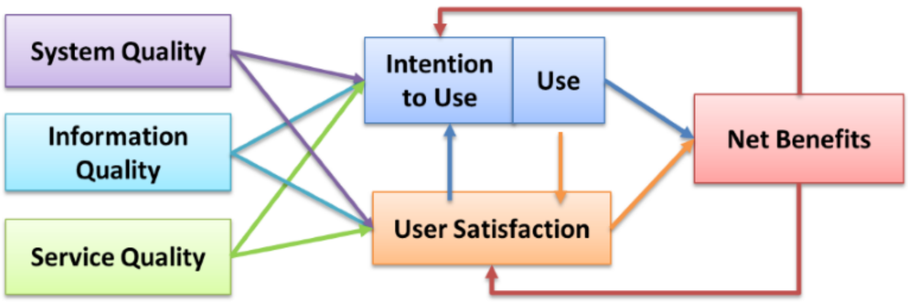


Figure 18 The Updated DeLone and McLean IS Success Model
Source: (DeLone and McLean 2003)

Under the concept information system within IS studies is meant either "some aspect of an application of information technology (IT), one individual application, a group of applications (including those of an entire organization), or an application of one type of IT" (Seddon 1997). As we have so many different types of information systems and contexts of their use, D&M model has been adapted to suit specific environments and it has been used for *IS success measurement* of e-learning systems (Lin 2007), (Balaban, Mu, and Divjak 2013), e-government systems (Wang and Liao 2008), e-commerce systems (Wang 2008), open source systems (S. M. Lee and Lee 2012), mobile and internet banking systems (Koo, Wati, and Chung 2013), etc. However, much of the past studies usually recycle measures and constructs of previous studies without much considerations about type and scope of the systems (Petter, DeLone, and McLean 2008; Gable, Sedera, and Chan 2008; Tate et al. 2014) and due the rapid changing technological environment there is great need to review this well respected success framework.

The model was primarily developed for stationary systems within organizational contexts i.e. as utilitarian systems. One of the strongest criticisms of the D&M IS Success model is done by Seddon (Seddon 1997). He argued that the mixed statistical support on the hypothesized relationships is due to the lack of theoretical clarity in the model's formation. Along with others (Wang 2008), (Gable, Sedera, and Chan 2008), (Sedera, Eden, and McLean 2013) he believed that IS success model needs further clarity in terms of defining its nature (whether it is of process or casual nature) and what measures are right to measure IS success. Dimension that was unclear then and still brings confusion is *IS use*. Seddon (Seddon 1997) claims that *IS use* is a behaviour, and not a success measure and he suggests replacement of D&M *IS use* with dimension *perceived usefulness*, which serves as a general perceptual measure of the *net benefits of IS use* whether it is in volitional or non-volitional usage context. Further, Wang (Wang 2008) stated that the nomological structure of the updated D&M model is slightly inconsistent with *IS acceptance* and *marketing literature*. So he re-specified the model and replaced *IS use* dimension with *perceived value* and added as ultimate depended variable *intention to reuse.* The aim of these changes was to simplify the return relationship between *use*, *satisfaction* and *intention to use* as depicted in the updated D&M model. This new depended dimension of success model *intention to use* is similar to *customer loyalty* dimension from marketing studies and presents a customer's favourable attitude towards an e-commerce system that results in repeated use or purchase behaviour (Wang 2008). Other criticism of the model was that the *net benefit* dimension of the updated DeLone and McLean IS success model was too broad to define (Wang 2008). As consequence, the researchers need to clearly and carefully define, who are the stakeholders within the context in which *net benefits* are to be measured. Sedera et al. (Sedera, Eden, and McLean 2013) made one of the largest IS success studies in organizational contexts which took seven years to complete. In their extensive study, they confirmed that IS success model is *casual* (variance model), and that *satisfaction* is rather a consequence of IS success than mediator. Although the *IS use* was a separate construct in DeLone and McLean model that had strong mediating role between *information quality* and *individual impact* still it was difficult to operationalize *IS use* within their study due its multidimensional nature (Sedera, Eden, and McLean 2013). Nevertheless, *DeLone and McLean IS success model* has become one of the most cited success evaluation frameworks in IS literature.

On the 15th panel held at the *Pacific Asia Conference on Information Systems* (PACIS) in Brisbane 2011, respectable researchers from the field of information system discussed the possible twenty year update of *D&M IS success model* (Tate et al. 2014). Several major implications from this panel can be drawn. Professor McLean suggested that dimension *service quality* (introduced success dimension into the updated DeLone and Mclean IS success model) may not add anything to the understanding of IS success beyond what was already encompassed in the original D&M model; and that maybe the *good service quality* is just a combination of *systems quality* and *information quality* and that the new term is redundant (Tate et al. 2014). Andrew Burton-Jones, a respected IS researcher as well, suggested that fresh approaches to theory and measurement of IS success are needed, and that these new IS streams should have multi-level view i.e. how individual impact turns into collective impact, and to research diffusion of IS beyond organizational context (Tate et al. 2014). DeLone and McLean IS success model still continues to provide an adequate explanation for the individual and organizational benefits of the utilitarian information systems. However, as information systems have evolved and become highly interactive, mobile and aren't just used in work related contexts but as well for personal and leisure purposes (more than ever before), dimensions information systems success should be redefined to fit these changes. "*What still remains to be discovered is if the D&M model is appropriate for hedonic IS. Some of the dimensions may no longer be relevant or may need to be measured differently for gaming, social networking, or other types of IS used for enjoyment*" was one of the conclusion remarks from (Petter, DeLone, and McLean 2008). DeLone and McLean IS model in its last updated version, may not adequately explain usage of non-work interactive mobile information systems. This is the main challenge the author of this thesis tries to revel within this study.

Table 2 DeLone and McLean Information System Success Dimensions

Dimension	**Description**	**Original or Updated D&M model**
Information quality	Presents the quality measures of the IS output (DeLone and McLean 1992). It is constituted of desirable characteristics of IS output (Urbach and Müller 2012), i.e. the quality of the information the system produces in reports and on-screen (Gable, Sedera, and Chan 2008). Some most commonly used attributes (characteristics) of the system output are *accuracy*, *currency*, *completeness,* etc.	***Original*** ***&*** **Updated**
System quality	Presents the measures of processing system. It is used as construct to describe the performance of IS from technical and design perspective (DeLone and McLean 1992) (Gable, Sedera, and Chan 2008). The measures of system quality are focused on usability aspects and performance characteristics of the system under examination (Urbach and Müller 2012). Early system measures include testing the performance of computer system such as *reliability, response time*, *turnaround time*, *system flexibility,* etc.	***Original*** ***&*** **Updated**
Service quality	Presents help and support to users by the IS department. This construct wasn't present in the original version of the DeLone and McLean model but was added later in their ten year update as a component of IS success (DeLone and McLean 2003). This dimension has value only if the system of analysis has support from IT department. Often used measures to measure service quality are *responsiveness*, *reliability*, and *empathy* of the support organization.	**Updated**

Dimension	Description	Original or Updated D&M model
Use/Intention to use	*Use* is the measure of recipient consumption of the output of an information system. It represents the degree and manner in which an information system is utilized by its users (Urbach and Müller 2012). But the application of this construct as dimension of success is questionable by some authors and its argued that it has multiple meanings that are often not clear in the studies (Seddon 1997). Some authors suggest that in case of the voluntary use *amount of use* (connect time, the functions utilized, or the frequency of use) could be used as success dimension, but that in mandatory contexts this interpretation may not be suitable. *System use* could also refers to active interaction between a user and the system interface in terms of browsing searching, or any other type of interactivity (Abbas Toloie-Eshlaghy 2013). Some studies replaced the *use* dimension with independent variables *perceived ease of use* and *perceived usefulness* from technology acceptance model (TAM) (Davis, Bagozzi, and Warshaw 1989), that contribute to attitude toward use, intention to use, and actual use (Seddon 1997). As there are difficulties in interpreting the dimension *use*, DeLone and McLean suggest in their updated version of the model that *intention to use* could be used as an alternative measure to *use* for some contexts. *Intention to use* is an attitude and means expected future consumption of an IS or its output (DeLone and McLean 2003). Within this study this dimension will be replaced with new dimension called *user experience quality dimension*.	***Original*** ***&*** **Updated**
User Satisfaction	Satisfaction is the measure of recipient response to the use of the output of an information	***Original***

Dimension	Description	Original or Updated D&M model
	system. It is the level of *satisfaction/content* when utilizing an information system (Urbach and Müller 2012). According to ISO 9241-11:1998 *satisfaction* is the freedom from discomfort and positive attitudes towards the use of the product (ISO 9241-11:1998 2014). Some researchers demonstrate that satisfaction is "*better conceived as an immediate antecedent (the ultimate dependent variable, rather than as a mediator between Quality and Impacts)"* (Sedera, Eden, and McLean 2013). Therefore within this study *satisfaction* will be considered as a *sub-dimension* of *perceived benefits of use* rather than a standalone dimension as was initially proposed by DeLone and McLean.	**&** **Updated**
Individual Impact	*Individual impact* is the measure of the effect of information on the recipient. It presents the benefits accruing to individuals from the system use (Seddon 1997). According to DeLone and McLean, the idea of dimension individual impact is "*an indication that an information system has given a user a better understanding of the decision context, has improved his or her decision making productivity, has produced a change in user activity, or has changed the decision maker's perception of the importance or usefulness of the information system*" (DeLone and McLean 1992).	***Original***
Organizational Impact	Organizational impact is the measure of the effect of information system on organizational performance. Organizational performance is not just summation of individual impacts although individual impact has effect on the performance of the whole organization. Organization	***Original***

Dimension	Description	Original or Updated D&M model
	performance is an important indicator for measuring the effectiveness of an information system, and that organizational impact is mainly related to cost, sales, and profit (DeLone and McLean 1992).	
Net Benefits	*Net Benefits* constitutes the extent to which IS contributes to the success of the different stakeholders: individual, organizational, societal, governmental, etc. (Urbach and Müller 2012). DeLone and McLean replaced the variables *individual* and *organizational impact* with one named *net benefits*. This change enables the model to be applied for multiple levels of analysis, whatever level of analysis the researcher considers the most relevant (Petter, DeLone, and McLean 2008).	**Updated**

Source: made by the author

2.9 Hedonic and Utilitarian Product Values

Consumer (user) behaviour is strongly motivated by perceived utilitarian and hedonic values from product consummation (usage). Satisfaction is no longer enough to attract and keep consumers. Studies suggest that if consumers have delightful experiences with a product usage (consummation), they are more willing to stay loyal to the company and to repute purchase or buy the next product from the same company.

2.9.1 Experience Economy

Today's market is driven by the consumers and marketers have to offer more than just basic functionalities in order to attract and keep them. As traditional approaches lose their effectiveness, researchers are actively looking for new approaches to attract and keep consumers and remain on top of the market. Many researchers advocate that the main route to reach long-lasting competitive advantages is putting stronger focus on the consumer (Gentile, Spiller, & Noci, 2007). One of the new insights is to expand consumer centric approach. Consumers do not seek just utilitarian value of consumption anymore (functional, instrumental, and practical benefits) but also seek for emotional hedonic value (experiential, and enjoyment-related benefits) (Chitturi et al., 2008). Consumers often seek sensations on multiple sensory channels in order to have a pleasurable experience of product consumption (Holbrook and Hirschman 1982). Focus from *offering a service* shifted towards *offering an experience.* This new economical stream is called *experience economy* (B. Joseph Pine and Gilmore 1999) (Figure 19). Consumers are not just satisfied with product consummation, they want to the have a *great experience* while consuming the product (B. Joseph Pine and Gilmore 1999). Prior economic offerings (commodities, goods, and services) are external to the buyer, while experiences are personal. They exist only in the mind of an individual who has been engaged on an emotional, physical, intellectual, or even spiritual level (B. Joseph Pine and Gilmore 1998). Experience of one is different from experience of other. Experience is not an amorphous construct, it is as real an offering as any service, good, or commodity (B. Joseph Pine and Gilmore 1998). Each stage in the evolution of products had its time and still relevant but if company want to be successful and leader in today's competitive market it should move from lower stages to upper stages. In the first phase, commodity business charges for undifferentiated products. In next phase goods business charges for distinctive, tangible things such as goods. In next phase, service business charges for the activities consumer perform, such as dinner. In the following stage, an experience business charges for the feeling customers get by engaging it, such as Walt Disney or Amsterdam Heineken museum. A transformation business charges for the benefit customers (or “guests”) receive by spending time there. Even though the concept of the experience economy emerged in the business field, it has spread to other of toady’s most important industries (tourism, architecture, hospitality, marketing, technology).

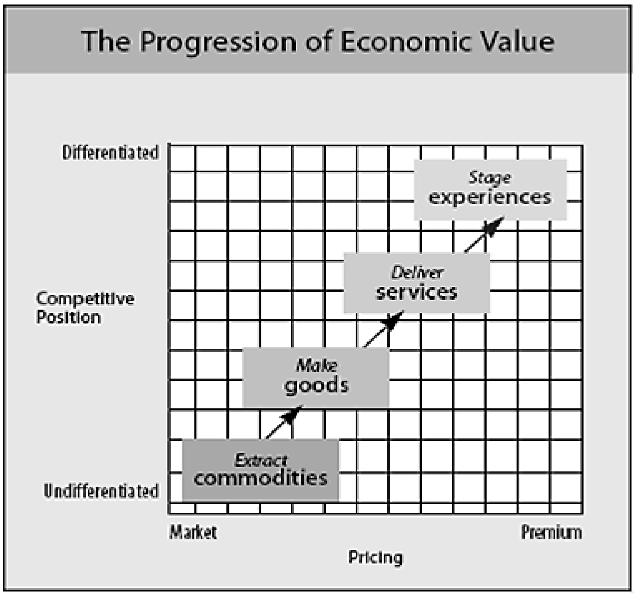


Figure 19 The Progression of Economic Value
Source: (B. Joseph Pine and Gilmore 1999)

New technologies enable new genres of experience, such as interactive games, Internet chat rooms and multi-player games, motion-based simulators, and virtual reality (B J Pine 2nd and Gilmore 1998). In a speech made at the November 1996 COMDEX computer trade show, Intel chairman Andrew Grove declared, “*We need to look at our business as more than simply the building and selling of personal computers. Our business is the delivery of information and lifelike interactive experiences*.” (B J Pine 2nd and Gilmore 1998). The whole interaction experience concept is primarily responsible for the huge and still leading success of Apple products (iPhone, iPad, Apple Watch).

According to Hassenzahl (Hassenzahl, 2013), some studies show that experiential purchases i.e., those connected to experiences a person has to live through, such as concerts, dinners, journeys) make people more happy than material purchases (i.e., the acquisition of tangible objects, such as clothing, jewellery, stereo equipment) of the same value. Gentile et al. (2007) argue that, regardless of the context, customers want to live positive consumption experiences, and that it is important to deliver an adequate balance between utilitarian and hedonic value. Consumers evaluate products/services both *objectively* and *subjectively*. Objective dimension is focused on utilitarian dimension of instrumentality (e.g., how useful or beneficial the object is), and hedonic dimension measures the experiential affect associated with the object (e.g., how pleasant and agreeable those associated feelings are) (Batra and Ahtola 1991). Research of the product hedonic values besides the utilitarian ones, has been addressed in various disciplines such as *sociology*, *psychology*, *economics*, and more recently and very intensively in the *human computer interaction* field. Consumers are no longer deemed just as rational decision makers but as experienced experiential seekers. In marketing literature this new paradigm is explored under the term *consumer/customer experience*, in tourism literature as *tourism experience* and in human computer interaction discipline (HCI) as *user experience*. All three disciplines have common ground and agree that consumption should be focused on creating *positive hedonic experiences* and not just on fulfilling utilitarian needs.

2.9.2 Human Computer Interaction

Human Computer Interaction (HCI) is field that studies the interaction (communication) between people (users) and computers. People interact with computers in many ways and the interface between users and the computers is primary way of interaction. However, HCI is not only limited to the user interface but on the general process of interaction. HCI is concerned with both the *hardware* and the *software* of *human-computer interaction* (Booth 2014). Three main components of HCI are *user*, *computer* and *interaction* between computer and users (Danino 2001). User is an individual or a group of users that work together. With the computer term means any technology ranging from desktop computers, websites, desktop or mobile application, mobile phones, tablets, etc. Interaction is communication between users and computers. HCI is interdisciplinary area and it is often regarded as the intersection of computer science, behavioural sciences, psychology and ergonomics. According to Association for Computing Machinery (ACM), human-computer interaction can be defined as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" (ACM 1992). HCI researchers try to solve problems in the design and use of technology in order to make computer-based systems easier to use, effective and satisfying for people in a wide variety of contexts (Tan and Nijholt 2010).

Research and practice of HCI started in the late 1970s and early 1980s, within an area of Computer Science, as result of the personal computer (PC) raise. First research streams was often about how people interacted with office automation program, such as word-processing, database and statistical software and how people reacted to the widgets, dialog boxes, and error messages of these systems (Lazar, Feng, and Hochheiser 2010). In late 1980s there were more research work that researched and tested usability of systems. But, a major expansion of HCI research began with mass Internet usage. Here researchers studied how to make web pages, e-mail and instant messaging systems more usable and more appealing to the users.

Early HCI evaluation measures were oriented towards measuring task completion success and included *task correctness*, *time performance*, *error rate*, *time to learn*, *retention over time*, *user satisfaction* (Lazar, Feng, and Hochheiser 2010). These measures were also adopted by the industry and standards related organization. Even though these metric are still often used they can only be applied in the situations where system usage can be quantified. However, many of technology today is used outside offices and voluntarily and therefore these industry measures cannot be fully applied in order to understand users' acceptance and the success of these systems. Beginning of 2000s the focus of research shifted from workplace efficiency towards user-generated content and it has been concentrated on collaboration, connection, emotion, and communication of ordinary users (Lazar, Feng, and Hochheiser 2010). Today we have sensor enabled computer devices that enable us more natural way of communication through voice, gesture, touch, etc. Computer technology is becoming increasingly ubiquitous and therefore there is great need to take a *human-cantered approach* in the design, development an evaluation of this technology. There is need for new measures for these new situations of use. The focus of today's HCI researchers is to develop new design methodologies, to experiment with new devices, to prototype new software systems, to explore new interaction paradigms, and to develop models and theories of interaction (Fransoo, Waefler, and Wilson 2010).

2.9.2.1 Usability

The focus of early HCI experts was on the lacks of interface design and how to improve their easy to use, and how to help users to accomplish instrumental goals (Hassenzahl and Tractinsky 2006), i.e. how to accomplish *usability* of a system. The term *usability* was introduced in 1980s in order to replace the term *user friendly*. But today both terms can be found in HCI literature. One of the first definition of the usability is that that systems should be easy to use, easy to learn, flexible and should engender a good attitude in people (Shackel 1990). More recent definitions add acceptability to the definition of usability. According to Holzinger (Holzinger 2005) usability is defined as ease of use and acceptability of a system for a particular class of users carrying out specific tasks in a specific environment. It is used to ensure that system under consideration is adapted to the users and their context of use. In summary, the general the idea of usability is to ensure that system should be easy to learn, easy to remember, and easy to use, and must lead to few errors. In practice there is almost 100 different usability tests, where most of them contain some combination of *completion rates*, *errors*, *task times*, *task-level satisfaction*, *test-level satisfaction*, *help access*, and *lists of usability problems* (typically including frequency and severity). Some of the most popular usability questionnaires are: (1) Questionnaire for User Interaction Satisfaction (QUIS), (2) Software Usability Measurement Inventory (SUMI); (3) System Usability Scale (SUS); (4) Post-Study System Usability Questionnaire (PSSUQ), etc.

Usability testing can be divided into three general categories (Battleson, Booth, and Weintrop 2001): *inquiry*, *inspection*, and *formal usability testing methods*. Inquiry uses techniques such as focus groups, interviews, questionnaires, and surveys in order to request information about particular system from the user. First two techniques are generally used at early stages of product development, while last two are generally used later in the product's life cycle (Battleson, Booth, and Weintrop 2001). Inspection methods include cognitive walkthrough and heuristic evaluation. Cognitive walkthrough is a task-oriented method by which the analyst explores the system's functionalities by simulating step-by-step user behaviour for a given task (Holzinger 2005). Heuristic evaluation is based on predefined checklist of heuristics e.g. Nielsen's Usability Heuristics. Expert, then uses the system several times and inspects the various interactive elements, and compares them with a list of usability principles (Holzinger 2005). This approach is relatively inexpensive to conduct, but are less useful in identifying usability errors than tests with actual users (Battleson, Booth, and Weintrop 2001). In formal usability testing, real users are performing some specific task while researcher monitors and records users' behaviour. Holzinger (Holzinger 2005) under the inspection methods adds the *action analysis*, and under the formal usability testing *thinking aloud* and *field observations* (see (Holzinger 2005)).

Usability as a system measure has been accepted by the International Standard Organization (ISO) and they define usability as the extent to which a product can be used by specified users to achieve specified goals with *effectiveness* (i.e., how well the system's performances meet the tasks for which it was designed), *efficiency* (i.e., how much resources such as time or effort is required to use the system in order to achieve tasks for which the system was design), and *satisfaction* (i.e. positive attitudes and responses from the intended users) in a specified environment (ISO, 1998). However, within the standard there haven't been specified guidelines how to measure these system characteristics i.e. usability of the system. With emergence of new technologies (such as the Web, portable media players such as iPods, smart devices iPhone), users are not necessarily seeking to achieve a task, but also to amuse and entertain themselves (Petrie and Bevan 2009). Therefore the evaluation methods of these interactive systems should go beyond effectiveness, efficiency, and satisfaction (Petrie and Bevan 2009). Usability is important, but on its own it is not enough to guarantee a product's success with customers (Battarbee and Koskinen 2005).

2.9.2.2 User Experience

Researchers began to research usability but then expanded their search and shifted their focus on *hedonic aspects* of technology use (Hassenzahl and Tractinsky 2006). The term *user experience* (UX) is used in different contexts with a wide range of meanings and there is no common definition. If we split the term and try to define words separately it means the following: *experience* is used to describe perceived on-going events and the wisdom gained from the interpretations of these events; and the *user's* part is combined of both pragmatic user goals and hedonic user goals. In some early attempts to define user experience there were several studies that made significant contribution to todays' concept of experience (Alben 1996; Hassenzahl and Tractinsky 2006; B. Joseph Pine and Gilmore 1999; Forlizzi and Battarbee 2004; Norman 2005; Shedroff 2001). Norman (Norman 2005) argues that "the emotional side of design may be more critical to a product's success than its practical elements". User experience is complex, and covers psychological, social and physiological concepts (Effie Lai-Chong Law, van Schaik, and Roto 2014). One of common descriptions of user experience is by Hassenzahl, where he defines user experience as *"*a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service" (Hassenzahl 2008). Law et al. (Effie Lai-Chong Law et al. 2009) provide similar definition of user experience as "*something individual (instead of social) that emerges from interacting with a product, system, service or an object*". Heo et al. (Heo et al. 2009) also note that user experience encompasses the user's thoughts and feelings about their interaction with the device. Basically *user experience* transmits the focus from the product and materials (functional/instrumental side) to human feelings (subjective side of product use), and it becomes a temporal phenomenon, present-oriented (which can also be a summary retrospective) and could change over time (Hassenzahl 2008). User experience occurs *before*, *during*, and *after interaction* with products and besides *usability goals* focuses on *hedonic qualities* of use as well. Hassenzahl argued that people perceive interactive products through two dimensions: *pragmatic quality* and *hedonic quality* (Hassenzahl 2005). Pragmatic quality represents the product's ability to support the achievement of "do-goals" (task oriented goals), focuses on products utility and usability in relation to potential task. Hedonic quality represents the product's ability to support the achievements of "be-goals", focuses on why someone owns and uses a particular product (because of its novelty, personal growth, self-expression, etc.). Further, Hassenzahl argues that the fulfilment of be-goals is the driving force behind an experience, and do-goals facilitate the potential fulfilment of be-goals (Hassenzahl 2005). User experience can be understand as individual perceptions that vary through the context of usage. According to ISO 9241-210 the user-experience is defined as "all aspects of the user's experience when interacting with the product, service, environment or facility (..) Person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service (...) User experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours and accomplishments that occur before, during and after use. (…) User experience is a consequence of brand image, presentation, functionality, system performance, interactive behaviour and assistive capabilities of the interactive system, the user's internal and physical state resulting from prior experiences, attitudes, skills and personality, and the context of use." (ISO/IEC 25010 2011). Definition by ISO leaves a lot of space for arbitrary interpretations. It is ambiguous and need to be refined (Effie Lai-Chong Law and Abrahão 2014). But in general confirm that user subjective feelings are an important part of product evaluation.

User experience presents a new paradigm for designing and evaluating modern interactive products (Bargas-Avila and Hornb\a ek 2011). Bevan (Bevan 2009) argues that regardless of the terminology used for user experience, in general there are two distinct objectives: (1) *optimizing human performance* or (2) *optimizing user satisfaction with achieving both pragmatic and hedonic goals*. Technology-oriented companies traditionally have tested their products against the usability and experiential aspects that were predominantly just the marketing strategy (Väänänen-vainio-mattila, Roto, and Hassenzahl 2008). The user experience concept challenges old approaches of measuring product/software quality and introduces new concepts such as *fun*, *beauty* and *pleasure* as part of the evaluation process (Isleifsdottir and Larusdottir 2008). Effie et al. (Effie Lai-Chong Law et al. 2009) recommends the term *user experience* should be scoped "to products, systems, services, and objects that a person interacts with through a user interface, these can be tools, knowledge systems, or entertainment services" (Figure 20).

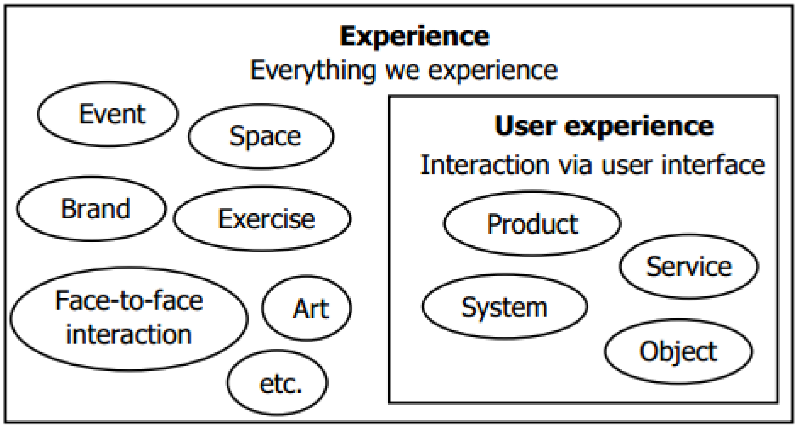


Figure 20 User Experience in Relation to Other Experiences
Source: (Effie Lai-Chong Law et al. 2009)

Hassenzahl and Ullrich (Hassenzahl and Ullrich 2007) state that when users are evaluating a product, they are judging the *overall quality of a product* based on their memory, momentary experience episodes. Summative judgments then guide users in decision whether they are satisfied with the products and whether they are willing to continue to use the products and recommend them to others (Kujala et al. 2011). High quality user experience affects user's intention to adopt the product (Hassenzahl and Tractinsky 2006) and also the user's *loyalty* towards it (Effie L. -C. Law and van Schaik 2010).

Even though, academia and industry have high interest in user experience, there is no common accepted way how to *evaluate* and *measure* user experience. Vermeeren et al. (Vermeeren et al. 2010) made summative literature review about the existing user experience measurement methods and published an online collection of their references along with the scope and the strengths and weaknesses of these methods. In total there are *96 user experience methods* listed, and some of the listed methods are quantitative and some are qualitative, and some use multi-method approach. But many of these methods lack a formal test for *validity* and *reliability* and are avoided as they are presumed not to be trustworthy or too complicated. Also, many methods do not take in account consequences that arise from interaction with the product. There are also many others attempts to define and measure user experience with quantitative data analysis methods such as psychophysiological measures heart rate measures, eye-tracking, skin conductance and EEG measures. These methods showed to be more laboratory oriented and more expensive to perform in practical field research. Therefore many researchers use simpler methodological approaches such as surveys or interviews. Some of the most popular methods used to measure user experience are the following:

- *User Experience Questionnaire* (UEQ) - (Laugwitz, Held, and Schrepp 2008) presented this questionnaire for assessment of the overall impression of a user when he or she interacts with a product. The scales of the questionnaire measure both usability aspects (*efficiency, perspicuity, dependability*) and user experience aspects (*originality, stimulation*).

- *AttrakDiff* – is used for measuring a product's *pragmatic quality* (usability), *hedonic quality stimulation* (novel, interesting), *hedonic quality identity* (identification with it) and *attractiveness* (perception value) ("AttrakDiff" 2013). Later, the simpler version of this instrument *AttrakDiff 2* was developed in which evocation was dropped out from the questionnaire.

- *Experience Sampling Method* (ESM) - is a method for collecting information about the daily life of individuals. It captures the stream of consciousness and links between the external context and contents of the mind (Hektner, Schmidt, and Csikszentmihalyi 2006). Individuals need to provide written answers on both open and close ended questions at several random points in time through the day and through the week.

- *iScale* – is an instrument that employs sketching as a procedure for reconstructing user experiences with a product (Karapanos, Martens, and Hassenzahl 2010).

- *Product Emotion Measurement instrument* (PrEmo) – is a visual instrument which aim is to simplify assessment of consumer emotions. It is based on animated cartoon characters that present a set of 14 emotions. Participants report responses by selecting one of the cartoon animations that corresponds with their feelings. "Of these 14 emotions, seven are pleasant (i.e. desire, pleasant surprise, inspiration, amusement, admiration, satisfaction, fascination), and seven are unpleasant (i.e. indignation, contempt, disgust, unpleasant surprise, dissatisfaction, disappointment, and boredom)" (Desmet 2005).

- *HED-UT Scale* - It addresses the utilitarian and the hedonic components of attitude. It was developed for "evaluating the effectiveness of advertisers in convincing consumers to assign a higher, or perhaps a lower, hedonic value to their offering" (Spangenberg, Voss, and Crowley

1997). It consists of 12 items measuring hedonic value, and 12 items measuring utilitarian value of a service.

- *Service User eXperience (ServUX)* – is a questionnaire developed in order to support assessment of modern web services in order to promote and support positive and engaging user experiences (Väänänen-Vainio-Mattila and Segerståhl 2009). The idea about this survey came in 2008 when the researchers wanted to address different characteristics of Web 2.0 tools which affect user experience of interactions with them. The questionnaire can be used for evaluation, research as well as development purposes of web services (Väänänen-Vainio-Mattila and Segerståhl 2009). Later it was extended and today's form of the questionnaire addresses distinct aspects such as: *cross-platform and crossmedial interaction*, *user-driven service composition*, *social communication and construction*, *dynamic content and functionality*, *contextual computing*, and other ServUX-related issues such as *trust* and *privacy*.

- *Components of User Experience CUE-Model* - Mahlke and Thüring (Mahlke and Thüring 2007) developed the model with the aim to explain UX as a consequence of the user's interaction with the system. "Usually, this interaction aims at accomplishing a particular task, takes place in a certain context and extends over a limited period of time. In this context, features of the user – such as knowledge or skills – as well as features of the system – such as functionality and interface design – affect the interaction and determine its major characteristics" (Mahlke and Thüring 2007). Minge and Riedel (2013) developed an extension of this model, the so called meCUE model. They extended and adapted the scales and put more focus on the following aspects: *effectiveness*, *efficiency*, *visual aesthetics*, *status*, *commitment*, *positive emotion*, *negative emotion*, *product loyalty* and *intention to use*.

- *Game Experience Questionnaire* (GEQ) – is a questionnaire that assesses experiential constructs of *immersion*, *tension*, *competence*, *flow*, *negative affect*, *positive affect* and *challenge* (Ijsselsteijn, de Kort, and Poels)(Gajadhar, de Kort, and IJsselsteijn 2008). The questionnaire components are organized in three modules: 1) *core module* – assess the experiences during game play; 2) *social presence module* – assess playing with others; 3) *post game module* - assess experiences after the player has stopped to play the game.

2.10 Summary Analysis of Literature Review

The view on information systems (IS) has changed dramatically in the last few decades as well. There are thousands, even millions, of information systems in the world, and not all relate to business (Kroenke 2011). Various information systems that we use today in organizational context are purely utilitarian or productive by their nature. However, there are many systems we aim to use for hedonic purposes (such as games and other entertainment services) (Heijden 2004), (Petter, DeLone, and McLean 2012), (Gerow et al. 2013). Within these two extremes there are many information systems that fulfil both purposes productivity (e.g. usefulness) and hedonism (e.g. enjoyment) e.g. tourism systems and fitness systems. Having access to the right information sources is not only crucial for the success of commercial businesses but also for social pursuits of individuals (Bilandzic, Foth, and De Luca 2008). The use of IS for personal purposes in non-work contexts such as the home has tended to be ignored (Vodanovich, Sundaram, and Myers 2010). One of the strongest criticisms of IS field is done by Yoo (Yoo 2010). He argues that IS researchers should move focus from traditional view that IS is only present in organizational context due the fact that we now live in a world of *ubiquitous* and *embedded digital artefacts*, which shape and mediate our everyday life experiences (Yoo 2010). This change in focus from organization-centric to individual-centric resulted in a definition of *personal/individual IS* (Baskerville 2011a), where *personal/individual IS* serves individuals for their personal leisure and/or business information activities and is oriented towards information needs of an individual or even to the individual's home and family (Baskerville 2011c). Rapid technological development has effects on users' expectations as well. According to Batra and Ahtola, consumers purchase goods and services or perform consumption behaviours based on two reasons" (Batra and Ahtola 1991): (1) consummatory affective (hedonic) gratification (from sensory attributes), and (2) instrumental, utilitarian reasons concerned with expectations of consequences (of a means-ends variety, from functional and non-sensory attributes). Users today want more than just a usable system, they want systems that will ensure them a pleasing and engaging experience (Preece, Sharp, and Rogers 2015). Gartner research director Brian Blau in 2013 said the following: "*We see that users are not put off by the fact that they have already paid for an app, and are willing to spend more if they are happy with the experience. As a result, we believe that IAP*[3] *is a promising and sustainable monetization method because*

[3] IAP – In-App Purchase

it encourages performance-based purchasing; that is, users only pay when they are happy with the experience, and developers have to work hard to earn the revenue through good design and performance" (Gartner 2013). From this statement we see that for users money is no longer key issue if they will get what they expect from the application i.e. "*happy experience*". Researchers Väänänen-vainio-mattila et al. (Väänänen-vainio-mattila, Roto, and Hassenzahl 2008) argue that product development is no longer only about "implementing features and testing their usability, but about designing products that are enjoyable and support fundamental human needs and values". Designers of modern interactive mobile information systems should strive to meet both *pragmatic* and *hedonic* users' expectations and even to surpass them in order to achieve success and competitive advantage on the market.

3. METHODOLOGY OF THE STUDY

This doctoral thesis follows the guidelines of the *design science research* (DSR) methodology approach (V Vaishnavi and Kuechler 2004; Hevner et al. 2004; Österle et al. 2011). Design science research is mostly used in disciplines like *engineering* and *computer science*. Nine years ago Hevner et al. published the seminal paper on "*Design Science in Information Systems Research*" in MIS Quarterly (Hevner et al. 2004). This paper made huge impact on many researchers in the field of information systems and encouraged researchers to cross the boundary between researching *IS impact* and *IS development*. Hevner and Chatterjee (Hevner and Chatterjee 2010) in their book explain the complementary between *behavioural sciences* and *design science research* paradigms in the context of information systems research as following: "*Behavioural science identifies a business need and develops and justifies theories that explain or predict phenomena related to this need. Design science research builds and evaluates artefacts that address particular business needs. Behavioural science researchers search for the truth, while design science researchers seek utility*". Design science researchers are focused on the understanding, explaining and improving IS. This research approach is dominant in the German-speaking countries and also of the Nordic countries, but the cases can also be found in the Netherlands, Italy, and France (Winter 2008) (Österle et al. 2011). Since 2006 annual conference on design science has been organized under the name "*Design Science Research in Information Systems & Technology* (DESRIST)". The outputs of the *design science research* can be grouped into five groups according to the work of Vaishnavi and Kuechler (Vijay Vaishnavi and Kuechler 2007):

(1) *constructs* (the conceptual vocabulary of a domain),

(2) *models* (a set of the propositions or statements expressing relationship between constructs),

(3) *methods* (a set of the steps used to perform a task i.e. *how-to-knowledge*),

(4) *instantiations* (the operationalization of the constructs, model, and methods) or

(5) *better theories* (artefact construction as analogous to experimental natural science).

Within this doctoral thesis, a five step process presented by Vaishnavi and Kuechler will be followed (Vijay Vaishnavi and Kuechler 2007) (Figure 21).

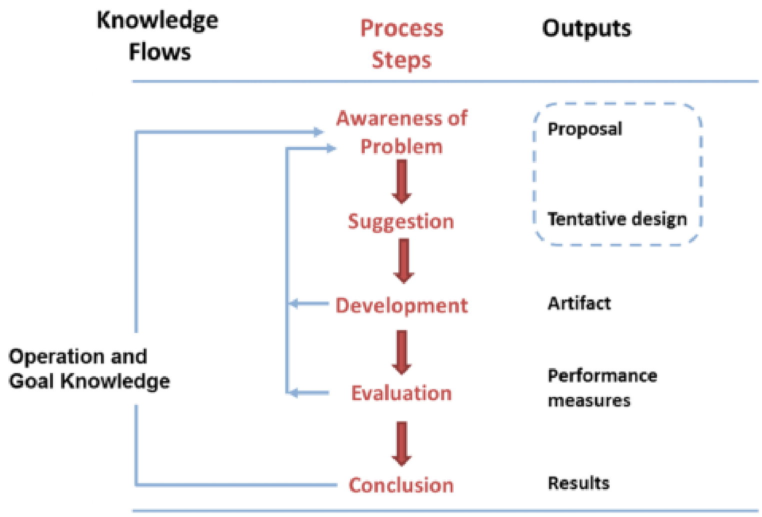


Figure 21 Design Research General Steps
Source: (Vijay Vaishnavi and Kuechler 2007)

The first step of the DSR is called *Problem Awareness*. In this step, based on theory and/or practice, researcher identifies the important problem or need from business, science or society whose solution is valuable. The output of this step is *proposal* of new research effort. The second step is *Suggestion*. In this step, researcher proposes the solution of the defined problem. Suggestion step results in *tentative design* of possible research problem solution. This is the most creative step, where researcher envision new functionalities, possibilities as layer above existing elements or as integration, improvement of the already existing elements. The third step is the *Development* of the artefact. In this step, researcher designs or develops the solution of the problem. Here most important is novelty or the development something slightly different from already existing. Once the artefact is developed, follows fourth step *Evaluation*, i.e. validation of artefacts due its objectives. Here the hypotheses about the behaviour of artefact are tested (confirm or contradict underlying hypothesis). If the gained results are not satisfactory the return loop to the problem formulation or in changing circumscription parameters are made. Then follows the final step where researcher makes *Conclusions* on the basis of the results of the evaluation. Development and evaluation of an artefact can be iterative until a planned outcome is achieved. Next chapters are organized according to the presented steps of the design science research in order for readers to more easily follow the doctoral dissertation plan and workflow.

4. PROBLEM AWARENESS

4.1 Problem Introduction

The research quest began with gathering relevant literature from the information systems studies and human computer interaction studies by using relevant and accessible databases such as Google Scholar, IEEE Xplore Digital Library, Science Direct and Springer Link. Majority of IS researchers are focused on research and investigation of the IS in the workplace/office, and ignore personal information systems. However, the boundaries between business and personal contexts of information technology use are no longer clear. In the following years, we'll be overwhelmed with feature reach devices that will allow us to access information everywhere, at any time, and in a personalized manner according to our own personal needs and with various input/output modalities (voice, gestures, facial expressions, motion and vitality sensors, etc.). Users want interactive systems that will meet both their utilitarian and hedonic needs. They want systems that are useful, easy and safe to use, satisfying, attractive, simulative, and enjoyable. All these characteristics, and even more, are important for the success of today's interactive systems. If a particular interactive system does not meet the user's needs, the user will simply choose another one (e.g. another website, another application, or another device). Today there are so many alternatives we can choose from. As there is variety of different interactive systems, it is very challenging to define an evaluation framework that will efficiently measure the success in all of the contexts of use. Different researchers in a different context can have different views about what success means for them. Researchers need to start their evaluation by defining the scope of their research and by defining the meaning of success within the defined scope. At the organizational level, IS success can mean an increase in *decision effectiveness* of managers, but at the individual level, IS success can mean improvements in *job performance*, *satisfaction level*, or even emergence of other feelings such as *joy, happiness,* as a result of *personal goals achievement*. Success is not one-dimensional; in fact it can mean multiple things at the same time. For example, the success of an online learning system can be due to the quality of the information, the speed of the system, the accessibility of the system, learning efficiency, the satisfaction level of users (i.e. teachers and students), etc.

Success evaluation of systems in their natural environment of usage is known as summative evaluation. This type of evaluation enables researchers to identify how the user perceives the system in terms of quality, what users like (what are the good sides of their systems) or dislike (what are the bad sides of their systems), what aspects of the system contribute more or less to the overall value of the system usage, and use these findings as strategies for system improvements.

Majority of IT/IS researchers have focused their attention to the problems of interactive systems design, especially due to different device characteristics (screen size, memory, integrated sensors, etc.), and the context of use (stationary, mobile, business, personal). However, to see whether the interactive systems meet the user's utilitarian and hedonic needs, these products need to be evaluated in the natural contexts of their use. Evaluation is important from the business and marketing perspective, and providers can reveal lacks or major problems with their early system prototypes and correct them before systems go to sale (Preece, Sharp, and Rogers 2015). Features of interactive system components such as icon size, speed of the interaction, logical sequence of actions, should be tested before the product is on the mass market. This is the type of evaluation known in literature as formative evaluations. After the product has been launched and users started using it, we should move the attention to the success measurement of the interactive systems.

Different mobile application stores (Such as Apple App Store, Google Play, and Windows Phone Store), enable users to find, buy, and install software applications with just a few clicks. To survive in this competitive environment (with millions of mobile apps available through various app stores) the question of application (system) quality is becoming more important question. Techniques as stars rating, comments and number of downloads are used to judge the application success and for app ranking/suggestion algorithms. If we consider applications just as one entity of mobile IS, are these techniques enough to make proper judgments which app is successful and which is not? These commonly used techniques have their drawbacks as well e.g. using "bots" that automatically download applications and drive up application rankings; rating is averaged over multiple release and not related to particular version; some developers pay people to review particular application; comments are sometimes short, not precise or written in different languages; there is no standard way for reviewing/analysing an application etc. The IS industry currently lacks an appropriate success evaluation tool that will clearly report the success of interactive information systems, that is, that will provide overall user judgment towards the system in their context of use. To achieve market leadership, developers of *interactive information systems* and their investors should broaden the set of measuring instruments in order to evaluate and monitor the *success* of their developed systems. These new methods should include *utilitarian* and *hedonic* measures to estimate the value of the interactive IS at the individual level of use. In practice, *interactive systems designers* propose the most effective and usable design for interactive systems, whereas *software engineers* develop the main brain, i.e. *applications* for the interactive systems. The success measurement of interactive systems in the natural environment of their use is the domain of *information systems researchers*. All three disciplines are interconnected and very important in today's competitive environment. However, the author's focus within this study is on the last, i.e. on the summative user judgements about the interactive mobile information systems in their natural context of use.

4.2 Research Questions

Information systems evaluation is important, whether in designing a new system or in evaluating an existing one, it is valuable to have comparative metrics. Within this study *interactive mobile information system* is considered to be an ensemble of interactive applications such as websites, games, or other applications, executed on interactive devices such as tablets, smartphones, etc., with the aim of *providing user relevant information* for his/her personal *contexts* (e.g. *information, communication, entertainment, transaction,* etc.). The focus is not on mobile technology specifically, but on the individual benefits the user gets from interactive mobile technology use. After an analysis of the available and relevant literature regarding the problem domain, the following research questions are proposed (Table 3).

Table 3 Research Questions

Number	Research Question
(1)	*What (interactive) mobile information system success means in the context of digitally mediated everyday life of individuals?*
(2)	*What measures should we use to measure the success of (interactive) mobile information systems when the use is voluntary and at the individual level?*
(3)	*Can we use the existing measures from the success theories for the mobile use context?*
(4)	*Should any changes be introduced to the existing IS success measurement models in order to capture both hedonic and utilitarian value for the*

Number	Research Question
	(interactive) mobile IS end-users?
(5)	*What does the user experience mean for the (interactive) mobile IS success measurement?*
(6)	*Can end-users provide more valuable feedback to mobile IS developers and also help other end-users discover worthwhile systems for specific contexts of use?*

Source: made by the author

As information systems have progressed significantly in the last ten years, becoming a highly interactive, mobile, and important part of our everyday life, and used for both utilitarian and hedonic purposes, the most popular success theory, DeLone and McLean IS success model, in its last updated version (2003) may not adequately explain the success of today's *interactive mobile information systems*. Therefore, the main goal of this thesis is to improve the updated DeLone and McLean IS success model to meet the modern measurement trends and to adequately measure the success of interactive mobile information systems at the individual level of use (such as: game systems, tourism systems).

4.3 Research Objectives

Determining what success means in different contexts of use results in various definitions of IS success. IS success is primarily subjective and depends on the perspective of different stakeholders. Usually IS researchers and practitioners implement *user evaluations*, i.e. an assessment made by the user, in order to measure IS success. They are performed by applying questionnaires where users are asked to respond about certain qualities of information systems along some continuum from positive to negative. This doctoral study will propose and develop a new success model that will be able to measure the success of modern interactive mobile IS. Within this study, the candidate will research and clarify which dimensions (constructs) are best for measuring the success of *modern interactive mobile information systems,* that support high mobility and high context interactions such as augmented reality systems for individual use, e.g. gaming or tourism. An overview of the main objectives of this study is presented in Table 4.

Table 4 Objectives of the Study

Number	Study objective
(1)	*Identification of the (interactive) mobile information system success dimensions at the individual level of use.*
(2)	*Instrument development for the (interactive) mobile information system success measurement at the individual level of use.*
(3)	*Development and validation of the proposed (interactive) mobile information system success model at the individual level of use in a concrete environment.*

Source: made by the author

This study will result in a success measurement model, i.e. *Interactive Mobile Information Systems Success Measurement model (IMISS model)*, a success measuring instrument, i.e. a questionnaire, and it will demonstrate the logic for the constructs and measure selection. The new measurement model will provide the means to reveal users' feelings, attitudes, and impressions immediately after the use of the interactive mobile information system, and use these findings as strategies for future mobile IS improvements.

5. SOLUTION SUGGESTION

Based on the discussion in the previous chapter, this study proposes a new comprehensive and multidimensional *interactive mobile information systems success model - IMISS model* which will be able to measure the success of the modern interactive mobile IS used in everyday life of individuals for both utilitarian and hedonic purposes. The new model will integrate some dimensions from the DeLone and McLean IS success model and user experience findings from HCI research, in order to contribute to the better understanding of today's interactive mobile IS success.

There are three main reasons why the DeLone and McLean IS success model is chosen as the starting framework. First, the model is one of the most popular and most used models to measure information system success in the IS literature (Petter and McLean 2009). Second, most IS researchers agree with the model founders that the concept of IS success is multidimensional, and that with specific modifications their model can be satisfactorily applied for different information systems e.g. *e-learning* (Balaban, Mu, and Divjak 2013), *e/m-banking* (K. C. Lee and Chung 2009), *e-government* (Scott, DeLone, and Golden 2009), *e/m-commerce* (Wang 2008), *etc.* Third, as many researchers have already tested and successfully validated the DeLone and McLean IS success model in different work and organizational contexts, mainly at the individual level of use, this model should be a good starting point for researching the success of interactive mobile information systems used in everyday life of individuals as well. The newly developed mobile information system success model will follow the DeLone and McLeans's suggestion to reduce the number of IS success measures in order to more easily compare research results and findings that can be validated in the future (DeLone and McLean 2003).

5.1 Re-conceptualizing the D&M IS Success Model

In meta-analysis done by Petter and McLean (Petter and McLean 2009) the majority of hypotheses implied by the updated DeLone and McLean model between success dimensions were supported. The relationship between service quality and other dimensions was not supported due to the lack of validation for this relationship in IS research. Further, at the 15th panel discussion held at the *Pacific Asia Conference on Information Systems* (PACIS) in Brisbane 2011, professor McLean said that the dimension *service quality* may not add anything to the understanding of IS success beyond what was already encompassed in the original D&M model, and that *service quality* could only be the combination of *systems quality* and *information quality* and that the use of the new term is redundant (Tate et al. 2014). Accordingly, the author will omit the *service quality* dimension in the IMISS model development within this study, due to the lack of theoretical support for this dimension in the success model formation. Further, based on the seven year research done by Sedera et al. (Sedera, Eden, and McLean 2013), findings confirm that the IS success model is *casual* (variance model), and that *satisfaction* is a consequence of IS success rather than a mediator. In IS literature, there was much opposition to the dimension "*IS use*" as part of a success model. Seddon (Seddon 1997) claimed that *IS use* is not a success measure, instead he claimed it to be a behaviour. He replaced *IS use* with the *perceived usefulness* dimension in order to adapt the model to both volitional and non-volitional usage contexts. He argues that this new dimension, along with the *user satisfaction* dimension, serves as a general perceptual measure of *the net benefits of IS use* (Seddon 1997). Wang used the dimension *perceived value,* instead of IS use, to measure the benefits that the user gets from using the IS (Wang 2008). Construct *IS use* is least understood amongst IS success constructs and it is the hardest to operationalise within the study due to its multidimensional nature (Sedera, Eden, and McLean 2013). In their updated version DeLone and McLean said that *use* must precede *user satisfaction* in the process sense, but *positive experience* with *use* will lead to greater *user satisfaction* in a *causal sense* (DeLone and McLean 2003). This argument suggests that *user experience with the IS use* in the case of the variance, casual relationship is an important precondition for IS success. Therefore, within the IMISS model, *IS use* as a construct will not be observed directly, instead the *user experience quality* dimension will be implemented with the meaning of *user experience with the IS use* as one of the success dimensions. The need for the *user experience* as one of the success dimensions stems from HCI literature as well. A short description of possible improvements regarding the IS success dimensions is presented within the next few sub-chapters.

5.1.1 Updating Existing Success Dimensions

5.1.1.1 Information Quality

DeLone and McLean defined *information quality* as the quality of information that systems produce (outputs). This dimension is a measure of semantic success of IS. The assessment is made from a more user centred perspective and therefore the measure is more subjective than objective. However, some of the indicators of quality can be measured objectively (Nedovic-Budic 1999). This construct has been operationalised in many different ways in IS literature. There isn't a generic, consistent measure of information quality in IS literature. The updated version of the DeLeone and McLean IS success model (2003) considers the following attributes (sub-dimensions) of the information quality dimension (Table 5): *completeness*, *ease of understanding*, *personalization*, *relevance*, *security*. Within the interactive mobile IS context the definition of *information quality* form the DeLone and McLean studies will be kept and their measures will be used as a starting point.

Table 5 Information Quality Measures Based on the Updated DeLone and McLean IS Success Model

Attributes	**Description**
Completeness	*Completeness refers to whether all of the data relevant to a specific system is present.*
Ease of understanding	*Ease of understanding is the understandability and clearness of the information that the information system provides*
Relevance	*Relevance represents all relevant information for the user and the depth and scope of the information.*
Personalization	*Personalization refers to the individualized presentation of information, and customized service.*
Security	*Security refers to the degree to which a system contains functionalities and mechanisms that protect the user from dangerous conditions and undesirable situations.*

Source: made by the author

The attribute *security* has not been recognized by other researchers as a part of information quality, rather than as a *system quality* measure (K. C. Lee and Chung 2009), (K. Ho et al. 2013). Similarly, in a later article DeLone and McLean conducted a literature review of the most used measures for measuring e-commerce success, and for the security measure they said (Delone and Mclean 2004) that "system security becomes a more significant system-quality issue, because e-commerce is typically conducted over the Internet rather than a private, proprietary network". We see that with this statement they lean more towards categorizing security as a system measure. Therefore, the author of this study decided to keep the most used attributes from the literature review and use them for the formation of the information quality dimension in the new IMISS model. Regarding other measures that received low literature review support, such as *security* and *personalization* (Table 6), the author reconceptualised them based on further IS literature review (Gable, Sedera, and Chan 2008), (Cheung and Lee 2005) and decided to move them to the *system quality* dimension.

These changes will later be checked in the development phase by involving experts from the information systems and human computer interaction domain.

Based on the analysis presented in Table 6, the most used attributes across the presented IS literature are: *accuracy* and *currency*. Accuracy refers to the extent to which information is correct, reliable, and certified to be free of errors. Currency refers to the user's perception that the information is new and frequently updated, and timely presented.

Table 6 Most Used Information Quality Measures across IS Literature

Information Quality (sub-dimensions)	(Delone and McLean 2003)	(Nelson and Todd 2005)	(Koo, Wati, and Chung 2013)	(Iivari 2005)	(McKinney, Yoon, and Zahedi 2002)	(Gable, Sedera, and Chan 2008)	(Alshibly 2014)*	(Jang 2010)*	(Wang and Liao 2008)*	(Lin 2007)*	(J.-H. Wu and Wang 2006)*	(Chen and Cheng 2009)*	(K. C. Lee and Chung 2009)*	(Gorla, Somers, and Wong 2010)*	(Cheung and Lee 2005)*	(K. Ho et al. 2013)	%****
Completeness	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓		69%
Easy of understanding	✓				✓	✓	✓	✓			✓			✓		✓	50%
Personalization*	✓																6%
Relevance	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	75%
Security*	✓							✓									13%
Accuracy**		✓	✓	✓		✓		✓	✓	✓		✓	✓		✓		63%
Currency**		✓	✓	✓		✓	✓		✓	✓	✓	✓	✓		✓	✓	50%
Presentation		✓	✓	✓		✓								✓	✓		38%
Reliability			✓		✓												13%
Consistency				✓		✓					✓						19%
Other				✓	✓	✓	✓							✓			~

Source: made by the author

* The values are extracted from the questionnaire items, they are not reported as separate sub-dimensions, and they represent items on the information quality measurement scale. ** Attributes received low literature support from the presented studies (less than 50%, but were part of the D&M updated model), therefore they will be reconceptualised. *** The most used measures for the information quality dimension that were not present in the updated D&M model. **** Percentage of the total number of studies that have used the measure as a sub-dimension or as an item within the measurement scale.

5.1.1.2 System Quality

System quality is a dimension that describes and assesses the desirable characteristics of the system. It measures the technical success of IS, i.e. it refers to how well the hardware and the software work together. The system quality measure is the most studied success dimension across IS literature. *System quality,* as well as information quality, have many different operationalisations in IS literature. DeLone and McLean suggested in their updated version that this dimension should include the following quality measures (Table 6): *adaptability*, *availability*, *reliability*, *response time,* and *usability*.

Table 6 System Quality Measures Based on the Updated DeLone and McLean IS Success Model

Attributes	Description
Adaptability (flexibility)	*Adaptability refers to systems that can adjust their content to the changing demands of the user.*
Availability	*Availability refers to the run time of the system for a desirable or expected length of time.*
Reliability	*Reliability refers to the dependability of system operations.*
Response Time (timeliness)	*Response Time/Timeliness refers to how quickly the system provides results to a user.*
Usability	*Usability refers to the ease with which a user can achieve a particular goal.*

Source: made by the author

Based on the definitions of measures and later consideration, even though attribute *usability* is used as a system measure in the updated DeLone and McLean IS success model, this measure relates more to the characteristic *IS use,* i.e. the experience of the user's interaction with the system, rather than the objective characteristic of the information system quality. Therefore, this measure will be placed under the new *user experience quality* dimension, which is supported by HCI literature. Some IS researchers haven't used only these measures, but have added new measures that were more appropriate for their context of use as well Table 7. Also, some researchers have excluded some of the initial DeLone and McLean system quality measures, or substituted existing ones with new ones. Within the mobile IS context, the definition of *system quality* form the DeLone and McLean studies will be kept, and all of their measures, except usability, will be used as a starting pool of attributes for system quality measurement. However, some additional measures will be added to the model, as the need for them arises from the literature review. This will again be validated in the development phase by involving IS and HCI experts.

Table 7 Most Used System Quality Measures across IS Literature

System Quality	(Delone and McLean 2003)	(Nelson and Todd 2005)	(Koo, Wati, and Chung 2013)	(Iivari 2005)	(McKinney, Yoon, and Zahedi 2002)	(Gable, Sedera, and Chan 2008)	(Alshibly 2014)*	(Jang 2010)*	(Wang and Liao 2008)*	(Lin 2007)*	(J.-H. Wu and Wang 2006)*	(Chen and Cheng 2009)*	(K. C. Lee and Chung 2009)*	(Gorla, Somers, and Wong 2010)*	(Cheung and Lee 2005)	(K. Ho et al. 2013)	100% ****
Adaptability	✓	✓	✓	✓		✓		✓				✓		✓			50%
Availability*	✓																6%
Reliability	✓	✓		✓		✓		✓		✓	✓	✓					50%
Response time	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓	✓	81%
Usability	✓				✓	✓	✓		✓		✓		✓				44%
Accessibility**		✓	✓		✓	✓				✓			✓	✓			44%
Navigation					✓							✓			✓	✓	25%
Other		✓	✓	✓	✓	✓	✓	✓							✓	✓	~

Source: made by the author

* The values are extracted from the questionnaire items, they are not reported as separate sub-dimensions, and they represent items on the system quality measurement scale.
** Attributes received low literature support from the presented studies (less than 50%, but were part of the D&M updated model). Due to the ubiquitous access demand of the modern interactive mobile IS, the author decided to keep this measure in this phase of the research. *** The most used measures for the system quality dimension that were not present in the updated D&M model. **** Percentage of the total number of studies that have used the measure as a sub-dimension or as an item within the measurement scale.

Based on the literature review (Table 7), it can be seen that most used attributes for measuring system quality are *adaptability, reliability,* and *response time*. *Availability* received low literature support from the presented studies; however, as it was present in the updated DeLone and McLean IS success model, it will be kept under this dimension in this phase of the research. An additional most used measure for system quality is *accessibility. Accessibility* represents the degree to which the system enables easy access to information for a user. The attribute *usability* will be moved to the user experience dimension due to more theoretical and practical support for it within that dimension (chapter 2.8.2). There is more support in literature for the attributes *security* and *personalization* to be part of the *system quality* measures (Gable, Sedera, and Chan 2008), (K. C. Lee and Chung 2009), (K. Ho et al. 2013), therefore they will be added to this dimension in this phase of the research.

5.1.1.3 Individual Benefits

Different stakeholders in the IS context can have different views about what *IS* benefits are to them. Majority of the studies that implemented and tested the DeLone and McLean IS success model have focused on the utilitarian system use and their net benefits values were primarily task oriented achievements (*performance*, *productivity*, *decision effectiveness*). Seddon (Seddon 1997) proposed the two constructs, *perceived usefulness* and *user satisfaction,* to be part of general perceptual measures of net benefits of IS use, in order for the model to be valid for both mandatory and voluntary contexts of use. Wang argues in his study that *perceived value* is a more comprehensive and reliable measure of *net benefits* in an e-commerce context (Wang 2008). Some studies implemented *trust* (Koo, Wati, and Chung 2013), (K. C. Lee and Chung 2009) or *satisfaction* (Nelson and Todd 2005), (McKinney, Yoon, and Zahedi 2002) as the ultimate dependent variable. Sedera et al. (Sedera, Eden, and McLean 2013) also argue that *satisfaction* is a consequence of IS success rather than a mediator. From the results in Table 8 we can see that the most used measures for the impact dimension, i.e. net benefits, are: *effectiveness, efficiency* and *satisfaction*. Effectiveness is the degree to which the system is enabling the tasks to be performed in a quick and effective manner. Efficiency is the relation between the accuracy and completeness with which the users achieve certain goals and the resources expended achieving them, whereas satisfaction represents the positive attitude towards the use of the product.

As the focus of this research is on *interactive systems* which are used in a non-work environment (e.g. *mobile tourism systems or mobile gaming systems*), there is need for clarification of what *net benefits* should encompass in the interactive mobile system use context. These types of systems can have both hedonic and utilitarian goals of use. Therefore, *net benefits* should capture both *hedonic* (subjective) and *pragmatic* (objective) values (outcomes) that the user receives from the use of these interactive systems. Within this study, it is premised that functional values of non-work systems (such as tourism systems, communication systems, gaming systems, etc.) will be defined as *pragmatic benefits* (*values*) of system use. They refer to the degree to which the user believes that using the system will help him/her in achieving functional goal(s). This dimension corresponds to the meaning of *perceived usefulness* in Seddon's (Seddon 1997) work and *perceived value* in Wang's (Wang 2008) work, whereas emotional values as outcomes of systems usage will be defined as *hedonic benefits* (*values*). Hedonic benefits are the more subjective and personal results achieved by interactive system use, such as satisfaction, enjoyment.

Table 8 Most Used Net Benefits Measures across IS Literature

Net Benefits (perceived value)	(Delone and McLean 2003)	(Nelson and Todd 2005)	(Koo, Wati, and Chung 2013)	(Iivari 2005)	(McKinney, Yoon, and Zahedi 2002)	(Gable, Sedera, and Chan 2008)	(Alshibly 2014)*	(Jang 2010)*	(Wang and Liao 2008)*	(J.-H. Wu and Wang 2006)*	(K. C. Lee and Chung 2009)*	(K. C. Lee and Chung 2009)*	(S.-Y. T. Lee, Kim, and Gupta 2009)	(Sedera, Eden, and McLean 2013)	**100%*** **
Effectiveness & Efficiency*	✓			✓		✓	✓	✓	✓	✓		✓	✓	✓	71%
Satisfaction	✓	✓	✓		✓						✓			✓	43%
Trust			✓								✓				14%

Source: made by the author

* The values are extracted from the questionnaire items, they are not reported as separate sub-dimensions, and they represent items on the net benefits (individual impact) measurement scale. ** This attribute is presented in IS literature through several attributes such as individual's work efficiency, effectiveness and/or productivity. *** Percentage of the total number of studies that have used the measure as a sub-dimension or as an item within the measurement scale.

5.1.2 Integrating New Success Dimensions

5.1.2.1 User Experience Quality

Whenever people use a product, they have their *user/consumer experience* with that product. It arises as a result of the interaction between the user and the product in some context. A review of relevant work in the disciplines of *information systems*, *human-computer interaction,* and *experience economy* revealed some insights for possible improvements regarding the *IS success measurements*. Measures that show whether the system is *easy to use*, *easy to learn* are not sufficient anymore. Today in the world of ubiquitous and interactive technology, there is a need to understand and measure a much broader aspect of the users' interaction with systems. It is evident from literature review that *user experience* as a concept is becoming an important part of the interactive information system evaluation as well. User experience is oriented towards *products*, *systems*, *services*, and *objects* when the user interacts with them through a user interface (Effie Lai-Chong Law et al. 2009). It explains the user's feelings and attitudes about using a product (Effie Lai-Chong Law et al. 2009), (Vermeeren et al. 2010). The concept of user experience goes beyond the instrumental characteristics and concerns hedonic aspects such as beauty, fun, pleasure, and personal growth, which satisfy general human needs. When users evaluate a product, they are judging the overall quality of a product based on their memory, momentary experience episodes (Hassenzahl and Ullrich 2007). This study will try to fill-in the missing gaps of the *IS use* dimension within the *D&M IS success model* by replacing the *IS use* dimension with the *user experience* dimension. This new dimension will describe and measure users' experiences (reflections, attitudes, and impressions) about the interaction with the IS. This new construct will integrate the findings from the HCI domain in order to capture both *hedonic* and *utilitarian* interaction experiences of system use, and to ensure the applicability of the theoretical perspective that was missing with *IS use*.

As there is no common agreed definition of user experience, within this study user experience is defined as follows: *User experience is a multi-dimensional construct of user's reflections, attitudes, and impressions that emerge as result of the user interaction with the system.* This new dimension within the new proposed success model is named *user experience quality* (UXQ) and it represents *the extent to which an interactive system meets the users' expectations towards a positive interaction experience*.

User experience as a concept can have many time spans: *before usage, during usage, after usage, and over time* (Virpi Roto et al. 2010). The optimal time span for evaluating user experience is still unclear and should be more precisely defined within the context of the research (Kujala et al. 2011). The user experience within this study will be the experience after system usage, which could be *episodic*, reflecting on actual system use experience, or *cumulative*, recollecting multiple periods of system use. It has already been reported that positive *user experience* has effects on the financial aspects and customer recommendations of the product/service (Kujala et al. 2011), therefore, within this study it is premised that this new dimension, *user experience quality,* should also have influence on the individuals' perception of received benefits, as a consequence of IS use. UXQ could be the key success driver dimension of the modern interactive mobile IS. The most used attributes (sub-dimensions) of user experience are shown in Table 9. From the results we can see that most used utilitarian attitudes are *control* and *usability* of the products whereas hedonic attributes are *stimulation* and *aesthetics*.

Table 9 Most Used User Experience Measures across HCI Literature

User Experience	(Laugwitz, Held, and Schrepp 2008)	(Hassenzahl, Burmester, and Koller 2003)	(Karapanos, Martens, and Hassenzahl 2012)	(Kujala et al. 2011)	(Väätäjä, Koponen, and Roto 2009)	(Mahlke and Thüring 2007)	(Lavie and Tractinsky 2004)	(V. Roto and Rautava 2008)	(Arhippainen 2013)	(Väänänen-Vainio-Mattila and Segerståhl 2009)	100%***
Aesthetics	✓	✓		✓	✓	✓	✓		✓		70%
Perspicuity	✓										10%
Control*	✓								✓	✓	30%
Stimulation	✓	✓	✓		✓						40%
Novelty	✓		✓								20%
Utility**	✓	✓	✓	✓	✓	✓		✓	✓		80%
Usability			✓	✓	✓	✓	✓	✓	✓		70%
Entertainment							✓	✓		✓	30%
Other		✓		✓	✓		✓	✓	✓	✓	~

Source: made by the author

* The meaning here is whether the user feels in control of the interaction, e.g. privacy control. **Utility is the degree to which a product/service is beneficial, practical to the user. This attribute represents more the perceived benefits (values) of use rather than just the experience of the interaction, therefore this measure will be moved to the net benefits dimension. *** Percentage of the total number of studies that have used the measure as a sub-dimension or as an item within the measurement scale.

Although the *Utility* dimension received relatively strong support in the HCI literature review (Table 10), from the IS perspective it belongs more in the benefits dimension (Seddon 1997), outcomes of product use, rather than judgments of the interaction with the system. Therefore this measure will be moved to the net benefits (perceived values) dimension.

Table 10 Description of the Most Used User Experience Attributes

Attributes	Description
Aesthetics	*Aesthetics represents the general impression towards the product; it is the attractiveness of the product.*
Stimulation	*Stimulation is the extent to which the product is interesting and exciting to use.*
Usability	*Usability refers to the ease with which a user can achieve a particular goal.*
Novelty	*Novelty refers to the degree to which the user perceives the product to be new, innovative, different, or unusual.*
Entertainment	*Entertainment refers to the feelings of fun, joy and excitement as result of the interaction with the system.*
Control	*Control refers to the extent to which the user has the control over the interaction with the product.*

Source: made by the author

The *Control* attribute within this study will be replaced with attribute *Privacy*, as there is great need for it in the context of the highly interactive, interconnected and sensor-reach systems (chapter 2.5), with the meaning of the extent to which users' has control of its privacy, i.e. are user's privacy rights protected while using the system.

5.1.2.2 Intention to Reuse

Wang (Wang 2008), in his application and validation of the DeLone and McLean IS success model, included the dimension *intention to reuse* as a measure of *e-commerce systems success*. His intention was to simplify the closed-loop relationships between the dimensions *use*, *satisfaction,* and *intention to use* that was present in the updated DeLone and McLean IS success model. The need for this new dimension arises from the economics and marketing literature, with the purpose of examining the users' attitudes towards the products/services and whether these attitudes will result in the *reuse* of products/services. This new dimension can be defined *"as the favourable attitude of the customer towards an e-commerce system that results in repeat use/purchase behaviour"* (Wang 2008). As researchers have already made claims that a high quality of user experience affects the user's *loyalty* towards it (Effie L. -C. Law and van Schaik 2010), and that both the utilitarian values and hedonic values (outcomes) are positively associated with the consumers' repeat usage (purchase) intention (Kujala et al. 2011), it is premised within this study that the dimension *intention to reuse* should be included as an ultimate dependent variable in the IMISS success model.

5.1.3 Summary of D&M IS Success Model Modifications

The possible solution of the proposed problem, i.e. *measuring the success of the interactive mobile IS at the individual level of use*, is in following the existing practice of IS success from business contexts and adapting it to the non-work environment where IS use is volitional and at the individual level. More specifically, the main changes planned to be introduced into the updated DeLone and McLean IS success model in the case of the interactive mobile information systems success measurement are the following:

- *The user experience quality dimension will be added to the existing DeLone and McLean IS success model as one of the success dimensions. This dimension will replace the dimensions "use" and "intention to use" from the updated existing DeLone and McLean model, which showed relatively low support in literature findings.*

- *Dependent variable net benefits will be redefined to capture both pragmatic and hedonic benefits of system use, due to the fact that more and more IS are used in non-work environments for achieving personal goals. This new dimension will be renamed to individual benefits and will include the sub-dimensions hedonic and pragmatic benefits* (*values*).

- *Intention to reuse will be added to the success model as a new final dependent variable. This new dimension arises from economics and marketing studies with the purpose of examining the users' intentions of reusing the product/service in the future (customer loyalty), and simplifies the return relationship of the updated DeLone and McLean IS success model as well.*

  The author believes that the *new proposed mobile IS success model* (i.e. reconceptualised and *refreshed* D&M IS success model) will have *more explanatory power* than the existing last updated model of the DeLone and McLean success model in the case of the modern *interactive mobile information system success measurement* when the use of these systems is voluntary and for personal purposes, i.e. at the individual level of use.

5.2 Conceptual Model and Study Hypotheses

The focus of this thesis is measuring the success of *interactive mobile IS* at the individual level of use, with the purpose of achieving personally relevant goals (e.g. using mobile augmented reality systems in tourism), not the use of mobile devices (e.g. smartphones, tablets) in general. Within this research concept, *mobile* means that the user and the device are *mobile* and that the *information system* can be used in different places to fulfil the user's context dependent pragmatic and hedonic needs. This new focus of interactive system evaluation takes a more holistic view of IS success and considers non-instrumental qualities to be equally important to the interaction and as outcomes of interactive IS. The assumption is that perceived *information system quality* and perceived *user experience quality* are the predictors of *perceived individual benefits (individual impacts)* which then lead to the behavioural *intentions of system reuse.*

The newly developed *Interactive Mobile Information System Success model* (IMISS model) has *four* main dimensions at the meta-level of analysis: *information system quality*, *user experience quality*, *individual benefits,* and *intention to reuse*. Descriptions of these dimensions are presented in Table 11.

Table 11 Description of the Interactive (Mobile) Information System Success Dimensions

Success Dimension	Description
Information system quality	*Information system quality represents the extent of the desirable information and system characteristics.*
User experience quality	*User experience quality is the extent to which an interactive system meets the users' expectations towards a positive interaction experience. It is composed of the utilitarian and hedonic experiences.*
Individual benefits (net benefits)	*Individual benefits represent all hedonic and utilitarian interactive system benefits that the user receives from the interaction with the system.*
Intention to reuse	*Intention to reuse is the favourable attitude of the user towards an interactive system that results in repeat use behaviour.*

Source: made by the author

The relationships between the success dimensions of the *interactive mobile information systems success model* (IMISS model) are presented in Figure 22.

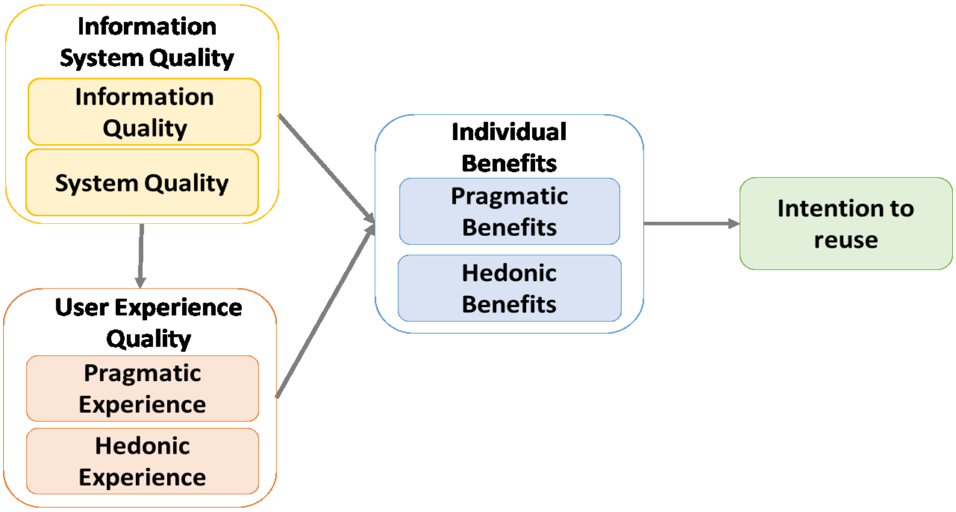


Figure 22 Determinants of the Interactive (Mobile) Information System Success Model (IMISS Model) at Meta Level
Source: made by the author

Based upon the presented modifications regarding the DeLone and McLean IS success model, the proposed hypotheses of this doctoral thesis are presented in Table 12.

Table 12 Hypotheses of the Research

Hypotheses	Statement
H1:	*Developed measurement instrument for mobile information system success measurement from end-user value perspective will be valid and reliable.*
H2:	*Developed mobile information systems success model will provide more explanatory power than existing DeLone and McLean information system success model when the use of mobile information system is at the individual level.*

Source: made by the author

The formulation of the first hypothesis can also be as follows: *Proposed measurement instrument for mobile information system success measurement from end-user value perspective will be valid and reliable.*
The formulation of the second hypothesis can also be sated as follows: *Proposed model for measuring the mobile information system success will provide more explanatory power than*

existing DeLone and McLean IS success model when the use of mobile information system is voluntary and at the individual level.

In order to perform the validation of the new IMISS model, a *success measurement questionnaire* will be developed. The purpose of the questionnaire is to help collect and organize data for assessing the success of the modern interactive mobile IS at the individual level of use. In order to test the first hypothesis (H1), the Moore and Benbasat questionnaire guidelines will be followed. The developed questionnaire will serve as basis for data collection and for the validity and reliability assessment of the IMISS model. The second hypothesis (H2) will be tested by using the *partial least squares structural equation modeling* (PLS-SEM) method and by comparing the explained variance of the *net benefits* dimension from the DeLone and McLean IS success model and *individual benefits* from the IMISS model.

6. SOLUTION DEVELOPMENT

In the development phase of the Design Science Research approach two artefacts as output will be developed. First is the *questionnaire* i.e. *success measurement instrument* and second is the *Interactive Mobile Information System Success model (IMISS model)*.

6.1 Development of the Measuring Instrument

Questionnaires as measurement instrument are useful research method that enable direct quantification of the subjective feelings, attitudes and experiences. They are easy to deploy and provide a standardized way for quantifying a particular aspect under consideration. Constructs present latent variables that are not directly measured. Measurement generally involves operationalization of constructs (unobserved variables) into the measurement variables and the development and application of an instrument to quantify these variables. Measurement variables (items or indicators) are directly measured observations. Multivariate measurement involves using several variables in order to indirectly measure concept to improve measurement accuracy (J. F. J. Hair et al. 2013). As part of this research, new measuring instrument questionnaire is developed. The questionnaire will be used for mobile information system success data collection. In order to develop a measurement instrument with good psychometric properties, development of the new questionnaire follows the guidelines proposed by Moore and Benbasat (Moore and Benbasat 1991). Their approach consists of three main steps (Figure 23): (1) *development of questionnaire items*; (2) *measurement scale development;* (3) *questionnaire testing*.

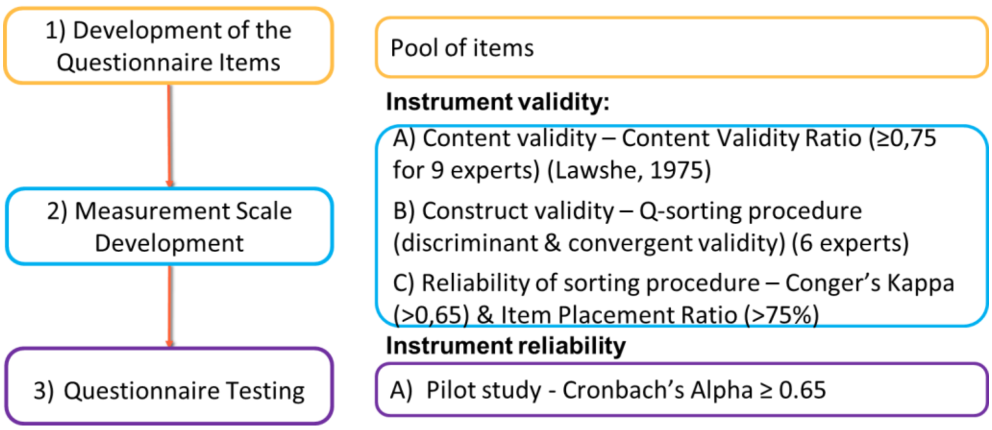


Figure 23 Questionnaire Development Steps
Source: made by the author

This research approach is also recommended in the work of Straub et al. how to effectively validate measuring instrument in IS positivist research (Straub, Boudreau, and Gefen 2004).

In designing the concept of the research instrument, the existing theoretical findings from the domain of *information systems* and *human-computer interaction* were taken into the account.

6.1.1 Development of the Questionnaire Items

Within this step *the pool of questionnaire items* is created and it represents manifest variables for each attribute and construct that is intended to be the part of the new success model i.e. *the mobile information systems success model*. Information quality, system quality and net benefits at individual level (perceived value) are operationalized from DeLone and McLean IS success model and then extended with several most common used attributes across studies to measure the same constructs. Four main concepts within IMISS model need to be distinguished. *Items (indicators)* present questionnaire statements. *Attributes* are composed of several items that describe the same characteristic. *Sub-dimensions* are composed of the groups of the attributes that are related to the some particular sub-dimension. Sub-dimensions of the IMISS model are *information quality, system quality, pragmatic experience, hedonic experience, pragmatic nefeits* (*values*) *and hedonic benefits* (*values*). *Success dimensions* of the interactive mobile IS success model are constructs at higher order level (meta-analysis). The main constructs of the IMISS model are: *information system quality, user experience quality, individual benefits (net benefits at the individual level)* and *intention to reuse*. Attributes and questionnaire items from other related instruments that were empirically tested are adopted and used in this research to enhance the validity and reliability of the instrument and to meet the new trends of using technology outside organizational context. Some studies didn't have attributes under the success dimensions only a set of items to measure the whole construct (or sometimes it is used one item per attribute/sub-construct).

From DeLone and McLean updated IS success model initial pool of *information quality* attributes and items is extracted (*completeness*, *ease of understanding* and *relevance*). Other attributes *personalization* and *security* are moved to the *system quality* dimension as there is more theoretical support for them to be in that success dimension. Across different information systems studies two additional and most commonly used attributes are added to the information quality dimension (*accuracy* and *currency*). The complete list of attributes along with the extracted items is shown in Table 13. The total number of the questionnaire items is 18 that have been used to measure the information quality. The items statements formulation is modified to stress the general type of information system that this new questionnaire is planned to be applied.

Table 13 Attributes and Items of the Information Quality Success Dimension

Attributes	***Items***
Completeness	*The interactive mobile information system provides me with complete set of information.*
	The interactive mobile information system provides me with all information I need for my activity.
	Information from the interactive mobile information system is sufficient for my activity.
	The amount of information from the interactive mobile information system is appropriate for my activity.
Understandability	*Information from the interactive mobile information system is easy to understand.*
	Information from the interactive mobile information system is comprehensible.
	Information from the interactive mobile information system is clear in meaning.
Relevance	*Information from the interactive mobile information system is relevant for my activity.*
	Information from the interactive mobile information system is exactly what I need for my activity.
	Information from the interactive mobile information system is important for my activity.
Accuracy	*Information from the interactive mobile information system is correct.*
	Information from the interactive mobile information system is free from errors.
	Information from the interactive mobile information system is accurate.
	Information from the interactive mobile information system is precise.
Currency	*Information from the interactive mobile information system is timely.*
	Information from the interactive mobile information system is up to date.
	Information from the interactive mobile information system is most current.
	Information from the interactive mobile information system is most recent.

N=18
Source: made by the author

From DeLone and McLean updated IS success model initial pool of attributes for *system quality* dimension is extracted (*adaptability, availability, reliability and response time*). Attribute *usability* is moved to the user experience dimension, due the more theoretical support to be in that dimension from HCI literature. As attributes *security* and *personalization* have more support to be part of the *system quality* measures (Gable, Sedera, and Chan 2008),

(K. C. Lee and Chung 2009), (K. Ho et al. 2013) they are added to this dimension. Across different information systems studies used and validated attributes that author decided to add to the *system quality* in this phase of the research are *accessibility*, *personalization* and *security* dimension. The complete list of attributes along with the extracted items is shown in Table 14. The total number of items is 26. The items statements formulation is modified to stress the type of information system that this new questionnaire is planned to be applied.

Table 14 System Quality attributes and items

Attributes	***Items***
Adaptability	*The interactive mobile information system is adaptable to meet my activity needs.*
	The interactive mobile information system is flexible to new demands or conditions.
	The interactive mobile information system is flexible in addressing my needs.
	The interactive mobile information system offers flexibility as to time and place of use.
Availability	*The interactive mobile information system launches and runs right away.*
	Information from the interactive mobile information system is quickly retrievable.
	The interactive mobile information system is always available for usage.
Reliability	*The interactive mobile information system operates reliably.*
	The interactive mobile information system performs reliably.
	The interactive mobile information system always does what it should.
	The operation of the interactive mobile information system is dependable.
Response Time	*The interactive mobile information system responds quickly enough.*
	The interactive mobile information system provides answers in a timely fashion.
	When I use the interactive mobile information system, system would give me immediate feedback.
	I can obtain the information from the interactive mobile information system without any delay.
Accessibility	*Interactive mobile information system allows information readily accessible to me.*
	Interactive mobile information system enables information to be accessed conveniently.
	The interactive mobile information system provides instant access.
Personalization	*Information presented from the interactive mobile information systems is well adapted to my activity.*
	The interactive mobile information system enables me to customize the presentation of information according to my personal needs.
	The output information of the interactive mobile information system adjusts to my use context.
	The interactive mobile information system enables me to filter the content according to my personal needs.
Security	*The use of the interactive mobile information system feels secure.*

Attributes	Items
	The interactive mobile information system has adequate security measures.
	The interactive mobile information system keeps the data secure from unauthorized access.
	I feel that there is little risk involved while using the interactive mobile information system.

N=26

Source: made by the author

Benefits on the individual level from DeLone and McLean studies are mainly studied in the task oriented environments and related to the performance of the individuals (e.g. *improved productivity, effectiveness, decision making,* etc.) and to the satisfaction. This construct is further extended with attribute *enjoyment*. Satisfaction here isn't placed as separated construct as it was in DeLone and McLean studies. Seddon in his IS success validation study argued that satisfaction should be part of benefits the user gets from the system usage not as a separate construct (Seddon 1997). Same claim was supported by Sedera et al. (Sedera, Eden, and McLean 2013). The complete list of attributes along with the extracted items is shown in Table 15. The total number of items is 14. The items statements formulation is modified to stress the type of information system that this new questionnaire is planned to be applied i.e. interactive mobile IS. However, in the concreate setting the name of the system will be used instead of the general term.

Table 15 Proposed Attributes and Items of the Success Dimension Perceived Values

Attributes	Items
Effectiveness	*The interactive mobile information system enhances my effectiveness.*
	The interactive mobile information system enables me to accomplish activity more quickly.
	The interactive mobile information system helps me to save time.
Efficiency	*The interactive mobile information system increases my efficiency.*
	The interactive mobile information system makes me productive.
	The interactive mobile information system helps me to optimize my activity.
Enjoyment	*It was entertaining to use the interactive mobile information system.*
	I enjoyed using the use of the interactive mobile information system.
	I felt happy because of the interactive mobile information system use.
	It was amusing to use the interactive mobile information system.
Satisfaction	*I am satisfied with the use of the interactive mobile information system.*
	I am pleased with the use of the interactive mobile information system.
	I am content with the use of the interactive mobile information system.
	I am delighted with the use of the interactive mobile information system.

N=14
Source: made by the author

For the pool of items of the proposed new success dimension *user experience quality* author extracted items and attributes that are most commonly used across literature review for capturing the *hedonic experience* and *pragmatic experience*. The author extracted in total 32 items that are most commonly used and validated *user experience* items across mentioned studies.

Table 16 Proposed Attributes and Items of the Success Dimension User Experience Quality

Attributes	***Items***
Aesthetics	*The interactive mobile information system has aesthetically pleasing design*
	I like the visual look of the interactive mobile information system.
	The design of the interactive mobile information system is attractive.
	The design of the interactive mobile information system is likable.
	The interactive mobile information system looks impressive.
Stimulation	*The use of the interactive mobile information system is motivating.*
	It is fun to use the interactive mobile information system.
	The use of the interactive mobile information system is playful.
	The use of the interactive mobile information system occupies my attention.
	The use of the interactive mobile information system is challenging.
Novelty	*The use of the interactive mobile information system is innovative.*
	The use of the interactive mobile information system is original/innovative.
	The use of the interactive mobile information system is different from other systems.
	The use of the interactive mobile information system is leading edge.
Usefulness	*The use of the interactive mobile information system is beneficial for my activity.*
	The interactive mobile information system is useful for my activity.
	The interactive mobile information system supports me in my activity.
	The interactive mobile information system is exactly what I need.
	The use of the interactive mobile information system helps me easier do the activity.
Privacy	*I have control over what personal information the interactive mobile information system is using.*
	My privacy rights are adequately protected while using the interactive mobile information system.
	I always know when and who have access to my personal information while using the interactive mobile information system.
	I have choice whether to or not expose my personal information while using the interactive mobile information system.
	The interactive mobile information system doesn't use personal information without my knowledge.
	The interactive mobile information system doesn't share personal information to third party without my approval.

Attributes	Items
	The interactive mobile information system provides me notice if third-party tries to access my personal information.
Usability	*The interactive mobile information system is easy to use.*
	The interactive mobile information system is user-friendly.
	The interactive mobile information system is easy to learn.
	It is convenient to use the interactive mobile information system.
	It is easy to become skilful at using the mobile interactive information system.
	The use of the interactive mobile information system doesn't require lot of mental effort.

N=32

Source: made by the author

Intention to reuse is the dimension that Wang introduced as a measure of e-commerce systems success in order to simplify the closed-loop relationships between dimensions *Use*, *Satisfaction* and *Intention to Use* (Wang 2008). This concept is similar to the concept loyalty from marketing area. This dimension is defined as *"the favourable attitude of the customer towards an e-commerce system that results in repeat use/purchase behaviour"* (Wang 2008). The list of proposed items for this dimension are presented in Table 17.

Table 17 Proposed Items of the Success Dimension Intention to Reuse

Attributes	Items
Intention to Reuse	*I plan to reuse the interactive mobile information system.*
	I will continue using the interactive mobile information system for similar activities.
	I intent to frequently use the interactive mobile information system for similar activities.

N=3

Source: made by the author

In total for this initial phase of the questionnaire formation there were 93 items and 23 attributes. Additionally to the questionnaire there were added questions about *IS use* from the DeLone and McLean IS success study that capture the nature of use, intensity of use and navigation patterns ("*I have used the interactive mobile information system for uses that it is intended."; "I have used the interactive mobile information system very intensively."; "The interactive mobile information system has good navigation options."*). In order to measure the net benefits of the D&M model two items were used to measure the performance of the interactive system use (*"It is efficient to use the interactive mobile system for my activity."; "The interactive mobile information system helps me to optimize my activity."*).

6.1.2 Measurement Scale Development

Many of these attributes, items might be irrelevant for the interactive mobile information system success measurement or might be redundant. Some of the attributes, items could be more appropriate to other construct than in the one which were initially placed, or maybe some additional items, attributes need to be included in the success measurement survey in the case of the mobile information systems use at individual (personal) level. Therefore, it is necessary to perform the *validity* of extracted attributes and items, more specifically the *content validity* and *construct validity*.

6.1.2.1 Content Validity

Content validity presents a subjective and systematic evaluation of how well the domain content of a construct is captured by its indicators (J. F. J. Hair et al. 2013). Based on the Straub et al. (Straub, Boudreau, and Gefen 2004) and Moore and Benbasat (Moore and Benbasat 1991) guidelines panel of experts (judges) are contacted to evaluate clarity, validity and appropriates of extracted items, attributes and dimensions. Experts from the field of *information systems* and *human-computer interaction* are asked to participate in the evaluation of the *content validity* of the proposed items, attributes and success dimensions. The experts were chosen based on the literature review of the relevant scientific work in mentioned research areas. The total of 9 experts, from the *Austria (N=2)*, *Slovenia (N=2)*, *Finland (N=1)*, *Brazil (N=1)*, *Spain (N=1)*, *Portugal (N=1)* and *Italy (N=1)*, agreed to participate in the item, attribute and success dimension evaluation process. The background experience of experts that have participated in this step is presented in appendix B. Experts needed to judge each item, attribute and success dimension whether it is appropriate based on their knowledge, experience and intuition within the context of measuring the success of the *interactive mobile information systems aimed for personal (non-work related) uses (communication, information, entertainment, and transaction)*.

Content validity evaluation is carried out by calculating the *Content Validity Ratio – CVR* based on Lawshe recommendations, (Lawshe 1975) where a panel of experts needs to evaluate each item, attribute and success dimension as *essential*, *useful (but not essential)* or *not relevant*. Based on the Lawshe calculations (*based on the number of experts and at significance level of 0.05*) necessary level of *CVR* is calculated. CVR is calculated based on the formula (1):

$$(1) \quad CVR = (n-N/2) / (N/2)$$

n is the frequency count of the number of experts that rated the item, attribute or dimension as either "*0 = I cannot determine relevance*", "*1 = Not relevant*", "*2 = Useful (but not essential)*" or "*3 = Essential*". N presents the total number of experts that participated in this process. *CVR* value can range from *-1* to *+1*. For the item, attribute or dimension where more than half of panellist say it is *essential or useful* the *content validity* of item, attribute or dimension is achieved. The more panellist who perceive item, attribute or dimension as *essential or important* then the grater the extent or degree of its *content validity* is achieved. When all panellist say that the item, attribute or dimension is *essential or useful CVR* value is 1.00. When more than half but less than all panellist say the item, attribute or dimension is *essential or useful* than the *CVR* values are between zero (0) and 0.99. When exactly half of panellist say the item, attribute or dimension is *essential or useful* the *CVR* value is zero (0). If less than half panellist say the item, attribute or dimension is *essential* or *useful* the value of CVR is negative. Items, attributes or dimensions that have small *CVR* will be excluded from the analysis. Because the number of panellist were 9 then *CVR* value needs to be 0,75 or higher to satisfy five percent significance level according to Lawshe (Lawshe 1975).

Table 18 Content Validity Ratio CVR Values

Number of panellist	Minimum CVR value*
5	0,99
6	0,99
7	0,99
8	0,78
9	**0,75**
10	0,62
11	0,59
12	0,56
13	0,54
14	0,51
15	0,49
20	0,42
25	0,37

Number of panellist	Minimum CVR value*
30	0,33
35	0,31
40	0,29

Source: (Lawshe 1975) *one tailed test, $p = 0,05$ (Lawshe 1975)

As the proposed list of items, attributes and dimensions is very long, and even though the minimum needed *CVR* value was satisfied, within this study items, attributes or dimensions that had more than half of experts (>4) said that the item, attribute or dimension is *essential* it was retained in the final form of the questionnaire. The exceptions were the *adaptability* and *personalization* sub-dimension. This items are retained even though they got relative low support from the experts because it is expected that adaptability and personalization will become one of the fundamental characteristic of the interactive and interconnected services and applications in the future (Arbanowski et al. 2004). The same is for *response time* (*timeliness*) attribute. The list of items and their *CVR* values can be seen in the Table 19.

Table 19 List of Items and Attributes with CVR Values

Items/Attributes	*CVR*	*#Essential*
Completeness	***1,00***	***5***
*The interactive mobile information system provides me with complete set of information.**	*1,00*	*2*
*The interactive mobile information system provides me with all information I need for my activity.**	*1,00*	*5*
Information from the interactive mobile information system is sufficient for my activity.	*1,00*	*6*
The amount of information from the interactive mobile information system is appropriate for my activity.	*1,00*	*5*
Understandability	***1,00***	***7***
Information from the interactive mobile information system is easy to understand.	*1,00*	*6*
*Information from the interactive mobile information system is comprehensible.**	*0,78*	*4*
Information from the interactive mobile information system is clear in meaning.	*1,00*	*7*
Relevance	***1,00***	***8***
Information from the interactive mobile information system is relevant for my activity.	*1,00*	*7*
*Information from the interactive mobile information system is exactly what I need for my activity.**	*1,00*	*3*
Information from the interactive mobile information system is important for my activity.	*1,00*	*5*
Accuracy	***1,00***	***8***
*Information from the interactive mobile information system is correct.**	*0,78*	*4*
*Information from the interactive mobile information system is free from errors.**	*0,78*	*4*
Information from the interactive mobile information system is accurate.	*1,00*	*6*
Information from the interactive mobile information system is precise.	*1,00*	*6*
Currency	***1,00***	***7***
Information from the interactive mobile information system is timely.	*1,00*	*6*
Information from the interactive mobile information system is up to date.	*1,00*	*7*
*Information from the interactive mobile information system is most current.**	*0,78*	*2*
*Information from the interactive mobile information system is most recent.**	*0,78*	*2*
Adaptability	***1,00***	***0***

Items/Attributes	*CVR*	*#Essential*
The interactive mobile information system is adaptable to meet my activity needs.	*1,00*	*4*
*The interactive mobile information system is flexible to new demands or conditions.**	*1,00*	*3*
*The interactive mobile information system is flexible in addressing my needs.**	*0,78*	*3*
The interactive mobile information system offers flexibility as to time and place of use.	*1,00*	*5*
Availability	***1,00***	***5***
The interactive mobile information system launches and runs right away.	*1,00*	*7*
*Information from the interactive mobile information system is quickly retrievable.**	*1,00*	*4*
The interactive mobile information system is always available for usage.	*1,00*	*5*
Reliability	***1,00***	***6***
*The interactive mobile information system operates reliably.**	*0,78*	*4*
The interactive mobile information system performs reliably.	*1,00*	*6*
The interactive mobile information system always does what it should.	*1,00*	*6*
*The operation of the interactive mobile information system is dependable. **	*0,33*	*2*
Response Time	***1,00***	***5***
*The interactive mobile information system responds quickly enough.**	*0,56*	*3*
*The interactive mobile information system provides answers in a timely fashion.**	*0,56*	*0*
When I use the interactive mobile information system, system would give me immediate feedback.	*1,00*	*5*
I can obtain the information from the interactive mobile information system without any delay.	*1,00*	*5*
Accessibility	***1,00***	***5***
Interactive mobile information system allows information readily accessible to me.	*0,78*	*4*
Interactive mobile information system enables information to be accessed conveniently.	*0,78*	*5*
*The interactive mobile information system provides incessant access.**	*0,33*	*3*
Personalization	***1,00***	***0***
*Information presented from the interactive mobile information systems is well adapted to my activity.**	*0,56*	*3*
The interactive mobile information system enables me to customize the presentation of information according to my personal needs.	*1,00*	*5*
*The output information of the interactive mobile information system adjusts to my use context.**	*1,00*	*4*

Items/Attributes	*CVR*	*#Essential*
The interactive mobile information system enables me to filter the content according to my personal needs.	*0,78*	*5*
Security	***0,78***	***5***
The use of the interactive mobile information system feels secure.	*1,00*	*4*
*The interactive mobile information system has adequate security measures.**	*0,56*	*2*
The interactive mobile information system keeps the data secure from unauthorized access.	*1,00*	*4*
*I feel that there is little risk involved while using the interactive mobile information system.**	*0,56*	*2*
Effectiveness*	***1,00***	***3***
*The interactive mobile information system enhances my effectiveness.**	*0,56*	*3*
*The interactive mobile information system enables me to accomplish activity more quickly.**	*0,56*	*4*
*The interactive mobile information system helps me to save time.**	*0,78*	*3*
Efficiency	***1,00***	***5***
The interactive mobile information system increases my efficiency.	*1,00*	*5*
*The interactive mobile information system makes me productive.**	*0,78*	*3*
The interactive mobile information system helps me to optimize my activity.	*1,00*	*5*
Enjoyment	***1,00***	***5***
It was entertaining to use the interactive mobile information system.	*1,00*	*5*
I enjoyed using the use of the interactive mobile information system.	*1,00*	*5*
*I felt happy because of the interactive mobile information system use.**	*0,33*	*0*
*It was amusing to use the interactive mobile information system.**	*0,11*	*1*
Satisfaction	***1,00***	***8***
I am satisfied with the use of the interactive mobile information system.	*0,78*	*6*
*I am pleased with the use of the interactive mobile information system.**	*0,56*	*1*
*I am content with the use of the interactive mobile information system.**	*0,56*	*1*
I am delighted with the use of the interactive mobile information system.	*1,00*	*5*
Aesthetics	***1,00***	***5***

Items/Attributes	*CVR*	*#Essential*
The interactive mobile information system has aesthetically pleasing design	*1,00*	*5*
I like the visual look of the interactive mobile information system.	*0,78*	*5*
*The design of the interactive mobile information system is attractive.**	*1,00*	*4*
*The design of the interactive mobile information system is likable.**	*0,33*	*1*
The interactive mobile information system looks impressive.	*0,11*	*1*
Stimulation	***1,00***	***5***
The use of the interactive mobile information system is motivating.	*1,00*	*5*
It is fun to use the interactive mobile information system.	*0,78*	*5*
*The use of the interactive mobile information system is playful.**	*0,78*	*0*
*The use of the interactive mobile information system occupies my attention.**	*-0,33*	*1*
*The use of the interactive mobile information system is challenging.**	*-0,33*	*1*
Novelty	***0,56***	***0***
The use of the interactive mobile information system is original/innovative.	*1,00*	*5*
*The use of the interactive mobile information system is different from other systems.**	*-0,33*	*0*
*The use of the interactive mobile information system is leading edge.**	*0,11*	*0*
Usefulness	***1,00***	***6***
*The use of the interactive mobile information system is beneficial for my activity.**	*0,78*	*4*
The interactive mobile information system is useful for my activity.	*1,00*	*5*
The interactive mobile information system supports me in my activity.	*1,00*	*6*
*The interactive mobile information system is exactly what I need.**	*0,78*	*3*
*The use of the interactive mobile information system helps me easier do the activity.**	*0,78*	*4*
Privacy	***1,00***	***5***
I have control over what personal information the interactive mobile information system is using.	*1,00*	*7*
My privacy rights are adequately protected while using the interactive mobile information system.	*0,78*	*6*
*I always know when and who have access to my personal information while using the interactive mobile information system.**	*1,00*	*4*

Items/Attributes	*CVR*	*#Essential*
*I have choice whether to or not expose my personal information while using the interactive mobile information system.**	*1,00*	*3*
The interactive mobile information system doesn't use personal information without my knowledge.	*1,00*	*5*
*The interactive mobile information system doesn't share personal information to third party without my approval.**	*0,78*	*4*
*The interactive mobile information system provides me notice if third-party tries to access my personal information.**	*0,33*	*2*
Usability	***1,00***	*7*
The interactive mobile information system is easy to use.	*1,00*	*8*
*The interactive mobile information system is user-friendly.**	*0,78*	*3*
The interactive mobile information system is easy to learn.	*1,00*	*7*
*It is convenient to use the interactive mobile information system.**	*0,78*	*4*
*It is easy to become skilful at using the mobile interactive information system.**	*0,56*	*4*
Intention to reuse	***1,00***	***5***
I plan to reuse the interactive mobile information system.	*0,78*	*6*
I will continue to use this or similar interactive mobile information system.	*0,78*	*5*
*I intent to frequently use the interactive mobile information system for similar activities.**	*0,78*	*4*

*Items with low support are dropped from the further analysis. **Attributes with low support are dropped from the further analysis.

Source: made by the author

The support for the main success dimension is shown in Table 20. Information quality and system quality on the meta-level of analysis are grouped in one success dimension *information system quality* in order to have more parsimonious model.

Table 20 CVR Values for the Success Dimensions

Success Dimension	**CVR**	***#Essential***
Information Quality	1,00	*8*
System Quality	1,00	*6*
User Experience	1,00	*7*
Individual Impact	1,00	*6*
Loyalty	1,00	*6*

Source: made by the author

As attribute *Novelty*, after the Content Validity has only one item that got five experts rated as "*essential*", and based on the comments of the judges that novelty could be perceived as one type of stimulation, it is decided to move this item under the attribute *Stimulation*. As attribute *Effectiveness* along with its items didn't get enough support, it was dropped from further analysis. The total of 46 manifest variables (items) were excluded from further analysis because they did not meet the defined requirement: CVR value greater than 0.75 and/or number of experts who marked the item as *essential* more than 4.

6.1.2.2 Construct Validity

In order to assess the *construct validity* the *card sorting technique* (also called *Q-sorting*) is used. The experts from the HCI and IS domain needed to sort the *attributes* under appropriate *constructs* (*IMISS success dimensions*). This technique combines *content* and *construct validation* through experts judgments. If an attribute is consistently placed under particular category (dimension), then *convergent validity* of an attribute with related construct is achieved, and *discriminant validity* towards others constructs (Straub, Boudreau, and Gefen 2004). In each sorting round different experts (judges) participated. The judges who participated in this step were different from the judges who participated in the content validity test. Experts in this phase were from Austria (N=2), Denmark (N=1), Brazil (N=1), Finland (N=1), USA (N=1). The background experience of experts that have participated in this step is presented in appendix D. The software used for this step is *conceptcodify*[4]. Judges are asked to sort attributes into predefined construct categories (success dimensions) based on their

[4] Online tool for performing card sorting technique. The tool is from August 2015 part of the optimalworkshop.com platform.

knowledge, experience and intuition. Sorting rounds were repeated two times until a *satisfactory level of agreement among experts* regarding constructs was achieved. For those attributes for which the experts haven't agreed through each round of sorting are excluded from the questionnaire. To assess the reliability of sorting procedures two measurement methods are used: *Conger's Kappa coefficient (inter-rater agreement coefficient when more than two experts participate)* and the *Item Hit Ratio* (Moore and Benbasat 1991). The second measure hit item ratio, is used to assess how many attributes were placed by the judges for each round under the *target* construct. Acceptable level of *coefficient* should be greater than *0.65* or that *hit ratio value* should be above *75%.* The higher the percentage of attribute placed in the target construct, the higher the degree of inter-judge agreement across panel is achieved. For scales that have a large percentage of the "correct" classification are explained to have a large degree of the construct validity and high potential for good reliability.

Table 21 Referent Values for Kappa Coefficient

Kappa coefficient values	The level of agreement
less than 0,20	poor
from 0,21 to 0,40	fair
from 0,41 to 0,60	moderate
from 0,61 to 0,80	good
more than 0,80	excellent

Source: (MedCalc 2015)

Conger's kappa values are calculated using the *AgreeStat tool*[5]. Conger's kappa values for the first round of sorting, where three judges participated, was κ_c=0.60882 which indicates a *good* level of inter-judge agreement (Table 21), but not enough, according to the Moore and Benbasat recommendations it should be greater than *0.65* (Moore and Benbasat 1991). The overall frequency which all judges placed attributes within the intended theoretical construct is calculated (Table 22). The combined inter-judge raw agreement scores averaged first round 79%. Which indicates the satisfactory level of agreement.

[5] A Software for Analysing the Extent of Agreement Among Raters with MS Excel

Table 22 Attribute Placement Ratios for the 1st round of Q-sort

	Actual categories							
Target Constructs	**IQ**	**SQ**	**UXQ**	**NB**	**ITR**	**N/A**	**Total**	**Target**
Information Quality (IQ)	**14**	0	1	0	0	0	15	93%
System Quality (SQ)	0	**14**	3	4	0	0	21	67%
User Experience Quality (UXQ)	0	1	**11**	0	0	0	12	92%
Individual Impact (Net Benefits NB)	0	1	3	**8**	0	0	12	67%
Intention to Reuse (ITR)	0	0	0	0	**3**	0	3	100%
Total Item Placements:	**63**	Hits:	**50**	Overall Hit Ratio:			**79%**	

Source: made by the author

Judges had problems with sorting the attribute *Efficiency*. All three judges had different view on the *Efficiency*. One judge put *Efficiency* under the *user experience* dimension, one under the *system quality* and one under the *net benefits dimension*. Clearly there is misunderstanding regarding the *Efficiency* dimension in the case of the interactive mobile information success measurement at the individual level of use. As the focus of this research is on the hedonic system use where, efficiency is not main goal of using the systems. The author decided to drop the attribute *efficiency* from further analysis, in order to improve the inter-rater agreement score in the next round. However, if the focus of the success measurement are systems used primarily for utilitarian reasons than author recommends inclusion of this attribute as one of the benefits user get from using the systems, regardless of the CVR score.

In the second round (Table 23) different judges have participated. Conger's kappa values for the second round of sorting, was κ_c=0.84547 and the overall hit ratio was 92% which indicates an excellent level of inter-judge agreement.

Table 23 Attribute Placement Ratios for the 2nd round of Q-sort

	Actual categories							
Target Constructs	**IQ**	**SQ**	**UXQ**	**NB**	**ITR**	**N/A**	**Total**	**Target**
Information Quality (IQ)	**15**	**0**	**0**	**0**	**0**	**0**	15	100%
System Quality (SQ)	**0**	**19**	**2**	**0**	**0**	**0**	21	90%
User Experience Quality (UXQ)	**0**	**1**	**10**	**1**	**0**	**0**	12	83%
Individual Impact (Net Benefits NB)	**0**	**0**	**1**	**8**	**0**	**0**	9	89%
Intention to Reuse (ITR)	**0**	**0**	**0**	**0**	**3**	**0**	3	100%
Total Item Placements:	**60**	Hits:	**55**	Overall Hit Ratio:			**92%**	

Source: made by the author

As the results of the Conger's kappa are at the satisfactory level and overall hit ratio is high, and therefore the next round of sorting wasn't conducted.

6.2 Development of the Conceptual Model

The relationship between success dimensions form *conceptual model*. Structural theory shows how the latent variables (constructs) are related to each other. Hair et al. in their book said that: "*Theory and logic should always determine the sequence of constructs in a conceptual model. If the literature is inconsistent or unclear researchers must use their best judgment to determine the sequence.*" (J. F. J. Hair et al. 2013). In order to show that proposed *interactive mobile information system success model* (chapter 5.4) fits the data, the *Partial Least Squares Structural Equation Modelling* method *(PLS-SEM)* is used. This is variance based method that estimates structural equation models in order to maximize the explained variance of the endogenous latent variables (J. F. J. Hair et al. 2013). Within this research latent constructs (success dimensions) consist of measuring variables that also have their own measurement variables, so the multidimensional evaluation will be performed. *PLS-SEM* method allows the evaluation of reflective and formative measurement models and structural models. Measurement models represent the relationship between the measurement variables (indicators) and construct, while the structural model represents the relationship between the constructs. Additional reasons why many scientists choose *PLS-SEM* method are following (Henseler, Ringle, and Sinkovics 2009), (J. F. Hair, Ringle, and Sarstedt 2011):

- it is suitable for the research of the cause and effect relationships;
- can be used in early stages of development and validation of theoretical models;
- it is suitable for the research that is oriented towards prediction;
- can be used when the sample is small;
- it is less demanding about the distribution of variables and error conditions;
- can be used when the structural model is complex (there is a large number of constructs and indicators);
- when the goal is to predict key target constructs or identify key "driver" constructs;
- when the research is exploratory or an extension of an existing structural theory;
- when formative constructs are part of the structural model;
- when the data doesn't meet distributional assumptions and has small sample, etc.

Once the data are collected, analysis of the data will be performed and the hypotheses will be tested using the PLS-PM method. The PLS-SEM algorithm uses the known elements to estimate the unknown elements of the model (J. F. J. Hair et al. 2013). First the construct scores are calculated, then these values are used to estimate each partial regression model in the path model. As results we get the estimates for all relationships in the measurement models (i.e. loadings and weights) and the structural model (i.e. the path coefficients) (Figure 24). Model evaluation is carried out in two steps: (1) *evaluation of the external model*, and (2) *evaluation of the internal model.*

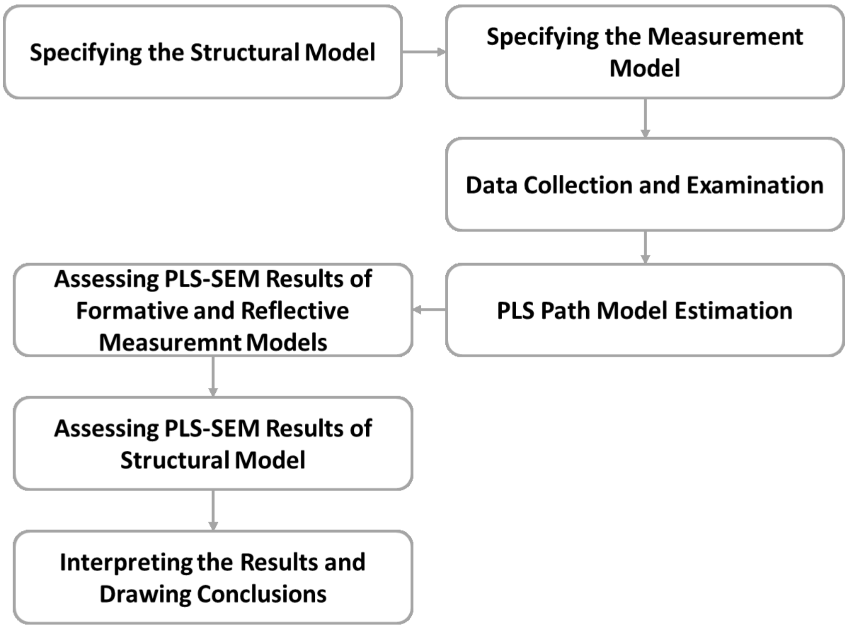


Figure 24 A systematic procedure for applying PLS-SEM
Source: (J. F. J. Hair et al. 2013)

Weather the external model is formative or reflective, the evaluation process is different (Figure 25). Analysis of the formative measurement models include assessment of the convergent validity, assessment of possible problem of collinearity among the indicators, and testing the significance and relevance of the outer weights. *Reliability* is not computed because formative indicators do not need to have mutual correlations (Wong 2013). The analysis of reflective measurement models include assessment of the internal consistency (composite) reliability and indicator reliability. Further, there is need to check for convergent validity (average variance extracted) and discriminant validity. After that follows the analysis of the structural model, which includes calculation of the coefficient of determination (R^2), predictive relevance (Q^2), size and significance of path coefficients, and effect size (f^2).

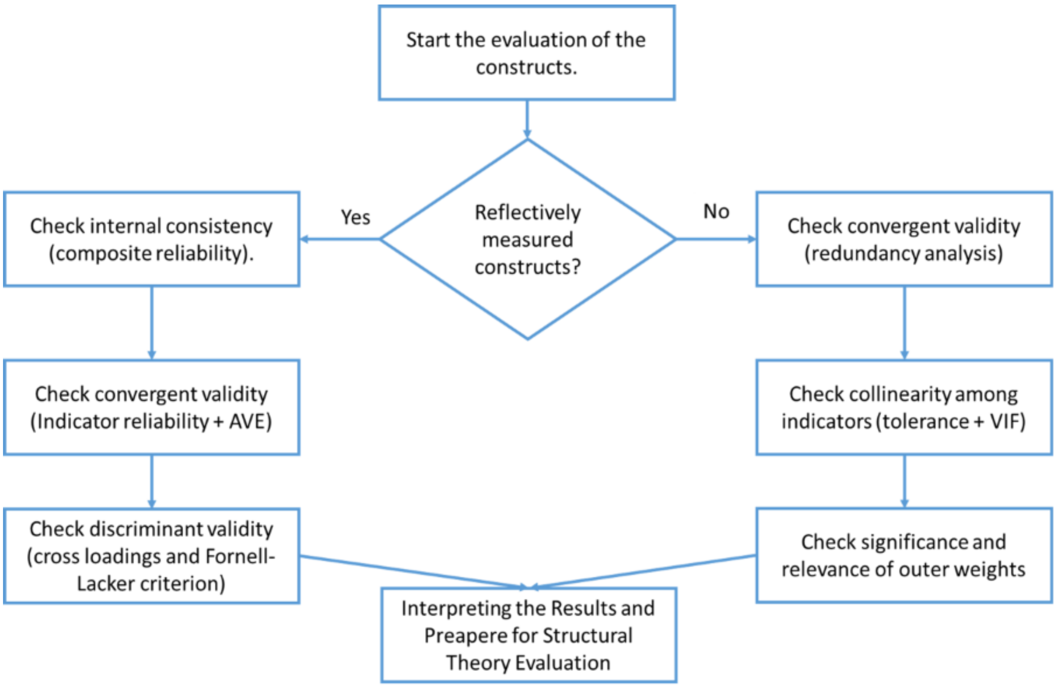


Figure 25 The steps of the measurement model analysis
Source: made by the author

Accepted practice of determining the sample size when using the PLS-PM is that the minimum sample size should be (J. F. Hair, Ringle, and Sarstedt 2011):

(1) e*qual or greater than 10 times of the maximum number of formative indicators used for measuring one construct (most complex latent exogenous constructs)*, or

(2) *10 times the largest number of structural directions (arrows) aimed at specific latent construct of the structural model*.

Goodhue and colleagues (Goodhue, Lewis, and Thompson 2012) in their research using Monte Carlo simulations analysed how effective PLS method is in comparison to the regression and LISREL method. They confirmed that PLS is effective as other two methods in the detection of existing relationships between latent variables, but with less accuracy compared to the LISREL method. However, in the case of the complex reflective models the sample size where all three methods gave similar optimal results were at round of 90 subjects. In the case of the formative measurement models researchers recommend the use of PLS-SEM over LISREL (CB-SEM) (J. F. Hair, Ringle, and Sarstedt 2011).

Higher-order component models (also in literature can be found under the names: *hierarchical latent variable models*, *hierarchical component models*, or *higher-order constructs*) are used for representations of multidimensional constructs at higher level of abstraction (Becker, Klein, and Wetzels 2012). In general in PLS-SEM literature we can approach modelling and evaluating hierarchical models by using different approaches:

(1) *the repeated indicator approach* (Becker, Klein, and Wetzels 2012),

(2) *the sequential latent variable score method or two-stage approach* (Becker, Klein, and Wetzels 2012),

(3) *the hybrid approach* (Becker, Klein, and Wetzels 2012) or

(4) *mixture of repeated indicator approach and two-stage approach* (J. F. J. Hair et al. 2013).

In order to assess the appropriateness of the first-order constructs in case of the higher component models, first assessment of the lower order model is computed and constructs scores for each latent variable in the path model are calculated. Then, this latent variable scores become manifest variables of the higher order construct.

Within this study new proposed *interactive mobile IS success model* is proposed and tested as *hierarchical-component structural model* (*third order model*). More specifically as the *reflective-formative hierarchical latent variable model (Mode B)* with using a *mixture* of the *repeated indicator approach* and the use of the latent variable scores in a *two-stage approach* according to the recommendations of Hair et al. (J. F. J. Hair et al. 2013). The questionnaire data present basis for the test of the relationships between success dimensions (constructs) and for comparison of the models. On the Figure 26 the proposed conceptual *interactive mobile IS success model* (IMISS model) is presented. *Information quality*, *system quality* and *net benefits at individual level* are constructs (dimensions) operationalized from DeLone and McLean IS success model. Based on the literature review in chapter 5.1 this study integrates *user experience quality* (composed of the pragmatic and hedonic experience) as intermediated dimension between *information system quality* and *net benefits*. Additional dimension is added as last depended variable *intention to reuse*.

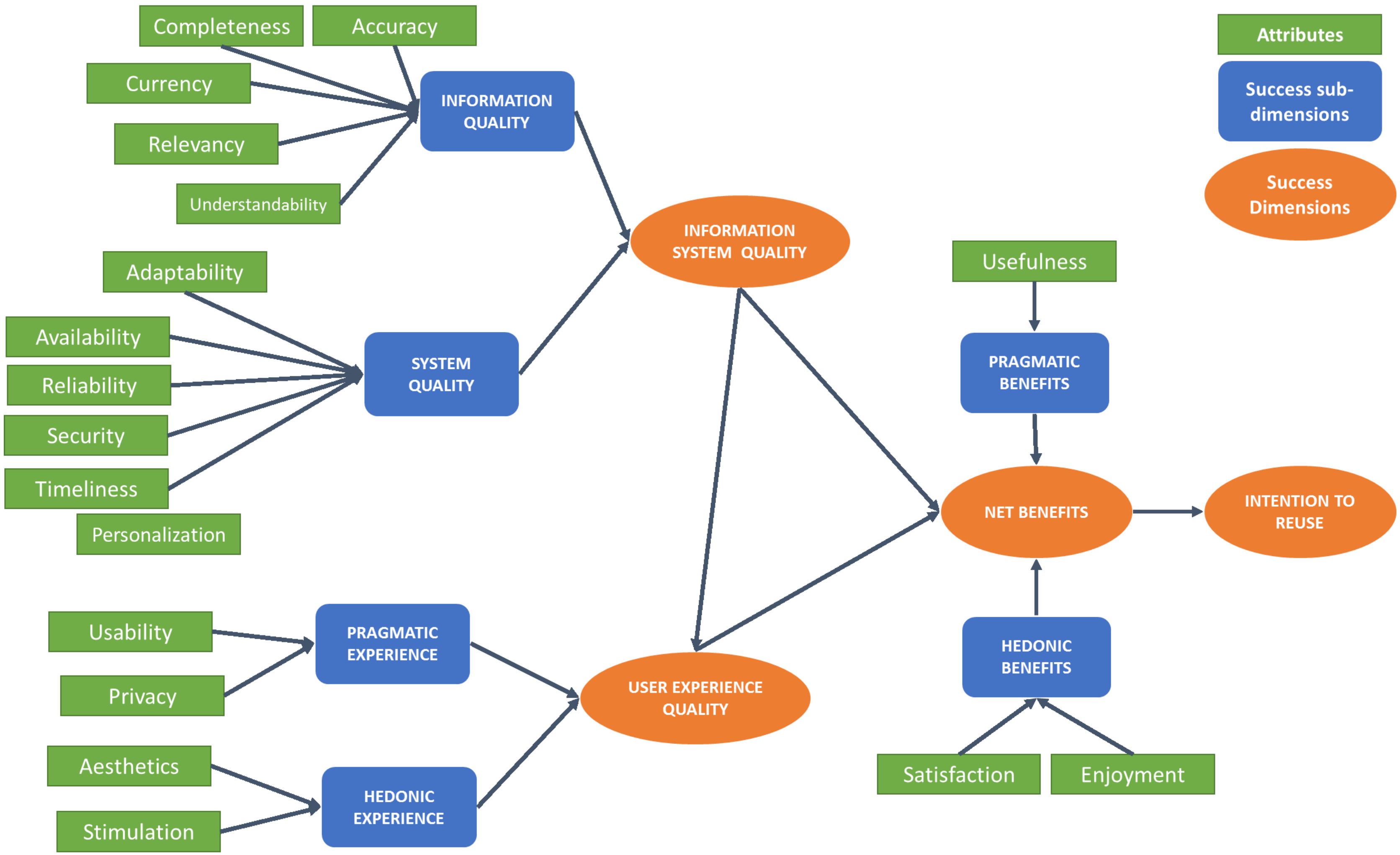


Figure 26 The Conceptual Model of the Study IMISS Model
Source: made by the author

7. ARTEFACTS EVALUATION

The fourth step of the design science research methodology is evaluation of the developed artefacts. This step is one of the most crucial steps of the design science research methodology. This step is composed of two sub-phases: (1) *pilot testing of the questionnaire*, (2) and *conceptual model evaluation*.

The evaluation of the questionnaire on the pilot data will be performed by using Cronbach's alpha measure. Cronbach's alpha is measure that determines the internal consistency or average correlation of items in a survey instrument in order to measure its reliability (Cronbach 1951). Scale should have at least two items in order to calculate Cronbach's alpha coefficient. Cronbach's alpha coefficient value range from *0* to *1*. Alpha coefficient may be used to describe the reliability of factors extracted from dichotomous scales (i.e. questions with two possible answers) and/or multi-point formatted questionnaires or scales (i.e., rating scale: 1 – poor, 5 – excellent) (Santos 1999).

The evaluation of the conceptual model (IMISS model) will include the *evaluation of the measurement model* and *evaluation of the structural model.* For this evaluation the *partial least squares – structural equation modelling* (PLS-SEM) method is used. This technique is based on the regression analysis and aims to maximize the explained variance of the depended latent variable (J. F. J. Hair et al. 2013). This method uses available data to estimate the path relationships in the model in order to minimize the residual variance of the endogenous variables. Within this study SmartPLS 2.0 software is used to validate the measurement and structural model of the proposed IMISS model. The analysis of the conceptual model starts with reliability analysis of manifest variable on all the levels of multidimensional conceptual model, and then continues to the structural model evaluation i.e. the relationships between success dimensions of the IMISS model.

7.1 Pilot-Questionnaire Testing

Questionnaire testing is the third step of Moore and Benbasat (Moore and Benbasat 1991) guidelines in questionnaire development (chapter 6.1.1). After the final list of questionnaire items is formed (as result of development phase), the pilot study is conducted to verify the form of questionnaire and statistically assess the reliability of the questionnaire. For the questionnaire implementation the online tool *kwiksurveys*[6] was used. All items were formulated as statements where respondents were able to self-position themselves on a scale from 1 to 5, 1 being strongly disagree and 5 strongly agree. The questionnaire had randomly organized items in its pilot version. There was no evidence to which attributes and dimension items belonged.

In order to test the questionnaire reliability, the successful and well accepted in practice mobile augmented reality game *Ingress* was selected as an example of the interactive mobile information system. This is the example of system with *high mobility* and *high context interactions* (chapter 2.4.3). On nine *Google+*[7] groups where *Ingress* gamers around the world “hangout” the invitation message to participate in the online survey has been posted. The gamers (participants) were asked to fill out the pilot version of the questionnaire. Pilot version of the questionnaire was available online from 05th of March till 20th of March in 2015. Large number of *Ingress* players after the initial opening the online survey and filling in their details have quit from further filling the survey. The respondents mainly had difficulties in completing the questionnaire because of its length based on the some of the comments they have left as response to the invitation message. In the end there were only 43 valid data sets from the participants that have filled out the whole survey (response rate 23% of all the respondents who opened the survey link 184).

To examine the reliability of the instrument (questionnaire), Cronbach’s alpha was computed (Cronbach 1970). The reliability of the scale indicates that the study is free from random error. With this metric the internal consistency of the scale is calculated. The accepted level of Cronbach’s alpha coefficient is of *0.60* for exploratory research and *0.70* for confirmatory research (Straub, Boudreau, and Gefen 2004). In order to reduce the number of items for the field study, items that have low item-item and item-scale correlation, are deleted. The target level of minimum reliability for this study is set to be above *0.65* in pilot study and above *0.70* in the field test. However, before the item will be deleted the check will be made to ensure that the domain coverage (i.e. *content validity*) of the construct would not suffer.

[6] *Kwiksurveys* is online tool that enables easy and quick development of the questionnaires or different kind of polls. The url address is following: https://kwiksurveys.com/
[7] Google+ (pronounced: Google Plus) is online communication and discussion platform offered by Google company. This platform enables creation of communities of interest and sharing their ideas, comments and experiences.

Table 24 Cronbach's Alpha Values for Pilot Data Ingress

Attributes	Cronbach's Alpha
Accessibility	0.6311
Accuracy	0.8903
Adaptability	0.7165
Aesthetics	0.8843
Availability	0.6503
Completeness	0.7303
Currency	0.7573
Enjoyment	0.8590
Intention to Reuse	0.8084
Personalization	0.7029
Privacy	0.8167
Relevance	0.7895
Reliability	0.7135
Response time	0.8496
Satisfaction	0.8863
Security	0.7215
Stimulation	0.7868
Understanding	0.8576
Usability	0.7266
Usefulness	0.8233

Source: made by the author

The results of the Cronbach's alpha for pilot data are presented in Table 26. Lowest Cronbach's Alpha was for the *Accessibility* attribute (0.6311). Because this value is below 0.65 it is decided to drop this attribute from the further analysis. One possible interpretation of this result could mean that just the present formulation of the accessibility items is not appropriate and maybe some new formulation of the accessibility items is needed. As this attribute is not present in the updated DeLone and McLean IS success model, it will be omitted from the further research steps. However, the author encourage future reformulation and re-examination of the accessibility items within the IMISS model. Attribute *Adaptability* (0.6503) also got relative low Cronbach's alpha values, but this attribute will be kept in further analysis because it was present in the updated DeLone and McLean IS success model. Summary of reliability analysis for main success dimensions (constructs) is shown in Table 25.

Table 25 Cronbach's Alpha Values for the Main Success Dimensions of the IMISS model

Constructs (dimensions)*	Number of Items	Cronbach's Alpha Value
Information System Quality	24	0.9290
User Experience Quality	10	0.7993
Individual Benefits	6	0.7355
Intention to Reuse	2	0.7118

* Higher order level constructs
Source: made by the author

From the results on pilot data presented in Table 24 and 25 we can conclude that the *reliability* of the questionnaire is achieved. Based on the literature review in chapter 6.1.1., and on the *content* and *construct validity* analysis in chapter 6.1.2., and on the summary from this chapter it can be concluded that the support for the acceptance of the first hypothesis is ensured i.e. *Developed measurement instrument for mobile information system success measurement from end-user value perspective is valid and reliable.* The support for the first hypothesis will also be re-examined within the evaluation of the conceptual model i.e. IMISS model evaluation process.

7.2 Validation of the Conceptual Model

Based on the results of the pilot-study minor modifications to the questionnaire are made and the final form of the questionnaire is developed. The final form of the questionnaire was also implemented by using the *kwiksurveys* tool. For the final field test, two presented augmented reality systems are employed as case studies: (1) mobile augmented reality game *Ingress,* and (2) mobile augmented reality city tour guide *VarazdinAR*. Both of the cases were presented in the chapter 2.4.3.

7.2.1 Sample Characteristics

7.2.1.1 Ingress Augmented Reality Game

On the nine Ingress Google+ groups, which were already used in pilot study, the invitation message to participate in the study was republished and on the five new ones the invitation for participation in the study was posted. The questionnaire was available online from 03th of April till 10th of July in 2015. The participants in *Ingress* study were active players and followers of the *Ingress* activities in their region. From 207 survey entries there were 79 entries that weren't complete (many respondents have answered on the few first pages and then decided to quit the survey), and 16 entries had all answers to all the questions the same such as *neutral, strongly disagree* or *strongly agree.* Incomplete or redundant data set are removed. In the end there were total of 112 valid data sets.

Table 26 Characteristics of the Respondents of the Ingress Survey

Characteristic	Number	Percentage
Gender		
Male	**86**	77%
Female	26	23%
Total	**112**	**100%**
Age groups		
<20	8	7%
21-29	31	28%
30-39	51	46%
40-49	16	14%
50-59	6	5%
60+	0	

Source: made by the author

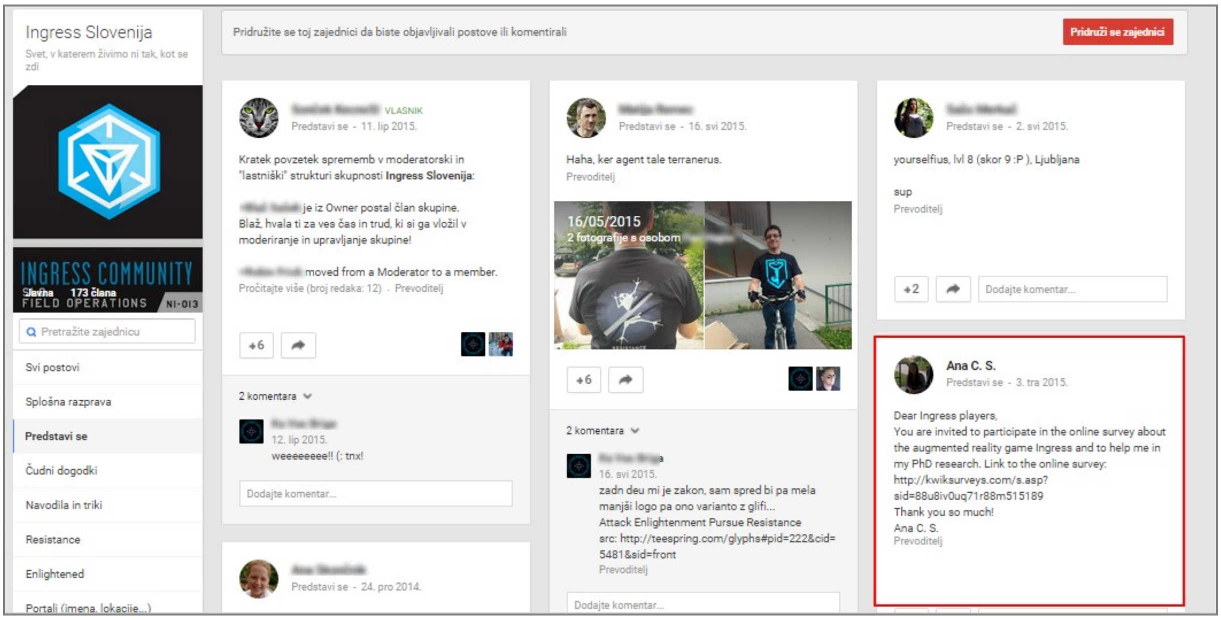


Figure 27 Example of the Ingress Group with Posted Invite Message

7.2.1.2 VarazdinAR Augmented Reality Game

As the *VarazdinAR* is newly developed augmented reality system by author for the tourists of the city Varazdin, it demanded different data gathering techniques. The invitation flyers were left in the Varazdin tourist office and on the information desk of the most prestige and most popular hotel in Varazdin, hotel Tourist, in period from June till August. Because of the low response of the city tourist to participate in the study it was decided to also invite students of the Faculty of Organization and Informatics to participate in the study in order to get sufficient data sample for model evaluation. In total there were 102 valid questionnaire answers on the *VarazdinAR* survey. Seven survey data entries were excluded because of too much missing data or because of the answering the same answer through the whole study. The majority of the *VarazdinAR* evaluation study participants were students of the first year at Faculty of Organization and Informatics, (*N=22*) and students of second year (*N=39*) at Faculty of Organization and Informatics. The rest were the responses from tourists of city Varazdin (*N=41*). The limitation of the second case is that students in majority participated in the study even though the system is primarily developed for the tourists. As many students weren't originally from city Varazdin, for them this was interesting way to discover the history of the city they are now studying as well to check the suitability of this system if they wish to better get to know the history of the city.

Table 27 Characteristics of the Respondents of the VarazdinAR Survey

Characteristic	Number	Percentage
Gender		
Male	64	63%
Female	38	37%
Total	**102**	**100%**
Age groups		
<20	26	**25%**
21-29	48	**47%**
30-39	19	**19%**
40-49	7	**7%**
50-59	0	**0%**
60+	2	**2%**

Source: made by the author

7.2.2 Evaluation of the First Order Measurement Model

In figure 28 we can see the representation of the structural model between first, second and third order latent constructs. All constructs of the IMISS model on the first level are reflective measurement models. Second order constructs (*information quality*, *system quality*, *pragmatic experience, hedonic experience, pragmatic values* and *hedonic values)* and third order constructs (*information system quality, user experience quality* and *perceived values*) are formative constructs and they are evaluated on the higher order level.

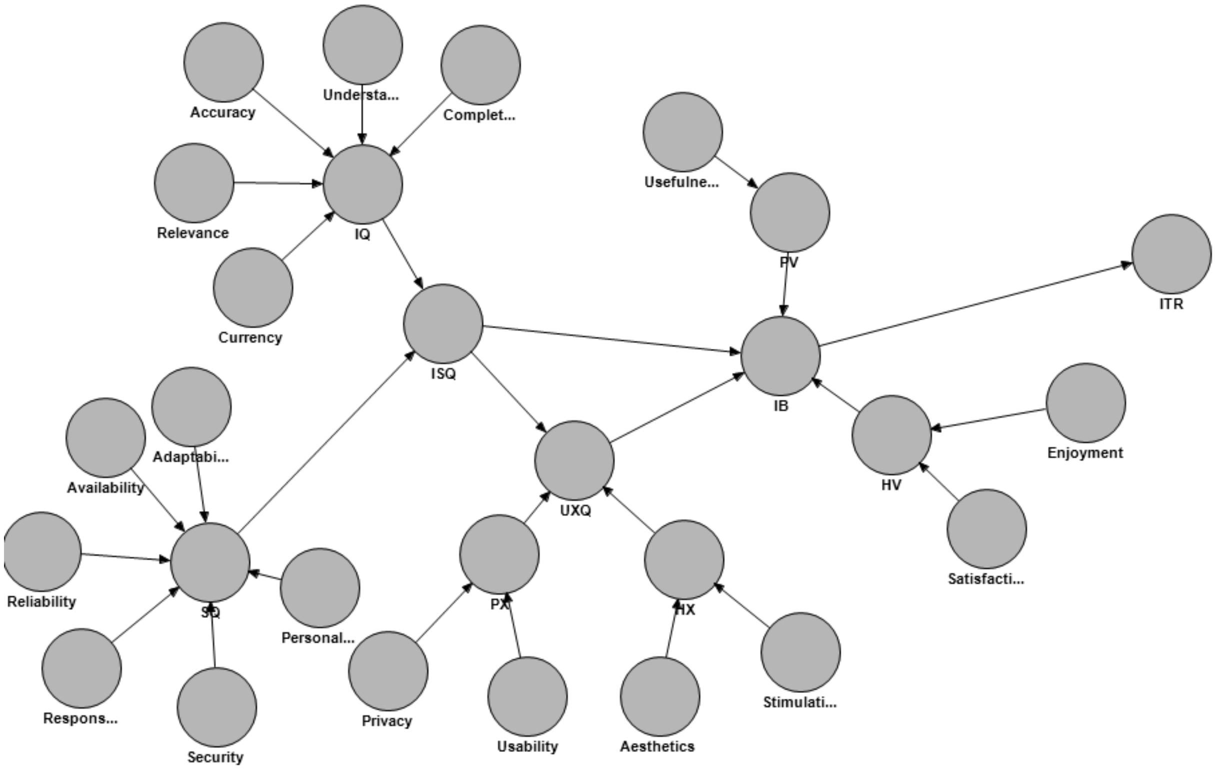


Figure 28 The Conceptual IMISS Model on the First Order Level
Source: made by the author

Reflective measurement model's validation assess the (1) *internal consistency* (*composite reliability*), (2) *indicator reliability*, (3) *convergent validity* and (4) *discriminant validity*. Accepted rules of thumb for evaluating reflective measurement models is shown in Table 28.

Table 28 Accepted Rules of Thumb for the Evaluation of the Reflective Measurement Models

Assessment measurement	**Description**
Internal consistency reliability	Composite reliability should be higher than 0.708.However, in exploratory research values of 0.60 to 0.70, are acceptable. Cronbach's alpha is considered as a conservative measure of internal consistency reliability.
Indicator reliability	Outer loadings of the indicator should be higher than 0.708. Indicators with outer loading values between 0.40 and 0.70 should be considered for removal if their deletion leads to an increase in composite reliability and average variance extracted (AVE) values.

Assessment measurement	Description
Convergent validity	The average variance extracted (AVE) values should be higher than 0.50.
Discriminant validity	Indicator's outer loading on its construct should be higher than all its cross loadings with outer constructs. The square root of the AVE (Fornell-Larcker criterion) of each construct should be higher than its highest correlation with any other construct.

Source: Adapted from (J. F. J. Hair et al. 2013)

7.2.2.1 Internal consistency assessment

The usual method for assessing the internal consistency of scales is *Cronbach's alpha*. The Cronbach's alpha is already calculated for the pilot data within the chapter 7.1. As PLS-PM practice is more favourable towards using the *composite reliability* measure for assessing the internal consistency, this measure will be used in order to (re)confirm the second part of the first hypothesis (i.e. reliability of the developed measurement instrument). Composite reliability is better measure than Cronbach's alpha measure, and overcomes its limitations regarding the number of items in the scale and its underestimation of the internal consistency reliability (J. F. J. Hair et al. 2013). Composite reliability takes into the account the different outer loadings of the indicators. The values between *0.60* and *0.70* are acceptable in exploratory research, however values between *0.70* and *0.90* can be considered as satisfactory. Values below *0.60* indicate a lack of internal consistency reliability (J. F. J. Hair et al. 2013).

Results of the internal consistency after the execution of the PLS-PM algorithm in software *SmartPLS 2.0* for the first case study, *augmented reality game Ingress,* is shown in the Table 29. From the presented results we can see that all reflective constructs have high levels of *internal consistency reliability*. Highest internal consistency reliability has attribute *Aesthetics* with value of *0.9448*, and lowest internal consistency has attribute *Adaptability* of *0.7464*.

Table 29 Internal Consistency of First Order Latent Constructs Ingress

Attributes	Composite Reliability
Accuracy	0.8931
Adaptability	0.7464
Aesthetics	0.9448

Attributes	Composite Reliability
Availability	0.8829
Completeness	0.8533
Currency	0.8861
Enjoyment	0.9152
Intention To Reuse	0.8624
Personalization	0.8371
Privacy	0.8582
Relevance	0.7832
Reliability	0.8725
Response-Time	0.8270
Satisfaction	0.8594
Security	0.8355
Stimulation	0.8404
Understandability	0.8330
Usability	0.8933
Usefulness	0.8055

Source: made by the author

Results of the *internal consistency* of the PLS-PM algorithm run for the *augmented reality city tour guide VarazdinAR* data set is shown in the Table 30. From the presented results it can be seen that all first level reflective constructs have high levels of internal consistency reliability. Highest internal consistency reliability has attribute *Responses time* with value of *0.9381*, and lowest reliability has attribute *Understandability* with value of *0.7677*.

Table 30 Internal Consistency of First Order Latent Constructs VarazdinAR

Attributes	Composite Reliability
Accuracy	0.8885
Adaptability	0.7715
Aesthetics	0.9332
Availability	0.8415
Completeness	0.8437
Currency	0.8498
Enjoyment	0.9036
Intention To Reuse	0.8833
Personalization	0.7852
Privacy	0.8172
Relevance	0.8258
Reliability	0.8553
Response Time/Timeliness	0.9381
Satisfaction	0.9120
Security	0.8669
Stimulation	0.8564

Attributes	Composite Reliability
Understandability	0.7677
Usability	0.8159
Usefulness	0.8469

Source: made by the author

7.2.2.2 Convergent validity

Convergent validity represent the extent to which measure correlates positively with alternative measures of the same construct. Items that are indicators (measures) of some construct should converge or share a high portion of the variance. In this case we should check the *outer loadings* and *average variance extracted* (AVE). In the reflective measurement models analysis we need to estimate the relationships between the reflective latent variables and their indicators (i.e. outer loading). Higher outer loadings on a construct indicate that indicators have much in common. Accepted rule of thumb is that the standardized outer loading should be close to *0,708* or *higher.* In social sciences in case of the newly developed scales even if *outer loadings* are below of 0.70, researchers should carefully consider whether they should remove indicator from scale or not and what effects that causes on the composite reliability of scale. If the removal increases composite reliability than indicators should be removed. Indicator should be considered to be kept in the study if its removal affects the content validity of the construct (J. F. J. Hair et al. 2013). The outer loadings of the two cases are presented in the Table 31 for augmented reality game *Ingress* and in Table 32 for the augmented reality *VarazdinAR*. From the presented results it can be seen that all outer loadings of the reflective constructs are above the recommended threshold value of *0.708*. The smallest outer loading in case of the augmented reality game *Ingress* is present in the item "*The mobile game Ingress doesn't use my personal information without my knowledge.*" of value 0.7637. The smallest outer loading in case of the augmented reality city tour system *VarazdinAR* is present in the item "*Information from the mobile system VarazdinAR is clear in meaning.*" of value 0.6768. Although this value is smaller than needed, it will be kept in the study because of its contribution to the content validity (see CVR value in the chapter 6.1.2.).

Table 31 Outer loadings Ingress

Items	***Outer loading***
Information from the mobile game Ingress is accurate.	0.9005
Information from the mobile game Ingress is precise.	0.896
The mobile game Ingress is adaptable to meet my gaming needs.	0.7703
The mobile game Ingress offers flexibility as to time and place of use.	0.7729
The mobile game Ingress has aesthetically pleasing design.	0.947
I like the visual look of the mobile game Ingress.	0.9455
The mobile game Ingress launches and runs right away.	0.876
The mobile game Ingress is always available for usage.	0.9019
Information from the mobile game Ingress is sufficient for the game.	0.8593
The amount of information from the mobile game Ingress is appropriate to play the game.	0.8658
Information from the mobile game Ingress is timely.	0.8867
Information from the mobile game Ingress is up to date.	0.897
It was entertaining to play the mobile game Ingress.	0.918
I enjoyed playing the mobile game Ingress.	0.9191
I plan to reuse the mobile game Ingress.	0.8343
I will continue to use the mobile game Ingress.	0.8574
The mobile game Ingress enables me to customize the presentation of information according to my personal needs.	0.8825
The mobile game Ingress enables me to filter the content according to my personal needs.	0.8134
I have control over what personal information the mobile game Ingress is using.	0.8193
My privacy rights are adequately protected while using the mobile game Ingress.	0.8676
The mobile game Ingress doesn't use my personal information without my knowledge.	0.7637
Information from the mobile game Ingress is relevant to play the game.	0.8343
Information from the mobile game Ingress is important to play the game.	0.7696
The mobile game Ingress performs reliably.	0.8918
The mobile game Ingress always does what it should.	0.8674
When I use the mobile game Ingress, game would give me immediate feedback.	0.8186
I can obtain the information from the mobile game Ingress without any delay.	0.8604
I am satisfied with the use of the mobile game Ingress.	0.8805
I am delighted with the use of the mobile game Ingress.	0.8554
The use of the mobile game Ingress feels secure.	0.8906
The mobile game Ingress keeps the data secure from unauthorized access.	0.8019
The use of the mobile game Ingress is motivating.	0.8549
The use of the mobile game Ingress is fun.	0.8478
Information from the mobile game Ingress is easy to understand.	0.8246
Information from the mobile game Ingress is clear in meaning.	0.8648
The mobile game Ingress is easy to use.	0.9244

Items	*Outer loading*
It is easy to learn how to use the mobile game Ingress.	0.8718
The use of the mobile game Ingress is useful for having game experience.	0.8292
The mobile game Ingress supports me in my gaming experience.	0.8132

Table 32 Outer loadings VarazdinAR

Items	*Outer Loading*
Information from the mobile system VarazdinAR is accurate.	0.8693
Information from the mobile system VarazdinAR is precise.	0.9183
The mobile system VarazdinAR is adaptable to meet my city tour needs.	0.7693
The mobile system VarazdinAR offers flexibility as to time and place of use.	0.8149
The mobile system VarazdinAR has pleasing design.	0.9375
I like the visual look of the mobile system VarazdinAR.	0.933
The mobile system VarazdinAR launches and runs right away.	0.8413
The mobile system VarazdinAR is always available for usage.	0.8632
Information from the mobile system VarazdinAR is sufficient for the city tour.	0.8658
The amount of information from the mobile system VarazdinAR is appropriate for the city tour.	0.8425
Information from the mobile system VarazdinAR is timely.	0.8988
Information from the mobile system VarazdinAR is up to date.	0.819
It was entertaining to use the mobile system VarazdinAR.	0.8924
I enjoyed using the mobile system VarazdinAR.	0.9231
I plan to reuse the mobile system VarazdinAR.	0.8721
I will continue to use this or similar augmented reality system for city tours.	0.9063
The mobile system VarazdinAR enables me to customize the presentation of information according to my personal needs.	0.8438
The mobile system VarazdinAR enables me to filter the content according to my personal needs.	0.7628
I have control over what personal information the mobile system VarazdinAR is using.	0.7819
My privacy rights are adequately protected while using the mobile system VarazdinAR.	0.7626
The mobile system VarazdinAR doesn't use my personal information without my knowledge.	0.7763
Information from the mobile system VarazdinAR is relevant to the city tour.	0.8460
Information from the mobile system VarazdinAR is important to the city tour.	0.8313
The mobile system VarazdinAR performs reliably.	0.8613
The mobile system VarazdinAR always does what it should.	0.8676
When I use the mobile system VarazdinAR, system would give me immediate feedback.	0.9403
I can obtain the information from the mobile system VarazdinAR without any delay.	0.9396
I am satisfied with the use of the mobile system VarazdinAR.	0.9029
I am delighted with the use of the mobile system VarazdinAR.	0.9282
The use of the mobile system VarazdinAR feels secure.	0.8901

Items	*Outer Loading*
The mobile system VarazdinAR keeps the data secure from unauthorized access.	0.8590
The use of the mobile system VarazdinAR is motivating.	0.8226
The use of the mobile system VarazdinAR is fun.	0.9065
Information from the mobile system VarazdinAR is easy to understand.	0.8926
Information from the mobile system VarazdinAR is clear in meaning.	0.6768
The mobile system VarazdinAR is easy to use.	0.8855
It is easy to learn how to use the mobile system VarazdinAR.	0.7720
The use of the mobile system VarazdinAR is useful for having tour experience.	0.8535
The mobile system VarazdinAR supports me in my city tour experience.	0.8605

Source: made by the author

Average variance extracted (AVE) is the measure with whom we measure *convergent validity* of the construct. This measure is the grand mean value of the squared loadings of the indicators associated with the construct. The calculation of this measure is as sum of square loadings divided by the number of indicators. This value is equivalent to the communality of a construct (J. F. J. Hair et al. 2013). AVE values of 0.50 or higher indicate that on average the constructs explain more than half of the variance of its indicators, otherwise more error remains in the items than the variance explained by the construct.

Table 33 Average Variance Extracted Ingress

Attributes	**AVE**
Accuracy	0.8068
Adaptability	0.5954
Aesthetics	0.8955
Availability	0.7904
Completeness	0.7441
Currency	0.7955
Enjoyment	0.8437
Intention To Reuse	0.7581
Personalization	0.7202
Privacy	0.6691
Relevance	0.6441
Reliability	0.7739
Response Time	0.7052
Satisfaction	0.7535
Security	0.7181
Stimulation	0.7248
Understandability	0.7139
Usability	0.8073
Usefulness	0.6744

Source: made by the author

From Table 33 we can see that all reflective latent variables have the minimum required AVE level of 0.50. AVE values range from *0.5954* to *0.8955* in the case of the *Ingress* augmented reality system.

Table 34 Average Variance Extracted VarazdinAR

Attributes	AVE
Accuracy	0.7994
Adaptability	0.6280
Aesthetics	0.8747
Availability	0.7264
Completeness	0.7297
Currency	0.7393
Enjoyment	0.8242
Intention To Reuse	0.7910
Personalization	0.6469
Privacy	0.5985
Relevance	0.7034
Reliability	0.7473
Response Time	0.8835
Satisfaction	0.8383
Security	0.7651
Stimulation	0.7493
Understandability	0.6274
Usability	0.6900
Usefulness	0.7344

Source: made by the author

From Table 34 we can see that in the case of the augmented reality city tour guide *VarazdinAR* all reflective latent variables have the minimum required level of 0.50. AVE values range from *0.5985* to *0.8835*. Thus it can be concluded that all reflective constructs have high levels of convergent validity.

7.2.2.3 Discriminant validity

Discriminant validity presents the extent to which a construct is truly distinct from other constructs. Or in other words, how much it correlates with other constructs, as well how much indicators represent only single construct (J. F. J. Hair et al. 2013). *Fornell-Larcker* criterion and *cross-loadings* measures are used to check for the *discriminant validity. Fornell-Larcker* criterion says that the square root of the AVE of each construct should be higher than the construct's highest correlation with any other construct. The logic of this method is based on the idea that a construct shares more variance with associated indicators than with any other construct. The results of *Fornell-Larcker* are presented in Table 35 for the augmented reality game *Ingress* and in Table 36 for the augmented reality city tour system *VarazdinAR*. From the results in the diagonal we can see that all reflective first order constructs have values above 0.70, and all are higher than the correlations of these constructs with other latent variables in the path model. The results of cross-loadings analysis are presented in Table 37 for augmented reality game *Ingress* and in Table 38 for the augmented reality city tour guide *VarazdinAR*. All indicators' loadings on a corresponding construct are higher than all of their cross-loadings with other constructs. We can conclude from the Fornell-Larcker criterion and the cross-loadings results that requirements of the discriminant validity of the measurement models for both cases have been met, i.e. that every reflective construct shares more variance with its own indicators than with others in the path model.

Table 35 Fornell-Larcker Criterion for the Case Ingress

	ACC	ADA	AES	AVA	COM	CUR	ENJ	ITR	PER	PRI	RLV	RLB	RT	SAT	SEC	STI	UND	USA	USE
ACC	**0.90**																		
ADA	0.24	**0.77**																	
AES	0.14	0.24	**0.95**																
AVA	0.41	0.34	0.20	**0.89**															
COM	0.31	0.34	0.24	0.21	**0.86**														
CUR	0.57	0.34	0.26	0.42	0.40	**0.89**													
ENJ	0.09	0.43	0.31	0.12	0.21	0.12	**0.92**												
ITR	0.21	0.28	0.28	0.16	0.23	0.26	0.50	**0.87**											
PER	0.27	0.22	0.24	0.46	0.28	0.42	0.14	0.06	**0.85**										
PRI	0.30	0.15	0.18	0.12	0.31	0.26	0.03	-0.03	0.22	**0.82**									
RLV	0.43	0.26	0.06	0.29	0.40	0.39	-0.04	0.01	0.28	0.36	**0.80**								
RLB	0.44	0.31	0.19	0.62	0.29	0.52	0.09	0.07	0.51	0.16	0.32	**0.88**							
RT	0.51	0.44	0.38	0.50	0.42	0.57	0.18	0.27	0.43	0.35	0.44	0.49	**0.84**						
SAT	0.30	0.44	0.46	0.31	0.39	0.42	0.57	0.45	0.33	0.22	0.23	0.35	0.44	**0.87**					
SEC	0.32	0.25	0.20	0.21	0.23	0.26	0.14	0.14	0.12	0.57	0.38	0.22	0.40	0.37	**0.85**				
STI	0.20	0.38	0.23	0.12	0.27	0.20	0.59	0.35	0.20	0.16	0.13	0.23	0.16	0.67	0.30	**0.85**			
UND	0.48	0.07	0.09	0.35	0.30	0.42	-0.03	0.10	0.37	0.28	0.57	0.42	0.41	0.22	0.20	0.09	**0.84**		
USA	0.22	0.27	0.33	0.28	0.13	0.27	0.26	0.19	0.21	-0.03	0.12	0.30	0.31	0.36	0.05	0.15	0.31	**0.90**	
USE	0.16	0.14	-0.01	0.03	0.11	0.07	0.17	0.04	0.05	0.13	0.16	0.03	0.14	0.10	0.37	0.20	-0.01	-0.09	**0.82**

ACC – Accuracy; ADA– Adaptability; AES– Aesthetics; AVA – Availability; COM – Completeness; CUR – Currency; ENJ – Enjoyment; ITR - Intention To Reuse; PER – Personalization; PRI – Privacy; RLV – Relevance; RLB – Reliability; RT - Response Time; SAT – Satisfaction; SEC – Security; STI – Stimulation; UND – Understandability; USA – Usability; USE - Usefulness

Table 36 Fornell-Larcker Criterion for the Case VarazdinAR

	ACC	ADA	AES	AVA	COM	CUR	ENJ	ITR	PER	PRI	RLV	RLB	RT	SAT	SEC	STI	UND	USA	USE
ACC	**0.89**																		
ADA	0.36	**0.79**																	
AES	0.36	0.45	**0.94**																
AVA	0.40	0.49	0.45	**0.85**															
COM	0.53	0.41	0.28	0.44	**0.85**														
CUR	0.57	0.29	0.24	0.29	0.42	**0.86**													
ENJ	0.43	0.47	0.31	0.33	0.35	0.30	**0.91**												
ITR	0.30	0.54	0.41	0.36	0.23	0.31	0.51	**0.89**											
PER	0.36	0.36	0.30	0.41	0.41	0.38	0.32	0.45	**0.80**										
PRI	0.33	0.21	0.18	0.38	0.33	0.34	0.30	0.16	0.31	**0.77**									
RLV	0.27	0.43	0.23	0.44	0.39	0.35	0.42	0.64	0.48	0.24	**0.84**								
RLB	0.63	0.60	0.43	0.55	0.53	0.45	0.42	0.50	0.44	0.34	0.48	**0.86**							
RT	0.61	0.43	0.31	0.65	0.39	0.45	0.29	0.41	0.35	0.30	0.40	0.67	**0.94**						
SAT	0.62	0.52	0.54	0.45	0.49	0.43	0.71	0.63	0.45	0.39	0.51	0.62	0.49	**0.92**					
SEC	0.45	0.43	0.39	0.54	0.47	0.34	0.42	0.38	0.37	0.55	0.34	0.55	0.38	0.50	**0.87**				
STI	0.11	0.45	0.38	0.28	0.21	0.07	0.47	0.57	0.32	0.09	0.50	0.26	0.13	0.44	0.31	**0.87**			
UND	0.27	0.22	0.21	0.25	0.29	0.25	0.34	0.27	0.25	0.31	0.26	0.21	0.22	0.42	0.29	0.21	**0.79**		
USA	0.43	0.35	0.30	0.42	0.34	0.28	0.32	0.29	0.29	0.20	0.23	0.36	0.34	0.35	0.21	0.23	0.40	**0.83**	
USE	0.27	0.32	0.22	0.16	0.16	0.28	0.39	0.27	0.21	0.09	0.11	0.26	0.09	0.30	0.36	0.23	0.18	0.23	**0.86**

ACC – Accuracy; ADA– Adaptability; AES– Aesthetics; AVA – Availability; COM – Completeness; CUR – Currency; ENJ – Enjoyment; ITR - Intention To Reuse; PER – Personalization; PRI – Privacy; RLV – Relevance; RLB – Reliability; RT - Response Time; SAT – Satisfaction; SEC – Security; STI – Stimulation; UND – Understandability; USA – Usability; USE - Usefulness

Table 37 Cross loadings Values for the Case Ingress

	ACC	ADA	AES	AVA	COM	CUR	ENJ	ITR	PER	PRI	RLV	RLB	RT	SAT	SEC	STI	UND	USA	USE
ACC3	0.90	0.35	0.18	0.32	0.29	0.55	0.20	0.24	0.18	0.33	0.40	0.35	0.50	0.36	0.40	0.30	0.38	0.14	0.22
ACC4	0.90	0.07	0.07	0.41	0.26	0.47	-0.04	0.13	0.31	0.21	0.37	0.44	0.42	0.18	0.18	0.06	0.49	0.26	0.07
CUR1	0.47	0.31	0.22	0.35	0.37	0.89	0.12	0.24	0.37	0.23	0.31	0.49	0.57	0.42	0.24	0.19	0.38	0.30	0.02
CUR2	0.55	0.29	0.25	0.40	0.33	0.90	0.09	0.23	0.39	0.24	0.38	0.44	0.45	0.34	0.23	0.16	0.37	0.19	0.10
ENJ1	0.17	0.40	0.37	0.06	0.24	0.15	0.92	0.46	0.13	0.09	0.03	0.14	0.26	0.52	0.17	0.52	0.01	0.18	0.22
ENJ2	-0.01	0.39	0.19	0.16	0.14	0.06	0.92	0.46	0.12	-0.04	-0.11	0.03	0.08	0.53	0.08	0.56	-0.07	0.30	0.09
SAT1	0.27	0.42	0.53	0.22	0.38	0.36	0.54	0.45	0.19	0.21	0.22	0.22	0.44	0.88	0.33	0.57	0.17	0.30	0.11
SAT4	0.26	0.35	0.26	0.33	0.28	0.38	0.45	0.32	0.40	0.17	0.19	0.40	0.33	0.86	0.31	0.60	0.21	0.34	0.05
COM3	0.29	0.27	0.21	0.12	0.86	0.33	0.26	0.23	0.23	0.22	0.30	0.24	0.37	0.36	0.21	0.31	0.26	0.18	0.06
COM4	0.24	0.32	0.21	0.24	0.87	0.35	0.09	0.17	0.25	0.31	0.39	0.27	0.35	0.30	0.20	0.16	0.25	0.04	0.13
UND1	0.34	0.04	0.10	0.24	0.25	0.36	-0.02	0.10	0.39	0.24	0.43	0.32	0.31	0.33	0.26	0.18	0.82	0.34	0.00
UND3	0.47	0.07	0.06	0.34	0.26	0.35	-0.04	0.06	0.24	0.23	0.53	0.39	0.38	0.06	0.09	-0.01	0.86	0.19	-0.02
SEC1	0.33	0.30	0.15	0.22	0.13	0.21	0.23	0.17	0.06	0.44	0.39	0.20	0.42	0.38	0.89	0.32	0.13	0.08	0.38
SEC3	0.21	0.09	0.20	0.13	0.29	0.23	-0.02	0.06	0.16	0.55	0.25	0.17	0.24	0.23	0.80	0.18	0.23	0.00	0.22
ITR1	0.28	0.26	0.22	0.18	0.23	0.29	0.40	0.86	0.09	0.05	0.10	0.11	0.35	0.36	0.20	0.28	0.10	0.17	0.14
ITR2	0.08	0.24	0.27	0.11	0.18	0.17	0.46	0.88	0.03	-0.10	-0.07	0.01	0.13	0.41	0.06	0.32	0.07	0.16	-0.06
RLV2	0.37	0.19	0.10	0.26	0.38	0.32	-0.10	-0.05	0.29	0.34	0.83	0.29	0.35	0.22	0.31	0.13	0.50	0.12	0.01
RLV3	0.33	0.22	0.00	0.20	0.26	0.30	0.03	0.08	0.15	0.23	0.77	0.23	0.35	0.15	0.31	0.07	0.41	0.06	0.27
PER2	0.30	0.15	0.16	0.45	0.21	0.40	-0.01	0.01	0.88	0.21	0.27	0.49	0.40	0.29	0.16	0.18	0.38	0.21	-0.02
PER4	0.14	0.24	0.25	0.32	0.27	0.32	0.27	0.11	0.81	0.17	0.20	0.36	0.32	0.27	0.03	0.16	0.24	0.14	0.11
ADA1	0.30	0.77	0.22	0.17	0.39	0.30	0.34	0.17	0.19	0.16	0.20	0.26	0.40	0.43	0.16	0.29	0.15	0.22	0.14
ADA3	0.07	0.77	0.14	0.36	0.14	0.22	0.33	0.26	0.15	0.07	0.19	0.21	0.27	0.25	0.22	0.30	-0.04	0.19	0.07
AVA2	0.29	0.32	0.13	0.88	0.15	0.28	0.16	0.13	0.45	0.02	0.23	0.52	0.35	0.22	0.10	0.12	0.34	0.20	-0.04
AVA3	0.43	0.29	0.23	0.90	0.21	0.46	0.05	0.15	0.37	0.18	0.28	0.59	0.52	0.33	0.27	0.10	0.28	0.30	0.08
RLB2	0.36	0.41	0.16	0.51	0.31	0.47	0.14	0.05	0.45	0.10	0.38	0.89	0.47	0.35	0.23	0.27	0.35	0.27	0.14
RLB3	0.41	0.12	0.17	0.59	0.21	0.44	0.01	0.07	0.44	0.19	0.18	0.87	0.40	0.27	0.16	0.13	0.39	0.25	-0.11
RT2	0.46	0.34	0.39	0.37	0.32	0.41	0.06	0.25	0.35	0.34	0.39	0.34	0.82	0.27	0.36	0.03	0.36	0.25	0.17
RT4	0.40	0.39	0.25	0.46	0.38	0.54	0.23	0.20	0.36	0.26	0.35	0.48	0.86	0.46	0.32	0.22	0.34	0.27	0.07
USA1	0.21	0.29	0.33	0.27	0.13	0.18	0.33	0.21	0.18	0.00	0.11	0.28	0.30	0.35	0.03	0.18	0.31	0.92	-0.11
USA2	0.19	0.17	0.26	0.24	0.09	0.34	0.11	0.13	0.20	-0.06	0.10	0.25	0.26	0.30	0.06	0.09	0.24	0.87	-0.04
AES1	0.17	0.29	0.95	0.23	0.23	0.26	0.38	0.35	0.22	0.18	0.09	0.20	0.40	0.47	0.23	0.23	0.12	0.37	0.02
AES2	0.09	0.16	0.95	0.15	0.23	0.23	0.20	0.17	0.22	0.15	0.03	0.16	0.31	0.41	0.15	0.21	0.06	0.26	-0.05
STI2	0.18	0.33	0.21	0.21	0.21	0.21	0.53	0.26	0.23	0.07	0.07	0.28	0.16	0.60	0.19	0.85	0.05	0.11	0.13
STI4	0.16	0.32	0.19	0.00	0.25	0.12	0.48	0.34	0.10	0.20	0.15	0.11	0.11	0.54	0.33	0.85	0.11	0.15	0.21
USE1	0.17	0.13	0.09	0.00	0.12	0.04	0.25	0.16	0.01	0.15	0.12	-0.02	0.15	0.11	0.32	0.21	-0.01	0.02	0.83
USE2	0.10	0.09	-0.12	0.04	0.06	0.07	0.02	-0.10	0.07	0.07	0.14	0.07	0.08	0.05	0.27	0.11	-0.01	-0.17	0.81

	ACC	ADA	AES	AVA	COM	CUR	ENJ	ITR	PER	PRI	RLV	RLB	RT	SAT	SEC	STI	UND	USA	USE
PRI1	0.20	0.17	0.13	0.03	0.22	0.21	0.05	0.00	0.19	0.82	0.27	0.13	0.29	0.25	0.47	0.23	0.16	-0.11	0.26
PRI2	0.28	0.10	0.13	0.12	0.35	0.26	-0.05	-0.08	0.24	0.87	0.36	0.20	0.34	0.16	0.54	0.11	0.30	-0.10	0.09
PRI4	0.27	0.09	0.18	0.13	0.20	0.16	0.07	0.01	0.11	0.76	0.25	0.06	0.24	0.12	0.39	0.06	0.23	0.13	-0.02

ACC – Accuracy; ADA – Adaptability; AES– Aesthetics; AVA – Availability; COM – Completeness; CUR – Currency; ENJ – Enjoyment; ITR - Intention To Reuse; PER – Personalization; PRI – Privacy; RLV – Relevance; RLB – Reliability; RT - Response Time; SAT – Satisfaction; SEC – Security; STI – Stimulation; UND – Understandability; USA – Usability; USE - Usefulness

Table 38 Cross Loadings Values for the Case VarazdinAR

	ACC	ADA	AES	AVA	COM	CUR	ENJ	ITR	PER	PRI	RLV	RLB	RT	SAT	SEC	STI	UND	USA	USE
ACC3	0.87	0.24	0.30	0.23	0.35	0.47	0.33	0.20	0.26	0.28	0.12	0.49	0.41	0.50	0.42	0.10	0.25	0.26	0.24
ACC4	0.92	0.39	0.33	0.46	0.57	0.54	0.43	0.32	0.38	0.32	0.34	0.62	0.65	0.61	0.38	0.09	0.24	0.49	0.24
CUR1	0.56	0.30	0.24	0.35	0.46	0.90	0.26	0.36	0.39	0.28	0.39	0.53	0.54	0.39	0.37	0.08	0.16	0.27	0.27
CUR2	0.41	0.18	0.17	0.12	0.24	0.82	0.27	0.15	0.25	0.31	0.19	0.21	0.19	0.34	0.19	0.03	0.29	0.20	0.21
ENJ1	0.36	0.33	0.10	0.20	0.31	0.28	0.89	0.36	0.31	0.26	0.33	0.30	0.18	0.53	0.37	0.31	0.29	0.28	0.41
ENJ2	0.41	0.51	0.44	0.39	0.32	0.27	0.92	0.55	0.28	0.28	0.42	0.44	0.33	0.74	0.39	0.53	0.33	0.31	0.31
SAT1	0.66	0.39	0.42	0.34	0.53	0.42	0.54	0.45	0.41	0.38	0.38	0.57	0.43	0.90	0.44	0.23	0.47	0.34	0.25
SAT4	0.49	0.56	0.55	0.47	0.39	0.37	0.74	0.69	0.42	0.34	0.54	0.57	0.47	0.93	0.48	0.54	0.31	0.30	0.30
COM3	0.49	0.36	0.36	0.42	0.87	0.37	0.28	0.22	0.42	0.39	0.38	0.56	0.40	0.50	0.44	0.15	0.20	0.23	0.04
COM4	0.41	0.33	0.11	0.33	0.84	0.35	0.31	0.17	0.27	0.17	0.28	0.35	0.26	0.34	0.35	0.21	0.31	0.36	0.23
UND1	0.26	0.25	0.14	0.23	0.31	0.23	0.34	0.27	0.24	0.34	0.25	0.25	0.27	0.43	0.29	0.16	0.89	0.35	0.07
UND3	0.16	0.07	0.21	0.16	0.12	0.15	0.18	0.13	0.14	0.11	0.14	0.06	0.03	0.20	0.14	0.19	0.68	0.27	0.27
SEC1	0.47	0.37	0.37	0.48	0.47	0.36	0.45	0.31	0.41	0.49	0.31	0.55	0.32	0.50	0.89	0.30	0.31	0.28	0.36
SEC3	0.31	0.38	0.31	0.45	0.34	0.22	0.27	0.35	0.23	0.48	0.28	0.41	0.34	0.37	0.86	0.22	0.19	0.08	0.25
ITR1	0.22	0.46	0.36	0.30	0.20	0.27	0.44	0.87	0.45	0.12	0.63	0.35	0.30	0.56	0.32	0.64	0.28	0.18	0.13
ITR2	0.30	0.50	0.37	0.34	0.20	0.28	0.46	0.91	0.35	0.16	0.52	0.53	0.42	0.56	0.35	0.40	0.21	0.34	0.33
RLV2	0.25	0.44	0.21	0.38	0.35	0.29	0.40	0.49	0.50	0.27	0.85	0.46	0.33	0.46	0.30	0.47	0.18	0.14	0.12
RLV3	0.20	0.28	0.18	0.36	0.30	0.30	0.30	0.58	0.31	0.14	0.83	0.35	0.35	0.39	0.26	0.38	0.26	0.24	0.06
PER2	0.41	0.30	0.17	0.32	0.39	0.43	0.24	0.34	0.84	0.27	0.41	0.42	0.37	0.40	0.26	0.11	0.17	0.27	0.07
PER4	0.15	0.27	0.32	0.35	0.25	0.16	0.29	0.38	0.76	0.23	0.36	0.27	0.16	0.32	0.34	0.44	0.23	0.20	0.28
ADA1	0.31	0.77	0.39	0.35	0.28	0.20	0.55	0.52	0.34	0.11	0.44	0.48	0.24	0.49	0.34	0.54	0.26	0.34	0.28
ADA3	0.26	0.81	0.33	0.43	0.36	0.26	0.21	0.35	0.23	0.22	0.26	0.47	0.43	0.35	0.33	0.19	0.11	0.22	0.23
AVA2	0.29	0.42	0.38	0.84	0.36	0.30	0.27	0.30	0.34	0.30	0.33	0.43	0.52	0.35	0.46	0.25	0.26	0.36	0.11
AVA3	0.38	0.42	0.38	0.86	0.40	0.20	0.30	0.32	0.37	0.36	0.41	0.50	0.59	0.41	0.46	0.23	0.18	0.36	0.16
RLB2	0.51	0.56	0.31	0.44	0.55	0.31	0.44	0.44	0.38	0.35	0.45	0.86	0.47	0.57	0.57	0.30	0.24	0.31	0.28
RLB3	0.57	0.48	0.44	0.50	0.38	0.46	0.28	0.42	0.37	0.23	0.39	0.87	0.69	0.51	0.38	0.16	0.13	0.31	0.17
RT2	0.60	0.38	0.25	0.59	0.41	0.47	0.31	0.34	0.33	0.33	0.35	0.65	0.94	0.47	0.39	0.10	0.20	0.35	0.12
RT4	0.55	0.43	0.34	0.64	0.32	0.38	0.23	0.43	0.32	0.22	0.41	0.61	0.94	0.45	0.33	0.15	0.21	0.28	0.04
USA1	0.39	0.36	0.30	0.40	0.39	0.22	0.37	0.29	0.25	0.23	0.23	0.37	0.31	0.36	0.23	0.30	0.29	0.89	0.27
USA2	0.31	0.20	0.17	0.28	0.14	0.25	0.14	0.19	0.23	0.09	0.14	0.20	0.24	0.20	0.11	0.05	0.39	0.77	0.09
AES1	0.41	0.45	0.94	0.45	0.33	0.28	0.31	0.38	0.30	0.18	0.24	0.49	0.32	0.54	0.43	0.38	0.21	0.32	0.27
AES2	0.26	0.39	0.93	0.38	0.19	0.17	0.27	0.39	0.25	0.16	0.19	0.32	0.27	0.47	0.29	0.34	0.17	0.23	0.13
STI2	0.10	0.31	0.21	0.18	0.13	0.02	0.39	0.49	0.18	-0.01	0.37	0.13	0.08	0.29	0.17	0.82	0.13	0.13	0.26
STI4	0.09	0.45	0.43	0.29	0.22	0.09	0.43	0.51	0.35	0.15	0.49	0.31	0.14	0.45	0.34	0.91	0.22	0.25	0.17
USE1	0.22	0.31	0.27	0.10	0.05	0.17	0.26	0.19	0.14	0.03	0.02	0.20	0.06	0.22	0.25	0.19	0.15	0.19	0.85
USE2	0.24	0.24	0.10	0.17	0.21	0.31	0.41	0.27	0.22	0.12	0.16	0.25	0.09	0.30	0.36	0.21	0.16	0.21	0.86

	ACC	ADA	AES	AVA	COM	CUR	ENJ	ITR	PER	PRI	RLV	RLB	RT	SAT	SEC	STI	UND	USA	USE
PRI1	0.43	0.22	0.17	0.33	0.33	0.42	0.33	0.12	0.35	0.78	0.17	0.30	0.31	0.47	0.34	-0.01	0.36	0.23	0.06
PRI2	0.19	0.07	0.09	0.25	0.21	0.11	0.07	-0.01	0.22	0.76	0.17	0.22	0.18	0.13	0.42	0.07	0.20	0.08	0.04
PRI4	0.14	0.19	0.15	0.31	0.22	0.24	0.28	0.25	0.14	0.78	0.23	0.25	0.18	0.28	0.53	0.15	0.14	0.15	0.11

ACC – Accuracy; ADA – Adaptability; AES– Aesthetics; AVA – Availability; COM – Completeness; CUR – Currency; ENJ – Enjoyment; ITR - Intention To Reuse; PER – Personalization; PRI – Privacy; RLV – Relevance; RLB – Reliability; RT - Response Time; SAT – Satisfaction; SEC – Security; STI – Stimulation; UND – Understandability; USA – Usability; USE - Usefulness

7.2.2.4 Summary of results

IMISS model is multidimensional model and on the first order level all measurement models are reflective. Therfore, criteria values for the indicator reliability, composite reliability, convergent validity and discriminant validity need to be checked. From the presented results in previous sub-chapters (i.e. *indicator reliability, composite reliability, convergent validity and discriminant validity*) it can be seen that all reflective measurement model evaluation criteria have been met. It can be conclude that criteria for reliability and validity of construct measures have been met and that there is enough statistical support for the suitability of their inclusion in the path model. As well with this analysis it has been provided support for the measures' reliability and validity, and therefore the support for the first hypothesis is ensured: H1: *Developed measurement instrument for mobile information system success measurement from end-user value perspective is valid and reliable.*

7.2.3 Evaluation of the Second Order Measurement Model

On the first level of the IMISS model all measurement models are reflective. On the second level all constructs (success sub-dimensions) except last dependent variable (*intention to reuse*) are formative constructs. The internal consistency perspective that was applied for the reflective measurement models cannot be applied for the formative measurement models. The formative measures do not necessarily covary (J. F. J. Hair et al. 2013). Evaluation of the formative constructs and indicators includes following:

(1) *assessment of the convergent validity,*
(2) *assessment of the collinearity,* and
(3) *assessment of the significance and relevance of the formative indicators*.

Accepted rules of thumb for the evaluation of the formative measurement models is presented in Table 39.

Table 39 Accepted Rules of Thumb for the Evaluation of the Formative Measurement Models

Assessment measurement	Description
Convergent validity	Convergent validity of the formative measurement models should be validated by (1) performing literature review and involving experts or (2) by performing redundancy analysis.

Assessment measurement	Description
Collinearity of indicators	Tolerance value of each indicator should be higher than 0.20 or variance inflation factor (VIF) value lower than 5. Otherwise, the indicator should be considered for (1) removal, (2) merging it with other indicators into a single index, or (3) creating higher-order construct.
Outer weights and outer loadings	By applying bootstrapping procedure, significance of outer weights and outer loadings should be assessed. If indicator weight is significant there is empirical support to retain the indicator. When it is not significant, but corresponding item loading is relatively high (i.e. > 0.50) then the indicator should be retained. Otherwise it should be deleted. However, if there is strong support from theoretical basis or experts assessment for keeping the indicator it should be kept in the model.

Source: Adapted from (J. F. J. Hair et al. 2013) and (Petter, Straub, and Rai 2007)

The representation of the conceptual model on the second-order level is presented on the figure 29. On this figure it can be seen that lower order constructs (in this study named as *attributes*) have become indicators of the higher order constructs (in this study named as *sub-dimensions*). IQ is used as short name for the *Information Quality*, SQ is short name for the *System Quality*, ISQ is short name for the *Information System Quality*, PX is short name for the *Pragmatic Experience*, HX is short name for the *Hedonic Experience*, UXQ is short name for the *User Experience Quality*, PB is short name for the *Pragmatic Benefits*, HB is short name for the *Hedonic Benefits*, IB is short name for the *Individual Benefits*, ITR is short name for the *Intention to Reuse*.

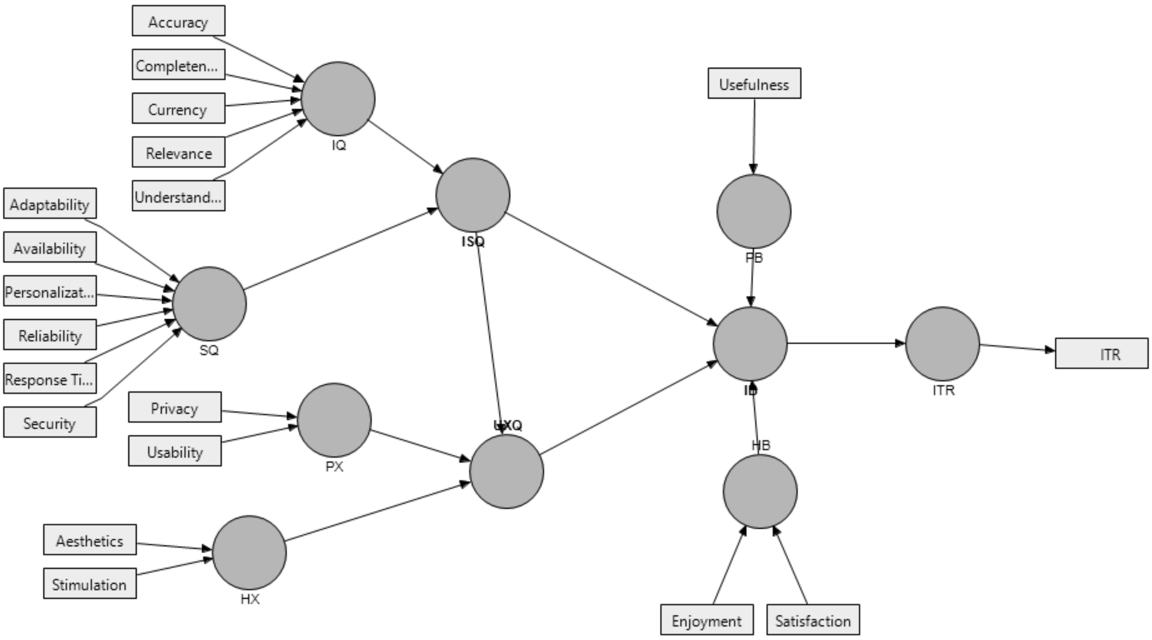


Figure 29 The Conceptual IMISS Model on the Second Order Level

Source: made by the author

7.2.3.1 Convergent validity of latent variables.

Formative constructs are encompassed from formative indicators that capture all aspects of the latent variable. Convergent validity is the measure that explains the extent to which indicators correlate positively with other indicators of the same construct. One way to assess convergent validity of the formative constructs is by doing the redundancy analysis, where the global reflective measure for the construct is used. Petter et al. report that by performing literature review and applying the card sorting technique (Q-sorting) is sufficient way to assess convergent and discriminant analysis of the constructs (Petter, Straub, and Rai 2007). Theoretical rational and experts opinion are usual basis for the development of the formative constructs. This has already been performed and explained in the chapter 6.1. with the help of the experts from the field of *human computer interaction* and *information systems*. Therefore the criteria for convergent validity and discriminant validity of the 2nd order formative measurement model have been achieved.

7.2.3.2 Indicators Collinearity

Presence of the high correlations between two formative indicators are not expected. High correlations between two formative indicators are referred to as *collinearity*. If more indicators are involved than it is called *multi-collinearity*. High levels of collinearity between formative indicators have impact on the estimation of the indicator weights and their statistical significance will be threatened (J. F. J. Hair et al. 2014). In order to check whether there is collinearity between indicators, the *tolerance* and *variance inflation factor* (VIF) are calculated. Tolerance is the measure that represents the amount of the variance of one formative indicator not explained by other indicators in the same block. The reciprocal value of the tolerance is VIF. The tolerance value of 0.20 or lower and VIF value of 5 and higher respectively indicate a potential collinearity problem. If that happens it should be considered for removing one of the corresponding indicators (J. F. J. Hair et al. 2014). As SmartPLS version 2 doesn't enable detection of collinearity, therefore the *SPSS* statistical software is used for this step. The results are presented in the Table 42 and they report that collinearity of indicators in this second-order formative model is not present, i.e. all tolerance values are above 0.20 and all VIF values are below 5.

Table 40 Collinearity Assessment of the Formative Measurement Model for Two Cases

Mobile AR Game Ingress			***Mobile AR City Tour Guide VarazdinAR***		
	Collinearity Statistics			***Collinearity Statistics***	
	Tolerance	***VIF***		***Tolerance***	***VIF***
Accuracy	0.592	1.690	Accuracy	0.572	1.750
Adaptability	0.782	1.279	Adaptability	0.593	1.686
Aesthetics	0.828	1.207	Aesthetics	0.796	1.257
Availability	0.543	1.841	Availability	0.445	2.250
Completeness	0.772	1.296	Completeness	0.640	1.563
Currency	0.606	1.650	Currency	0.625	1.601
Enjoyment	0.660	1.516	Enjoyment	0.464	2.153
Personalization	0.679	1.472	Personalization	0.754	1.326
Privacy	0.942	1.062	Privacy	0.943	1.060
Relevance	0.597	1.675	Relevance	0.790	1.266
Reliability	0.525	1.906	Reliability	0.368	2.714
Satisfaction	0.673	1.486	Satisfaction	0.500	2.000
Security	0.826	1.211	Security	0.592	1.689
Stimulation	0.922	1.084	Stimulation	0.838	1.193
Response time	0.553	1.810	Response time	0.418	2.390
Understanding	0.596	1.677	Understanding	0.872	1.147
Usability	0.871	1.148	Usability	0.875	1.143
Usefulness	0.971	1.030	Usefulness	0.844	1.185

Source: made by the author

7.2.3.3 Significance and relevance of the formative indicators

In order to evaluate the contribution of the formative indicators and their relevance, the *outer weights* are calculated. This measure is the result of a multiple regression with the latent variable scores as dependent variable and the formative indicators as the independent variable (J. F. J. Hair et al. 2013). Formative constructs are formed as linear combination of the indicator scores and the outer weights in the formative measurement model. If there is a large number of formative indicators that is used to measure a construct, then usually some indicators have low or even non-significant outer weights. Relative contribution of indicators, or their relative importance can be revealed by comparing the values of outer weights with each other. In order to see statistical significance of each outer weight the *bootstrapping procedure* should be applied. The non-significant indicators weights should be carefully considered whether they should be excluded from the model. If the *absolute contribution* (or *absolute importance*) of indicator to the construct, calculated through the *outer loadings*, is high (i.e. above 0.50) the indicator should be kept in the model and interpreted as absolutely important but not relatively important. If outer loading is low, the researcher should examine whether there is content overlap between indicators in the same construct. If there is strong support from theoretical basis or experts assessment for keeping the indicator it should be kept in the model. Otherwise there is no empirical support for keeping the indicator and it should be removed (J. F. J. Hair et al. 2013). Bootstrapping procedure was carried out with 112, for the mobile AR game *Ingress* and 102, for the mobile AR city tour guide *VarazdinAR* cases and 5000 samples. The results of the significance and relevance of two case studies are shown in Table 41 and Table 42.

Table 41 Outer Weights, Outer Loadings and Significance Testing Results for the Mobile AR Game *Ingress*

Relationships	Outer Weight	t-value	p-value	Sign.	Outer Loading	t-value	p-value	Sign.
Accuracy -> IQ	0.2411	1.7781	0.078	*	0.7179	7.5252	0.000	***
Adaptability -> SQ	0.3515	2.9486	0.004	***	0.6886	7.8731	0.000	***
Aesthetics -> HX	0.5742	5.3318	0.000	***	0.7365	7.3603	0.000	***
Availability -> SQ	-0.0693	0.5362	0.593	NS	0.5469	4.3305	0.000	***
Completeness -> IQ	0.4152	3.3083	0.001	***	0.7474	7.7577	0.000	***
Currency -> IQ	0.4837	3.6452	0.000	***	0.8513	13.0321	0.000	***
Enjoyment -> HV	0.2663	2.2717	0.025	**	0.7372	8.0821	0.000	***

Relationships	Outer Weight	t-value	p-value	Sign.	Outer Loading	t-value	p-value	Sign.
Personalization -> SQ	0.2286	2.1764	0.032	**	0.5835	5.7786	0.000	***
Privacy -> PX	0.6822	4.1556	0.000	***	0.6579	3.6356	0.000	***
Relevance -> IQ	0.1594	0.9045	0.368	NS	0.6237	5.3797	0.000	***
Reliability -> SQ	0.2202	1.3947	0.166	NS	0.6566	6.0328	0.000	***
Response Time -> SQ	0.3683	2.9294	0.004	***	0.8294	11.9445	0.000	***
Satisfaction -> HV	0.8235	9.2881	0.000	***	0.9758	48.428	0.000	***
Security -> SQ	0.3357	2.7708	0.007	***	0.6328	5.0322	0.000	***
Stimulation -> HX	0.6956	6.8637	0.000	***	0.8296	11.5709	0.000	***
Understandability -> IQ	0.0101	0.0543	0.957	NS	0.5428	3.7623	0.000	***
Usability -> PX	0.7535	4.9646	0.000	***	0.7315	4.8555	0.000	***

*p<0.10; **p<0.05; ***p<0.01; NS = not significant. Source: made by the author

Table 42 Outer Weights, Outer Loadings and Significance Testing Results of Mobile AR City Tour Guide *VarazdinAR*

Relationships	Outer weight	t-value	p-value	Sign.	Outer Loading	t-value	p-value	Sign.
Accuracy->IQ	0.5002	4.6781	0.000	***	0.8083	11.8506	0.000	***
Adaptability->SQ	0.2498	2.1646	0.033	**	0.7471	8.9043	0.000	***
Aesthetics->HX	0.7188	4.4727	0.000	***	0.8997	9.779	0.000	***
Availability->SQ	0.089	0.7221	0.472	NS	0.7253	9.1752	0.000	***
Completeness->IQ	0.2078	2.0047	0.048	**	0.7182	8.3728	0.000	***
Currency->IQ	0.0419	0.4169	0.678	NS	0.6179	6.4642	0.000	***
Enjoyment->HV	0.2743	2.1071	0.038	**	0.8306	11.6193	0.000	***
Personalization->SQ	0.2718	2.8901	0.005	***	0.6783	7.8238	0.000	***
Privacy->PX	0.5597	3.1021	0.002	***	0.7051	4.1457	0.000	***
Relevance->IQ	0.4199	4.132	0.000	***	0.7089	7.273	0.000	***
Reliability->SQ	0.2938	2.2003	0.030	**	0.8593	14.6946	0.000	***
Response Time->SQ	0.1294	0.831	0.408	NS	0.6981	7.5049	0.000	***
Satisfaction->HV	0.7871	7.1302	0.000	***	0.981	48.4262	0.000	***
Security->SQ	0.2922	2.6919	0.008	***	0.7585	11.7298	0.000	***
Stimulation->HX	0.4726	2.1423	0.035	**	0.7476	3.943	0.000	***
Understandability->IQ	0.2269	2.4469	0.016	**	0.5417	5.5675	0.000	***
Usability->PX	0.7239	4.5691	0.000	***	0.8363	7.5961	0.000	***

**p<0.10; **p<0.05; ***p<0.01; NS = not significant.* Source: made by the author

From the results in Table 41 and Table 42 it can be seen that several relationships between indicators and constructs have nonsignificant outer weights. In that case according to the Haier et al. (J. F. J. Hair et al. 2013) we need to check the outer loading values. Indicators that have non-significant outer weights but significant outer loadings (loading values above 0.50) are absolutely important but not relatively important. However, formative indicators should never be discarded simply on the basis of statistical outcomes. If prior research and theory provides support for the relevance of non-significant indicators they should be kept in the model (J. F. J. Hair et al. 2013, p. 127-130,158). Therefore, it is decided to keep all the attributes on the second order level of analysis.

7.2.3.4 Summary of results

On the second level of analysis of the IMISS model, all latent variables are formative. In case of the formative measurement models the convergent validity, the collinearity, and the significance and relevance of the formative indicators need to be assessed. Based on the presented results in previous sub-chapters it can be concluded that criteria for convergent validity, indicator collinearity and significance and relevance of the formative indicators have been achieved and we can continue to assess the model on the higher order level.

7.2.4 Evaluation of the Third Order Measurement Model

On the final higher meta-level (the third order level) all constructs are formative constructs except the final depended variable *intention to reuse*. Evaluation of the formative constructs and indicators includes following:

(1) *assessment of the convergent validity,*

(2) *assessment of collinearity,* and

(3) *the assessment of the significance and relevance of the formative indicators*.

The representation of the conceptual model on the third-order level is presented on the Figure 30. On this figure it can be seen that lower order constructs (in this study named as *sub-dimensions*) have become indicators of the higher order constructs (in this study named as *success dimensions*). ISQ is short name for the *Information System Quality*, UXQ is short name for the *User Experience Quality*, IB is short name for the *Individual Benefits*, ITR is short name for the *Intention to Reuse*.

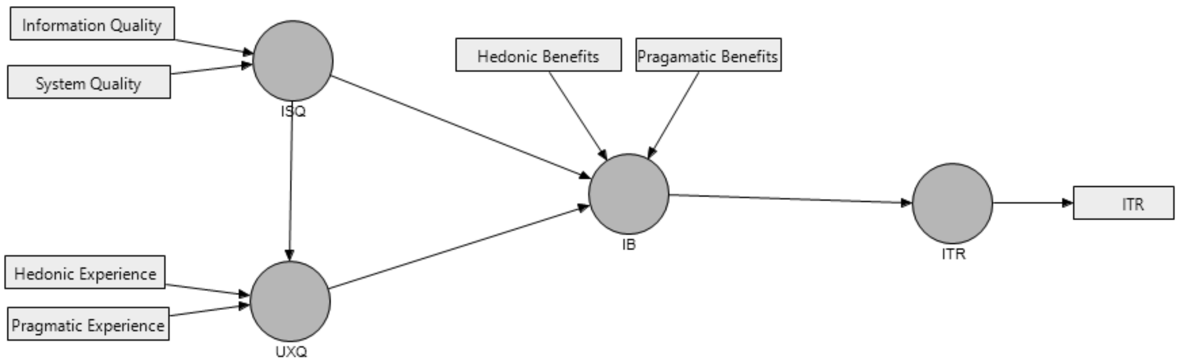


Figure 30 The Conceptual IMISS Model on the Third Order Level
Source: made by the author

7.2.4.1 Convergent validity of latent variables.

Convergent validity has already been supported by performing the Q-sorting method (described in chapter 6.1.) and relaying on already existing theoretical basis of the DeLone and McLean success model, and as well on the acceptance theory models.

7.2.4.2 Indicators Collinearity

To assess whether there is collinearity between indicators, the *tolerance* and *variance inflation factor* (VIF) are calculated. Tolerance is the measure that represents the amount of the variance of one formative indicator not explained by other indicators in the same block. The reciprocal value of the tolerance is VIF. The tolerance value of 0.20 or lower and VIF value of 5 and higher respectively indicates a potential collinearity problem. If that happens one should consider removing one of the corresponding indicators (J. F. J. Hair et al. 2013). As *SmartPLS* version 2 doesn't enable detection of collinearity, the *SPSS* statistical software is used for this step. The results for both cases are presented in the Table 43 and from the results it can be seen that collinearity of indicators in this third-order formative model is not present.

Table 43 Collinearity Assessment of Formative Measurement Model on the third level

Mobile AR Game Ingress			***Mobile AR City Tour Guide VarazdinAR***		
	Collinearity Statistics			***Collinearity Statistics***	
	Tolerance	***VIF***		***Tolerance***	***VIF***
Information Quality -> Information System Quality	0.531	1.882	Information Quality->Information System Quality	0.450	2.221
System Quality -> Information System Quality	0.531	1.882	System Quality -> Information System Quality	0.450	2.221
Pragmatic Experience -> User	0.866	1.154	Pragmatic Experience -> User	0.889	1.125

Mobile AR Game Ingress			*Mobile AR City Tour Guide VarazdinAR*		
Experience Quality			Experience Quality		
Hedonic Experience -> User Experience Quality	0.866	1.154	Hedonic Experience -> User Experience Quality	0.889	1.125
Pragmatic Benefits -> Individual Benefits	0.779	1.284	Pragmatic Benefits -> Individual Benefits	0.645	1.550
Hedonic Benefits -> Individual Benefits	0.779	1.284	Hedonic Benefits -> Individual Benefits	0.645	1.550

Source: made by the author

All VIF values are below threshold value of 5, and all tolerance values are above 0.20. Therefore it can be concluded, that collinearity does not reach critical level in any of the formative constructs on the third level of analysis. Collinearity is not issue for the PLS path model estimation in both of the cases.

7.2.4.3 Significance and relevance of the formative indicators

In this step the outer weights are analysed for their significance and relevance, by performing the bootstrapping procedure (Table 44 and Table 45). Bootstrapping procedure was carried out with 112, for the mobile AR game *Ingress* and 102, for the mobile AR city tour guide *VarazdinAR* cases and 5000 samples.

Table 44 Significance and Relevance of the Formative Indicators on the Third Order Level for Mobile AR game Ingress

Relationship	Outer Weight	t-value	p-value	Sign.	Outer Loading	t-value	p-value	Sign.
Hedonic Experience -> User Experience Quality	0.7807	10.4939	0.000	***	0.9288	23.8324	0.000	***
Hedonic Benefits -> Individual Benefits	0.9861	50.316	0.000	***	0.9966	123.7264	0.000	***
Information Quality -> Information System Quality	0.1592	0.93	0.354	NS	0.7676	8.5943	0.000	***
Pragmatic Benefits -> Individual Benefits	0.0832	0.9912	0.324	NS	0.207	1.7766	0.078	*
Pragmatic Experience -> User Experience Quality	0.399	4.0263	0.000	***	0.6889	7.5397	0.000	***
System Quality -> Information System Quality	0.8837	6.4857	0.000	***	0.9933	45.4682	0.000	***

**p<0.10; **p<0.05; ***p<0.01; NS = not significant.* Source: made by the author

Looking at the significance level in Table 44, it can be seen that in the case of the Ingress mobile AR game all most all formative indicators are significant except the relationship from the sub-dimension *Information Quality* to the success dimension *Information System Quality* and relationship from *Pragmatic Benefits* to the *Individual Benefits* success dimension. Even though the outer weight of the relationship from the success sub-dimension *Information Quality* to the *Information System Quality* success dimension is non-significant, the outer loading for this relationship is above 0.50. Based on the Hair et al. (J. F. J. Hair et al. 2013) recommendations and because there is enough theoretical support for the indicator (sub-dimension) retention, the *Information Quality* sub-dimension will be kept in the study. This can be explained as follows: if the developers of the game want to achieve more success they have to first focus on the improvement of the quality of the information their system is having. One possible reason why the relationship between *Pragmatic Benefits* and *Individual Benefits* is non-significant could be because the system under consideration is not used to complete some useful task instead it is used to achieve enjoyment related benefits. As the prime purpose of this thesis is to develop the model that could be applied on variety of different systems aimed to help individuals in the fulfilling their personal relevant goals ranging from task fulfilment to having fun. Therefore, even though the relationship between the *Pragmatic Benefits* and *Individual Benefits* is non-significant and the outer loading is below 0.50 this indicator (sub-dimension) will be kept in the study because there is strong support from theoretical basis and experts assessment for keeping this sub-dimension in the model.

Table 45 Significance and Relevance of the Formative Indicators on the Third Order Level for Mobile AR City tour guide VarazdinAR

Relationship	Outer Weight	t-value	p-value	Sign.	Outer loading	t-value	p-value	Sign.
Hedonic Experience -> User Experience Quality	0.6302	5.6843	0.000	***	0.8273	8.4433	0.000	***
Hedonic Benefits -> Individual Benefits	0.9601	19.6539	0.000	***	0.9954	78.6671	0.000	***
Information Quality -> Information System Quality	0.516	3.8189	0.000	***	0.9358	25.1954	0.000	***
Pragmatic Experience -> User Experience Quality	0.5953	4.8698	0.000	***	0.804	11.38	0.000	***
Pragmatic Benfits -> Individual Benefits	0.1022	1.0799	0.283	NS	0.4333	3.6519	0.000	***
System Quality -> Information System Quality	0.5482	4.0985	0.000	***	0.9433	27.6654	0.000	***

**p<0.10; **p<0.05; ***p<0.01; NS = not significant.* Source: made by the author

Looking at the significance level in Table 45, it can be seen that in the case of the VarazdinAR city tour guide system almost all formative indicators are significant except the relationship from the sub-dimension *Pragmatic Benefits* to the *Individual Benefits* success dimension. Even though the relationship between the *Pragmatic Benefits* and *Individual Benefits* is non-significant and the outer loading is below 0.50 (but significant) this sub-dimension will be kept in the model. There is enough theoretical basis to keep this sub-dimension in the IMISS model. One possible explanation of these results is that developer(s) of this system should try to increase utility of the information the system provides in order to achieve more success.

7.2.4.4 Summary of results

On the third level of analysis of the IMISS model all latent variables are formative. Therefore the same assessment steps are made as in previous level of analysis. The convergent validity, the collinearity, and the significance and relevance of the formative indicators are assessed. Based on the presented results in previous sub-chapters it can be concluded that criteria for convergent validity, indicator collinearity and significance and relevance of the formative indicators have been achieved. Therefore, we can proceed to the structural model analysis.

7.2.5 Evaluation of the Structural Model Results

After the measurement model assessment i.e. after the confirmation that the constructs are reliable and valid, follows the assessment of the structural model. This analysis involves examining the relationships between success dimensions. Structural model relationships are hypothesized relationships among success dimensions (constructs). "*When examining the structural model, it is important to understand that PLS-SEM fits the model to the sample data to obtain the best parameter estimates by maximizing the explained variance of the endogenous latent variable.*" (J. F. J. Hair et al. 2013, p. 168). The relationships between success dimensions are assumed to be casual and positive (Figure 31). Analysing the relationship between success dimension it can be identified how success dimension *Information System Quality* contribute to the *User Experience Quality* and which dimension *Information System Quality* or *User Experience Quality* dimension has more effect on the *Individual Benefits* dimension of the system under consideration.

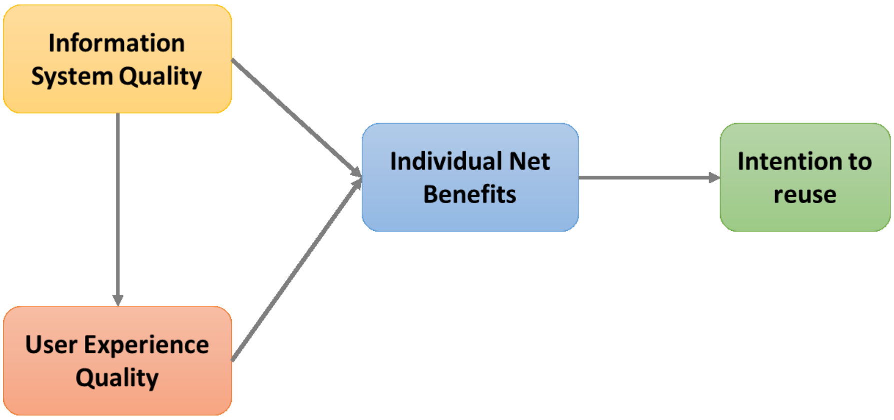


Figure 31 Proposed Relationships Between new Success Model
Source: made by the author

The key criteria for assessment of the structural model in *PLS-SEM* include the examination of the:

(1) *collinearity issues,*

(2) *assessment of the significance and relevance of the structural model relationships,*

(3) *assessment of the* R^2 *values (coefficient of determination),*

(4) *assessment of effect sizes* f^2 *and*

(5) *assessment of the predictive relevance* Q^2.

Accepted rules of thumb for structural model evaluation are presented in Table 46.

Table 46 Accepted Rules of Thumb for the Evaluation of the Structural Measurement Models

Assessment measurement	Description
Collinearity issue	The tolerance value of each predictor construct should be higher than 0.20 or VIF value lower than 5. Otherwise, construct should be considered for the elimination, or merging predictors into one construct, or creating higher-order construct.
Significance of path coefficients	By applying bootstrap method, the significance of path coefficients is assessed.
Coefficient of determination R^2	R^2 values of *0.75*, *0.50* or *0.25* for the endogenous construct can be described as respectively substantial, moderate and weak.
Adjusted R^2_{adj} ***value***	R^2_{adj} is used when comparing the R^2 values of models with different number of exogenous latent variables and/or data sets with different sample size.
Effect size f^2	*Effect size* f^2 enables the assessment of the exogenous construct's

Assessment measurement	Description
	contribution to an endogenous latent variable's R^2 value. The f^2 values of *0.02*, *0.15* and *0.35* present exogenous construct's *small*, *medium* or *large* effect on an endogenous construct.
Predictive relevance Q^2	By applying blindfolding procedure for certain omission distance we can reveal predictive relevance of the model. It can be only applied to the reflective endogenous constructs. Values larger than *0* indicate that exogenous constructs have predictive relevance for the endogenous construct under consideration.

Source: Adapted from (J. F. J. Hair et al. 2013)

7.2.5.1 Collinearity assessment

Structural model is in its basics the formative model, therefore we need to perform almost similar evaluation steps as in formative measurement models. First we need to check *tolerance* and *VIF* values. If tolerance values are below 0.20 or VIF above 5.00 in the predictor constructs the values are indicators of collinearity. If that happens then the construct should be considered either for the removal of the constructs, joining of the predictors into one single construct or for the creation of the higher-order construct to treat collinearity problem. The results of the collinearity analysis for the augmented reality game *Ingress* and augmented reality city tour guide *VarazdinAR* are presented in the Table 47.

Table 47 Collinearity Statistics of the Structural Model for Two Case Studies

Ingress			**VarazdinAR**		
	Collinearity Statistics			**Collinearity Statistics**	
	Tolerance	**VIF**		**Tolerance**	**VIF**
Information System Quality	0.657	1.522	Information System Quality	0.502	1.991
User Experience Quality	0.657	1.522	User Experience Quality	0.502	1.991

Source: made by the author

The results in the Table 47 show that all VIF values are below the threshold of 5 and tolerance value are above 0.20. Therefore it can be concluded that collinearity among the predictor constructs is not an issue in the structural model of the IMISS model.

7.2.5.2 Significance of the path coefficients

To examine the hypothesized associations among latent variables in the research framework, the path coefficients' goodness is calculated. The path coefficients *β* have standardized values between *-1* and *+1*. Values of path coefficients close to *+1* represent strong positive relationship. If path coefficients are close to *0* the relationship is weak. By applying bootstrap procedure we asses weather the formative indicator/construct is statistically significant i.e. whether it statistically contributes to its corresponding construct.

Significance and relevance of the structural model path coefficients is calculated by performing bootstrap procedure. Bootstrapping procedure was carried out with 112 cases, for the mobile AR game *Ingress,* and 102 cases, for the mobile AR city tour guide *VarazdinAR,* and with 5000 samples. The significance and relevance for the structural path coefficients of the augmented reality game *Ingress* is presented in Table 48 and total effect in Table 49, whereas the significance and relevance for the structural path coefficients of the augmented reality city tour system *VarazdinAR* is presented in the Table 50 and total effect in Table 51.

Table 48 Significance and Relevance of the Structural Model Path Coefficients for the Mobile AR Game Ingress

Relationships	*β*	*t-value*	*p-value*	*Significance*
Individual Benefit -> Intention To Reuse	0.4969	6.7368	0.000	***
Information System Quality -> Individual Benefit	0.1925	2.2697	0.025	**
Information System Quality -> User Experience Quality	0.5966	7.8727	0.000	***
User Experience Quality -> Individual Benefit	0.6365	8.1912	0.000	***

**p<0,10 **p<0,05 ***p<0,01 NS = not significant,* Source: made by the author

Table 49 Total Effect for the Mobile AR Game Ingress

Relationships	*Total Effect*	*t-value*	*p-value*	*Significance*
Individual Benefit -> Intention To Reuse	0.4969	6.73	0.000	***
Information System Quality -> Individual Benefit	0.5722	8.5103	0.000	***
Information System Quality -> Intention To Reuse	0.2843	4.9999	0.000	***
Information System Quality -> User Experience Quality	0.5966	8.2461	0.000	***
User Experience Quality -> Individual Benefit	0.6365	8.3737	0.000	***
User Experience Quality -> Intention To Reuse	0.3163	5.1992	0.000	***

**p<0,10 **p<0,05 ***p<0,01 NS = not significant;* source: made by the author

Interpretation of the results from the Tables 48 and 49 is following:

- Success dimension *Information System Quality* significantly contributes to the latent variable *User Experience Quality* (β = *0.5966, p<0.01*) and has the total effect of *0.5966* the second largest total effect.
- Although the direct effect of *Information System Quality* on *Individual Benefits* is not strong (β = *0.1925, p<0.05*), the total effect (the sum of direct and indirect effect) is quite strong *0.5722.* This is the third largest total effect. This implies that the quality of information system has strong influence on the *Individual Benefits* through the *User Experience Quality* dimensions.
- Success dimension *User Experience Quality* significantly contributes to the latent variable *Individual Benefits* (β = *0.6365, p<0.01*) and has the largest total effect of *0.6365*.
- Success dimension *Individual Benefits* significantly contribute to the latent variable to *Intention to Reuse* (β = *0.4969, p<0.01*) and has fourth largest total effect of *0.4969*.

From the results it can be concluded that the largest predictor of *Individual Benefits* in the case of the hedonic augmented reality game system was from perceived *User Experience Quality* (β = 0.6365; $p < 0.01$).

Table 50 Significance and relevance of the structural model path coefficients for VarazdinAR

Relationships	***β***	***t-value***	***p-value***	***Significance***
Individual Benefit -> Intention To Reuse	0.6355	9.8978	0.000	***
Information System Quality -> Individual Benefit	0.5795	6.2443	0.000	***
Information System Quality -> User Experience Quality	**0.7054**	12.2001	0.000	***
User Experience Quality -> Individual Benefit	0.2517	2.3594	0.020	**

**p<0,10 **p<0,05 ***p<0,01 NS = not significant;* source: made by the author

Table 51 Significance and relevance of the total effect for VarazdinAR

Relationships	**Total Effect**	**t-value**	***p-value***	***Significance***
Individual Benefit -> Intention To Reuse	0.6355	9.7911	0.000	***
Information System Quality -> Individual Benefit	0.7570	14.2545	0.000	***
Information System Quality -> Intention To Reuse	0.4811	7.1893	0.000	***
Information System Quality -> User Experience Quality	0.7054	12.4989	0.000	***
User Experience Quality -> Individual Benefit	0.2517	2.4395	0.016	**

Relationships	Total Effect	t-value	*p-value*	*Significance*
User Experience Quality -> Intention To Reuse	0.1599	2.3258	0.022	**

*p<0,10 **p<0,05 ***p<0,01 NS = not significant; source: made by the author

Interpretation of the results from the Tables 48 and 49 is following:

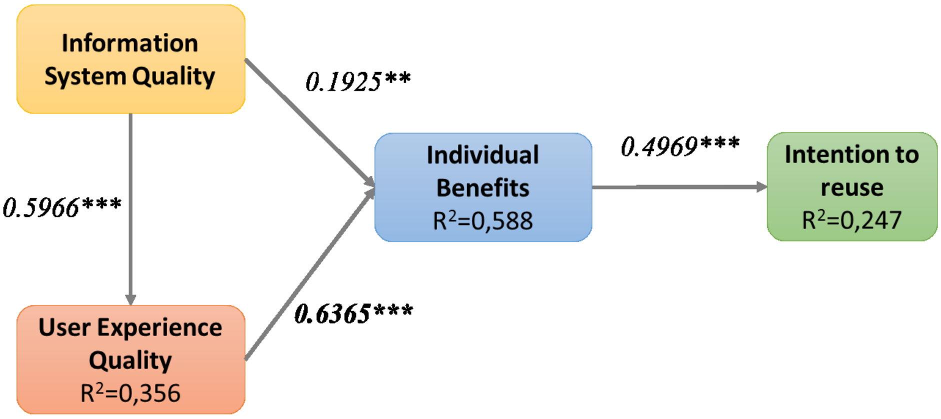
- Success dimension *Information System Quality* significantly contributes to the latent variable *User Experience Quality* ($\beta = 0.7054, p<0.01$) and has the total effect of 0.7054 and it is the second largest total effect. This success dimension has highest direct effect on the dimension individual benefits.
- Success dimension *Information System Quality* significantly contributes to the latent variable *Individual Benefits* ($\beta = 0.5795, p<0.01$), and has the largest total effect (the sum of direct and indirect effect) 0.757. This implies that the quality of information system has strong influence on the *Individual Benefits* through the *User Experience Quality* dimensions.
- Success dimension *User Experience Quality* doesn't have strong contribution to the latent variable *Individual Benefits* ($\beta = 0.2517, p<0.05$). It has the smallest total effect of *0.2517*.
- Success dimension *Individual Benefits* significantly contribute to the latent variable to the latent variable *Intention to Reuse* ($\beta = 0.6355, p<0.01$) and has total effect of *0.6355*.

From the results it can be concluded that the largest predictor of *Individual Benefits* in the case of the hedonic city tourism system was from *Information System Quality* dimension($\beta = 0.5795$; $p < 0.01$).

From the presented analysis, it can be concluded that the relationships between the success dimensions *Information System Quality, User Experience Quality, Individual Benefits* and *Intention to Reuse* are positive and significant. *User Experience Quality* success dimension has greater influence on the *Individual Benefits* success dimension in the case of the hedonic game system, while in the case of the hedonic tourism system greater influence on the *Individual Benefits* will come from the success dimension *Information System Quality*.

7.2.5.3 Coefficient of the Determination R^2 values

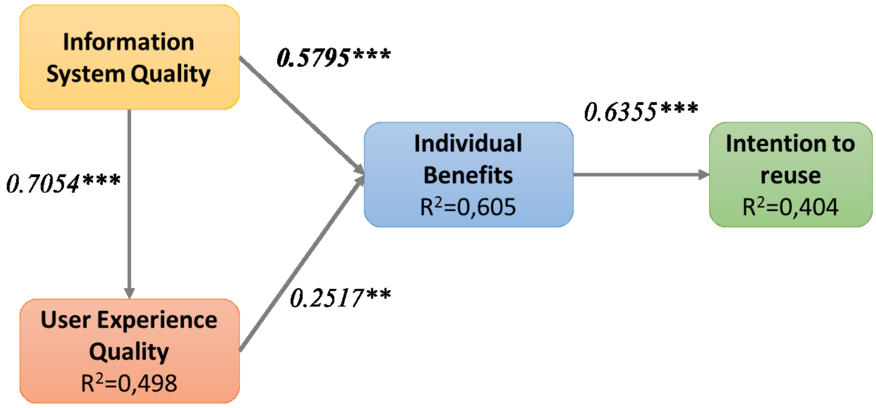
Coefficient of the determination R^2 is a measure of the model's predictive accuracy. The R^2 calculated as the squared correlation between specific endogenous construct's actual and predicted values. It is a measure of the proportion of an endogenous construct's variance that is explained by its predictor construct. It represents the exogenous latent variables' combined effect on the endogenous latent variable. It is the amount of variance in the endogenous constructs explained by all of the exogenous constructs linked to it. The R^2 values range from *0* to *1*, where higher values indicate higher levels of predictive accuracy. In disciplines such as consumer behaviours R^2 values of 0.20 are considered as high, whereas in marketing studies R^2 values of 0.75 are considered to be substantial, values of 0.50 are considered to be moderate and values of 0.25 or considered to be weak (J. F. J. Hair, Hult, Ringle, Sarstedt, et al. 2013) page 175. Figure 32 and 33 presents the results of estimated path coefficients, their significance in the research model, and variance explained of success constructs for our systems under consideration.



*****p<0.05; ***p<0.01.***

Figure 32 Path Coefficients and Coefficient of Determination for Mobile AR Game Ingress
Source: made by the author

PLS-SEM analysis of the mobile AR game *Ingress* sample data based on the IMISS model (Fig. 32) show that IMISS model explains 35.6% variance of the *User Experience Quality* dimension that came from *Information System Quality* dimension. Further, IMISS model explain 58.8% of the variance of the *Individual Benefits*, this explanation came mostly from perceived *User Experience Quality* dimesnion. Success dimension *Individual Benefits* explains 24.7% of the variance of the *Intention to Reuse* success dimension.



***p<0.05; ***p<0.01.*

Figure 33 Path Coefficients and Coefficient of Determination for the Mobile City Tour Guide VarazdinAR
Source: made by the author

PLS-SEM analysis of the mobile tourism system *VarazdinAR* sample data based on the IMISS model (Fig. 33) show that IMISS model explains 49.8% variance of the *User Experience Quality* dimension that came from *Information System Quality* dimension. Further, IMISS model explain 60.5% of the variance of the *Individual Benefits*, this explanation came mostly from perceived *Information System Quality* dimesnion. Success dimension *Individual Benefits* explains 40.4% of the variance of the *Intention to Reuse* success dimension.

Table 52 Coefficient of Determination for the Two Case Studies

Ingress		VarazdinAR	
Dimension	R^2	*Dimension*	R^2
Individual Benefits	0,588	Individual Benefits	0.605
Intention to Reuse	0,247	Intention to Reuse	0,404
User Experience Quality	0,356	User Experience Quality	0,498

Source: made by the author

Comparison of the results for two case studies is presented in the Table 52. The smallest R^2 value for the mobile augmented reality game *Ingress* is for the success dimension *Intention to Reuse* of *0.247*, and in the second case *VarazdinAR* the R^2 value for the same success construct is *0.404*. The largest R^2 value for mobile augmented reality game *Ingress* is *0.588* for the success dimension *Individual Benefits*, and in the second case *VarazdinAR* the R^2 value is *0.605* for the same success dimension.

In the proposed IMISS model in the case of the game *Ingress* the 35.6% and in the case of the city tour guide *VarazdinAR* the 49.8% of variance in latent variable *User Experience Quality* was explained by latent variable *Information System Quality*. Following rule of thumb we can conclude that predictors of the *User Experience Quality* success dimension have *moderate explanatory power*. The 58.8% in case of the game Ingress and 60.5% in the case of *VarazdinAR* of variance in latent variable *Individual Benefits* was explained by the latent variables *Information System Quality* and *User Experience Quality* success dimensions. Following rule of thumb we can conclude that predictors of the *Individual Benefits* success dimension have *moderate to high explanatory power*. The 24.7% in case of the game Ingress and 40.4% in the case of *VarazdinAR* of variance in latent variable *Intention to Reuse* was explained by the latent variable *Individual Benefits*. Following rule of thumb we can conclude that predictor of the *Intention to Reuse* success dimension has *moderate explanatory power*. Results suggest that perceived quality has positive impact on the perceived benefits which than positively impacts on the behaviour intention towards reusing the systems.

7.2.5.4 Effect size f^2

Effect size f^2 is a measure that shows weather the change in the R^2 values of all endogenous constructs occurs if a specified exogenous construct has been omitted from the model, i.e. to see whether the omitted construct has a substantive impact on the endogenous constructs (J. F. J. Hair, Hult, Ringle, Sarstedt, et al. 2013). Effect size f^2 allows assessing an exogenous construct's contribution to an endogenous latent variable's R^2 value. The effect size is calculated based on the formula (2):

$$(2) \qquad f^2 = \frac{R^2_{include} - R^2_{exclude}}{1 - R^2_{include}}$$

$R^2_{include}$ and $R^2_{exclude}$ are R^2 values of the endogenous latent variable when selected exogenous latent variable is included in or excluded from the model. The change in R^2 values is calculated by estimating the PLS path model twice, once with included exogenous latent variable, once with excluded. The f^2 values of 0.02, 0.15 and 0.35 indicate an exogenous construct's small, medium or large effect on and endogenous construct (J. F. J. Hair, Hult, Ringle, Sarstedt, et al. 2013). In order to calculate the f^2 effect size value of selected endogenous latent variable, we need to calculate the $R^2_{include}$ and $R^2_{exclude}$ values. $R^2_{include}$ value has already been calculated and presented in Table 52. To calculate values of $R^2_{exclude}$ we need to delete a specific predecessor of the endogenous latent variable

Table 53 Effect Size for the Mobile AR Game Ingress

R^2 of Individual Benefits (IB)	
Exogenous dimension	***f^2 effect size***
Information System Quality	*0.033 (small effect)*
User Experience Quality	*0.686 (large effect)*

Source: made by the author

From the results presented in Table 53, it can be concluded that the *Information System Quality* (ISQ) has *small effect size* on the endogenous variable *Individual Benefits* (IB). Whereas *User Experience Quality* (UXQ) has *large effect size* on the endogenous variable *Individual Benefits* (IB).

Table 54 Effect Size for the Mobile AR City Tour Guide VarazdinAR

R^2 of Individual Benefits (IB)	
Exogenous dimension	***f^2 effect size***
Information System Quality	*0.410 (large effect)*
User Experience Quality	*0.068 (small effect)*

Source: made by the author

For the augmented reality city tour guide *VarazdinAR*, from the results in Table 54 it can be seen that the *Information System Quality* (ISQ) has *large effect size* on the endogenous variable *Individual Benefits* (IB). Whereas *User Experience Quality* (UXQ) has *small effect size* on the endogenous variable *Individual Benefits* (IB).

The difference is mainly because both of systems are hedonic systems but their main purposes is different. Augmented reality game *Ingress* is used mainly for the entertainment purposes therefore *User Experience Quality* dimension is much more important to the users than *Information System Quality*. However, in other case study where prime purpose is information seeking, such as in the augmented reality city tour system *VarazdinAR*, the *Information System Quality* is more important than *User Experience Quality*.

7.2.5.5 Predictive relevance Q^2

Stone-Geisser's Q^2 value is an indicator of the model's predictive relevance. When PLS-PM exhibits predictive relevance, it means that model accurately predicts the data points of indicators in reflective measurement models of endogenous constructs and endogenous single-item constructs. This procedure doesn't apply on the formative endogenous constructs. Q^2 values larger than zero for a certain reflective construct indicate the path model's predictive relevance for this particular construct. Q^2 values are obtained by using *blindfolding procedure* for a certain omission distance. This is sample reuse techniques that omits every predefined distance data point in the endogenous construct's indicators, to simulate missing values in the data set, and estimates the parameters with the remaining data points. The difference between the true and data points and the predicted ones are used as input for the Q^2 measure. This is the iterative process that repeats until each data point has been omitted and the model re-estimated. The q^2 *effect size* is similar to the f^2 effect size approach for assessing R^2 values, the relative impact of predictive relevance can be compared by means of the measure q^2 effect size. The effect size is calculated based on the formula (3):

$$(3) \qquad q^2 = \frac{Q^2_{include} - Q^2_{exclude}}{1 - Q^2_{include}}$$

Recommendations are that values of *0.02*, *0.15* and *0.35* are respectively small, medium and large. However, q^2 effect size measure can be only calculated in the case of the reflective endogenous variable that have more than one predictors which is not case in the IMISS model. Predictive relevance can be calculated only for the endogenous reflective constructs. In the IMISS model only the last endogenous *Intention to Reuse* dimension is the reflective latent variable. Therefore $\boldsymbol{Q^2}$ value can be calculated only for last depended variable of the IMISSS model.

Table 55 Predictive relevance

Ingress		***VarazdinAR***	
Total	$\boldsymbol{Q^2}$	***Total***	$\boldsymbol{Q^2}$
Intention To Reuse	0,2254	**Intention To Reuse**	0,3930

Source: made by the author

From Table 55 it can be seen that predictive relevance of endogenous construct *Intention to Reuse* in both cases is above zero, which implies that the model has predictive relevance regarding the endogenous latent construct.

7.2.5.6 Summary of results

After it was confirmed that the constructs measures are reliable and valid, the next step addressed the assessment of the structural model. This step included the examination of the model's predictive capabilities and the relationships between the constructs. The presented results confirmed that relationships between the success dimensions *Information System Quality*, *User Experience Quality*, *Individual Benefits* and *Intention to Reuse* are positive and significant. *User Experience Quality* contributes more to the perception of the *Individual Benefits* in the case of the hedonic game system, while in the case of the hedonic tourism system greater influence comes from the *Information System Quality* success dimension. Further results revealed that the *Information System Quality* success dimension has large effect size on the endogenous variable Individual Benefits in case of the hedonic tourism system, but small effect size in case of the hedonic game system. As opposed to *User Experience Quality* success dimension where this dimension has large effect size on the endogenous variable *Individual Benefits* in case of the hedonic game system, but small effect size in case of the hedonic tourism system. The difference is mainly because both of systems are hedonic systems but their main purposes is different. Augmented reality game *Ingress* is used mainly for the entertainment purposes therefore *User Experience Quality* dimension is much more important to the users than *Information System Quality*. However, in other case study where prime purpose is information seeking, such as in the augmented reality city tour system *VarazdinAR*, the *Information System Quality* is more important than *User Experience Quality*.

7.2.6 Comparison of the Explanatory Powers of the Two Models

The ultimate quest in the social sciences is to find the models are good at explaining data, i.e. the models with high R^2 values, and those that have fewer exogenous constructs. Those models are called *parsimonious* models (J. F. J. Hair et al. 2014). The prime objective of this chapter is to empirically compare the IMISS model with the updated DeLone and McLean IS success model on the same data set in order to see which model is better in explaining and predicting the success of hedonic information systems. R^2 values of the dependent variable (success dimension) *individual benefits (individual impacts)* of the two models, i.e. IMISS model and the updated DeLone and McLean IS success model, will be compared.

The understanding of the relationships between theoretical constructs derived from multiple theoretical domains is important for advancing theories in each of their referent domains. In order to perform the comparison of the two models more fairly, the adjusted R^2 (R^2_{adj}) measure for the new proposed IMISS model will be used (J. F. J. Hair et al. 2014). Adjusted R^2 (R^2_{adj}) compares the *explanatory power* of the regression models that contain different numbers of predictors. Here is the formula based on which the R^2 values of the two models are compared (4):

$$(4)\ R^2_{adj} = 1-(1-R^2)\cdot\frac{n-1}{n-k-1}$$

n is the sample size and k is the number of exogenous latent variables used to predict the endogenous latent variable under consideration. The R^2adj value reduces the R^2 value by the number of explaining constructs and the sample size and thus systematically compensates for adding a no-significant exogenous construct merely to increase the explained variance R^2. The R^2adj increases only if the new added construct improves the model more than would be expected by chance (Frost 2013). It decreases when a predictor improves the model by less than the expected chance. The R^2adj is always lower than R^2.

The PLS-SEM algorithm was performed on the same data set with the updated DeLone and McLean IS success model in order to fit the model to the sample data and to obtain the estimates of the explained variance of the endogenous latent variable *individual benefits (individual impacts)*. The return relationships from the *net benefits* to the *intention to use* and to *satisfaction* are not evaluated here. The PLS analysis doesn't support the evaluation of the return relationships (loops in the inner model); therefore, the benefits are evaluated as an immediate consequence of system usage, which was also hypothesised in the original DeLone and McLean IS success model. Further, it must be mentioned that the *service quality* success dimension that was part of the updated the DeLone and McLean success model was excluded due to the reasons explained in Chapter 5.1. The results of running the PLS-SEM algorithm on the *Ingress* and *VarazdinAR* sample data based on the updated DeLone and McLean IS success model are shown in Table 56.

Table 56 D&M Model R^2 Values for the Dimension Individual Benefits for Two Case Studies

D&M Ingress		***D&M VarazdinAR***	
Individual Impact	$R^2 = 0.220$	Individual Impact	$R^2 = 0.331$

Source: made by the author

R^2adj of the dependent variable *individual benefits (individual impact)* of the proposed IMISS model and the difference between the two models with the data from the two case studies are presented in Table 57. The updated DeLone and McLean IS success explains 22.00% of the variance of the endogenous variable *individual impact* for the augmented reality game *Ingress*, and 33.10% of the variance of the endogenous variable *individual impact* for the augmented reality city tour guide *VarazdinAR,* whereas the new IMISS model explains 58.04% of the variance of the endogenous variable *individual benefits (individual impact)* for the augmented reality game *Ingress* and 59.77% of the variance of the endogenous variable *individual benefits (individual impact)* for the augmented reality city tour guide *VarazdinAR*.

Table 57 Comparison of the Explanatory Power of the Two Success Models

Individual Impacts Success Dimension		
	Ingress	***VarazdinAR***
D&M R^2	**0.2200**	**0.3310**
IMISS R^2	0.5880	0.6050
IMISS R^2adj	**0.5804**	**0.5977**

Source: made by the author

When comparing the R^2 values of the two models, it can be seen that the IMISS model has much higher R^2 values. The results show that the IMISS model, in case of hedonic system success measurement, outperforms the updated DeLone and McLean IS success model, i.e. the IMISS model performs substantially better in explaining and predicting *individual benefits* in the case of hedonic systems. Therefore, it can be concluded that the new proposed IMISS model has *more explanatory power* for explaining and predicting the *individual impacts/benefits* dimension than the updated DeLone and McLean IS success model. The IMISS model provides better understanding of the relationships between *information system quality* and *perceived individual benefits* through *user experience quality*. Therefore, the support for the acceptance of the hypothesis H2: "*Developed mobile information systems success model will provide more explanatory power than existing DeLone and McLean information system success model when the use of mobile information system is at the individual level."* is ensured.

7.3 Summary of Research Findings

The fifth step of the *design science research* methodology represents the summarization of the research findings and drawing conclusions. The main motivation of this doctoral thesis was to reveal what the success of interactive mobile information systems mean in the today's technologically mediated life, and to reveal what system characteristics contribute to the fact that some interactive mobile information systems have more success than others. Literature review revealed that there is an absence of an adequate success measurement framework for today's interactive mobile information systems used for fulfilling personal needs of its users.

The updated DeLone and McLean IS success model has been chosen as the main foundation for the development of the new success measurement framework. The DeLone and McLean IS success model has been used and tested in different environments (e.g. e/m-commerce, e-government, e/m-banking, e-learning, etc.) mostly for utilitarian purposes. However, technology today is not only crucial for the success of commercial businesses but has become an important part of our everyday life activities. We use technology to communicate with our friends and families (e.g. Skype, Viber, Facebook, etc.), to entertain ourselves (e.g. Angry Birds, Youtube, Last.fm, etc.), to find information (e.g. news website, weather forecast, Google, etc.), and/or to complete transactions (e.g. Amazon, eBay, etc.). Consumer behaviour is strongly motivated by perceived utilitarian and hedonic values received from product consummation, and the product is evaluated both objectively (e.g., how useful or beneficial the object is) and subjectively (e.g., how pleasant and agreeable those associated feelings are). Consumers have so many alternatives to choose from (thousands of different interactive devices and millions of different applications); therefore, if a company wants to achieve success in today's highly competitive marketplace, it has to offer more than basic functionalities. The economy has progressed from selling commodities to selling and staging an experience. Even if a company believes that it has a special product, it has to evaluate the success of the product in the natural environment of its consumption. As an outcome of this study, a new success framework has been proposed. Within this framework beliefs about product quality (information system quality), interaction beliefs (user experience quality), perceived benefits (outcomes and values), and intentions for reusing the system are integrated into one single framework, the interactive mobile information systems success model (IMISS model).

The first hypothesis of this research is related to the validity and reliability of the new developed measuring instrument questionnaire. In order to test the validity of the questionnaire, the literature review of available and relevant information system success studies has been carried out. The questionnaire items from these studies were extracted to form the initial pool of items (Chapter 6.1.1). For the new success dimension, i.e. the user experience quality dimension, the literature from the field of human computer interaction has been reviewed. After the initial pool of items is created, experts from the field of human computer interaction and information systems are asked to participate in the item, attribute, and success dimension evaluation study. With this step, the content validity of the proposed items, attributes, and dimensions is ensured (Chapter 6.1.2.1). The items, attributes, and dimensions that satisfied the content validity assessment criteria were used for the next step of validity assessments, i.e. convergent and discriminant analysis. For this step of the analysis the experts from the field of information systems and human computer interaction were involved again in order to sort the attributes to the appropriate success dimension. In total, two rounds of sorting were conducted and some changes were made in order to improve the inter-rater agreement level (Chapter 6.1.2.2). In order to test the reliability of the measuring instrument further, Cronbach's alpha measure was used for pilot data (Chapter 7.1) and the composite reliability measure was used for field study data (Chapter 7.2.3.1.).

This study validates the new proposed IMISS model on two highly mobile and highly context dependent interactive systems. Both systems are hedonic systems, one primarily used for the purpose of entertainment (augmented reality game *Ingress*) while the other is used for satisfying information seeking needs (augmented reality city tour guide system *VarazdinAR*). The PLS-SEM method is applied for the validation of the IMISS model's relationships. The IMISS model has been tested and verified empirically. The research presented in this paper forms one of the initial attempts towards empirically understanding the influence of selected constructs from a well-established IS success model on the success measurement of interactive mobile information systems. If the interactive system's *information system quality* level is high, it will have a positive effect on the perception of *user experience quality*. *Information system quality* would strongly influence the perceived *individual benefits* both directly and indirectly. *User experience quality* also has a significant positive influence on the perceived *individual benefits*, which would then influence the behavioural *intention to reuse* the system, especially in the case of the entertainment seeking systems. The success of interactive mobile information systems is heavily dependent on the quality of the user experience in interaction with the system, in the case of entertainment systems (e.g. gaming systems). However, in case of hedonic systems intended for information seeking purposes (e.g. tourism systems), *user experience quality* is important, but *information system quality* is a more important determinant of success. The proposed IMISS model also satisfies the parsimonious fit.

The second hypothesis is related to the comparison of the new proposed model, the IMISS model, to the updated DeLone and McLean IS success model in terms of explaining the dependent variable *net benefits* (impacts/benefits the user receives from the IS) at the individual level of use. In order to compare the explained variance of the dependent variable more fairly, the *net benefits* values of the two models, in the case of the IMISS model the *adjusted coefficient of determination* (R^2_{adj}), are used. The results of the comparison revealed that the new model, in the case of interactive mobile information systems used for hedonic purposes such as gaming or tourism, has more explanatory power than the updated DeLone and McLean IS success model. The results of the path model provide significant support for the relationships between *information system quality*, *user experience quality*, *individual benefits,* and *intention to reuse* in the case of the two hedonic systems. With this new measurement framework (IMISS model), IS producers/developers can capture user reflections about their products in order to reveal their strengths and potential weaknesses, and use these findings as strategies for improvement.

7.4 Limitations and Future Research Directions

The first limitation is related to the sample size of case studies. A relatively low sample size is used in both cases. However, according to the recommendation from Chapter 6.2., the sample size is sufficient. Nevertheless, it would be beneficial to repeat the research on a greater sample. The second limitation is related to the sample characteristics in the case of augmented reality city tour guide system *VarazdinAR*. This system is primarily aimed at foreign tourists in the City of Varaždin. But due the low response from tourists in the data collection process, the students of the Faculty of Organization and Informatics, University of Zagreb were invited to participate in the system evaluation. In the end, the majority of the participants were students. However, as the system is oriented towards fulfilling the information needs of the users, it is still judged based on the quality of the information it provides, depending on the usage context, the system characteristics, and the quality of interaction experience with the system. Nevertheless, a future study should conduct surveys to capture the perception of the actual targeted group of users in order to reveal the real success of this system, and re-validate the IMISS model with new data. The third limitation of this study is that it has been focused on two main constructs as predictors of individual benefits, which may have limited the total variance explained. Future studies should consider incorporating other relevant constructs (such as *Trust*, *Empowerment,* etc.) or incorporating other attributes (such as *Navigability, Delight, Social aspects* etc.) within the IMISS model, in order to gain further understanding of the factors that contribute to the success of the interactive mobile technology in their usage context. Further, the IMISS model should also be validated on other types of hedonic interactive mobile systems such as ones used for communication and/or transactions.

8 CONCLUSION

Access to information plays an important role in our everyday life. Having access to the right information sources is not only crucial for the success of commercial businesses but also for social pursuits of individuals (Bilandzic, Foth, and De Luca 2008). The so called customer-focused era, which began in the 2000s, demonstrates through social media, social networking, and peer-to-peer computing that information systems are no longer used for business and productivity alone, but also for hedonic uses such as entertainment (Heijden 2004), (Petter, DeLone, and McLean 2012). Parallel to organisational IS research, new research directions emerged, which study information and communication services that have become ubiquitous and are used in everyday life of individuals. There is a growing number of different portable devices with numerous applications that have become the preferred mechanism for many individuals to interact with friends, family, and colleagues, to transact business and to access the information on the Internet, social media sites, news portals and to entertain themselves (Middleton, Scheepers, and Tuunainen 2014). Some researchers have mainly been oriented towards user acceptance prerequisites, i.e. drivers that lead some users to accept or reject a particular system or application as a part of the system, e.g. easy to use or perceived usefulness, while others were more oriented towards success measurement of these systems, i.e. how users perceive the system characteristics and what outcomes/impacts of use they perceive. Both research streams have been changing along with the changes in technology. However, they still lag behind practice.

The success evaluation of these interactive systems demands different criteria of evaluation. It is still relevant to evaluate whether the basic usability functions are met, such as easy to learn or easy to use, however, efficiency and effectiveness are much less important. The crucial success factor is not to achieve some particular task in a limited period of time, as it is in work oriented systems, but rather to evoke an emotional reaction as a result of the interaction with the system. In IS/IT literature many guidelines can be found on how to design for interactive, mobile, and ubiquitous systems. However, the success evaluation of these systems is still rare. If an evaluation is performed, it is oriented either towards usability or towards user experience evaluation, but there is a clear lack of summative success evaluation tools for these interactive systems in their natural contexts of use. Understanding the value that the user gets from using particular interactive systems on the individual level is a crucial step in information system success evaluation.

Information system success measures in the early phases of information systems were evaluated quantitatively and relatively objectively. Current research recognizes that many measures of information systems success should be subjective and should include intangible benefits. Information systems success evaluation has progressed from originally focusing on speed and accuracy, which was a more quantitative and objective evaluation, towards considering the strategic and social impacts of the system, which is a more qualitative and subjective evaluation (Petter, DeLone, and McLean 2012). More and more studies report that consumers' attitudes toward products are bi-dimensional. Offering just functional values is no longer enough to have a competitive advantage on the market. Therefore, the providers of these modern interactive systems should strive to meet both pragmatic and hedonic users' expectations, and even to surpass them, in order to achieve a competitive advantage on the market. The hedonic benefits (values) are becoming key drivers of future interactive information system success. And IS providers need to measure whether they have achieved the intended goal, and where and how they should or could improve. Experiential, hedonic evaluation is becoming particularly important for interactive mobile information systems that are voluntary in their use, e.g. tourism guides, game systems, fitness/health systems, photo/file sharing systems, communication systems, etc.

The main contributions of this thesis are a valid and reliable measuring instrument questionnaire, and a valid and reliable multi-dimensional interactive mobile information systems success model (IMISS model). Both developed artefacts are results of the application of the design science research methodology and represent valuable tools that serve both science and practice. The IMISS model is developed upon the well-known DeLone and McLean IS success model. This study summarizes the findings from the information system success literature, acceptance literature, and findings from human computer interaction literature regarding usability and user experience and integrate these findings into the DeLone and McLean success model. The goal was to improve one of the most popular and most used existing success evaluation frameworks within the information system field, i.e. the DeLone and McLean information system success model, in order to meet modern trends of ubiquitous computing and experiential computing. The IMISS model, on its meta-level, is compounded of four success dimensions: *information system quality*, *user experience quality*, *individual benefits*, and *intention to reuse*. The IMISS model replaces the *system use* dimension from the DeLone and McLean success model with the *user experience quality* dimension. The *user experience quality* dimension represents the experience with system usage, and provides an adequate component for analysing the success of modern interactive mobile information systems. Within this study it is assumed that perceived *information system quality* and perceived *user experience quality* are predictors of *individual benefits* (individual impacts), which then influence the behavioural intentions, i.e. *system reuse*. The evaluation of the IMISS model demonstrates that *information system quality* is a strong predecessor of *user experience quality*.

This research contributes to IS/IT success literature in general by developing and validating the interactive mobile IS success model for success assessment of interactive technology use in the everyday life of users. Better understanding of interactive mobile information systems success contributes both to theory and practice. The created model, together with the questionnaire, can help developers of modern interactive mobile information systems to measure the success of the developed systems and to reveal how the users perceive their systems. In addition, the IMISS model can be used as a guide for understanding the drivers of interactive system success. It can help to reveal which system features affect the perception of the benefits as the outcomes of system use in a greater or lesser degree and whether the users have the intention of further system usage. If the IMISS model would be used as a standardized success model it would be much easier to perform evaluations and comparisons of similar systems. All these findings can then be transformed into strategies for future system improvments. The additional advantage of the IMISS model is the introduction of hedonic (subjective) success attributes next to pragmatic (objective) success attributes during system evaluation, as part of the usage experience and as part of the net benefits (individual impacts). These characteristics correspond to the changes on the consumer market, i.e. experience economy. Researchers can broaden their knowledge about the positive outcomes of interactive mobile information systems use and practitioners can use these findings to improve the added value of the systems they deliver.

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Appendix A: Invitation letter for experts to participate in Item, Attribute, Dimension evaluation

Dear Madam/Sir,

My name is Ana Ćorić Samardžija and I am working as a young researcher and teaching assistant (PhD student) at the University of Zagreb, Faculty of Organization and Informatics, Varaždin Croatia. My research supervisors are Prof. Neven Vrček, Ph.D., University of Zagreb, Croatia and Prof. Wolf Rauch, Ph.D., Karl-Franzens-Universität Graz, Austria.

The goal of this doctoral study is to describe and expand the understanding of the ***success concept*** in the case of the ***modern mobile interactive information systems*** (e.g. augmented reality tourism systems, augmented reality games etc.) in everyday life of the individuals (leisure purposes), following the research of the DeLone & McLean (1992, 2003) information system success model and user experience studies from Human Computer Interaction literature.

I'm following the questionnaire development guidelines from the Lawshe (1975), Moore and Benbasat (1991) and Straub, Boudreau and Gefen (2004) to ensure content and construct validity of the questionnaire. It is very important to include relevant items and attributes to define the precise set of the questionnaire attributes which will show accurate state of the success factors.

You have been chosen as one of the experts familiar with ***interactive information systems*** and ***human computer interaction*** field and I believe that you have enough experience to make valuable contribution to the evaluation of this questionnaire.

This questionnaire is an essential part of my PhD and it is of vital importance for it to be correctly designed in order to get valid data. The estimated time needed for evaluation is approximately half an hour.

Once you start the survey you are expected to fill in the whole questionnaire in one session. It is not possible to save partially filled form and continue later, however you can go backward and forward between pages without losing the data you filled in during the same session.

Thank you very much for your effort!
Please feel free to contact me for every question or remark!

Ana Ćorić Samardžija mag.inf., Young Researcher / Teaching Assistant
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Appendix B: Experts involved in research – Item, Attribute, Dimension evaluation

No	Country	Education level	Level of expertise (1-basic knowledge to 3 advanced knowledge) in HCI	Level of expertise (1-basic knowledge to 3 advanced knowledge) (mobile)IS	Number of research projects in (mobile) IS as key leader	Number of research projects in HCI as key leader
1	Austria	MsC	3	3	4	6
2	Austria	PhD	2	3	8	2
3	Slovenia	PhD	3	3	15	10
4	Slovenia	PhD	2	2	2	8
5	Finland	PhD	3	3	5	10
6	Brazil	PhD	3	3	27	27
7	Spain	PhD	3	3	10	9
8	Portugal	PhD	3	3	10	40
9	Italy	PhD	3	3	10	4
Mean			**2.78**	**2.89**	**10.11**	**12.89**

There were 5 male and 4 female experts. All of the experts reported their self-evaluated expertise on the scale from 1 to 3 (*1-basic knowledge with HCI and/or mobile IS; 2-intermediate knowledge with HCI and/or mobile IS; and/or 3-advanced knowledge with HCI and mobile IS*). The average score of HCI knowledge was 2.78, which shows a respectable level of expertise. The average score of (mobile) IS knowledge was 2.89, which shows also a respectable level of expertise. In average experts were key leader of 10.11 (mobile) IS projects, and 12.89 HCI projects.

Appendix C: Invitation letter for experts to participate in Q-sorting

First part:

Dear Sir/Madam,

My name is Ana Ćorić Samardžija and I am working as a young researcher and teaching assistant (PhD student) at the University of Zagreb, Faculty of Organization and Informatics, Varaždin Croatia. My research supervisors are Prof. Neven Vrček, Ph.D., University of Zagreb, Croatia and Prof. Wolf Rauch, Ph.D., Karl-Franzens-Universität Graz, Austria.

The goal of my doctoral study is to describe and expand the understanding of the success concept in the case of the modern mobile interactive information systems (e.g. augmented reality tourism systems, augmented reality games etc.). One of the most important parts of my PhD research is development of the measuring instrument – questionnaire, which will be used to collect data related to the ***success dimensions of the modern interactive mobile information systems***. It is very important to include relevant items/statements and to define the precise set of the attributes which will show accurate state of the interactive system success concept.

I'm following the questionnaire development guidelines from the Lawshe (1975), Moore and Benbasat (1991) and Straub, Boudreau and Gefen (2004). To ensure content and construct validity of the questionnaire I need help of the experts who have experience and knowledge in field of mobile information systems and human computer/mobile interaction field.

You have been chosen as one of the experts familiar with ***interactive information systems*** and ***human computer interaction*** field and I believe that you have enough experience to make valuable contribution to the evaluation of this questionnaire.

Please replay to this e-mail if you are accepting the invitation to participate in this research in order to get further details.

Thank you very much for your time and willingness to help me!

Sincerely,

Ana Ćorić Samardžija mag.inf., Young Researcher/Teaching Assistant
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Second part:

Dear Sir/Madam, thank you for accepting to participate in this research.

Expected contribution from your side is to sort the suggested quality attributes under proposed constructs (dimensions) in the case of the interactive mobile information systems in general context of use (e.g. augmented reality systems, sensor-rich mobile systems – fitness & health system etc.) in order to evaluate the success of these systems.

Before you start sorting procedure please just fill in the short questionnaire about your level of expertise: *url to google form.*

And here is the link for the card sorting procedure: *url to the card sorting space*, where you need to use drag&drop function to place quality attributes under appropriate information system success dimensions.

The estimated time needed for card-sorting procedure is approximately 20 minutes.

Thank you for time and contribution,

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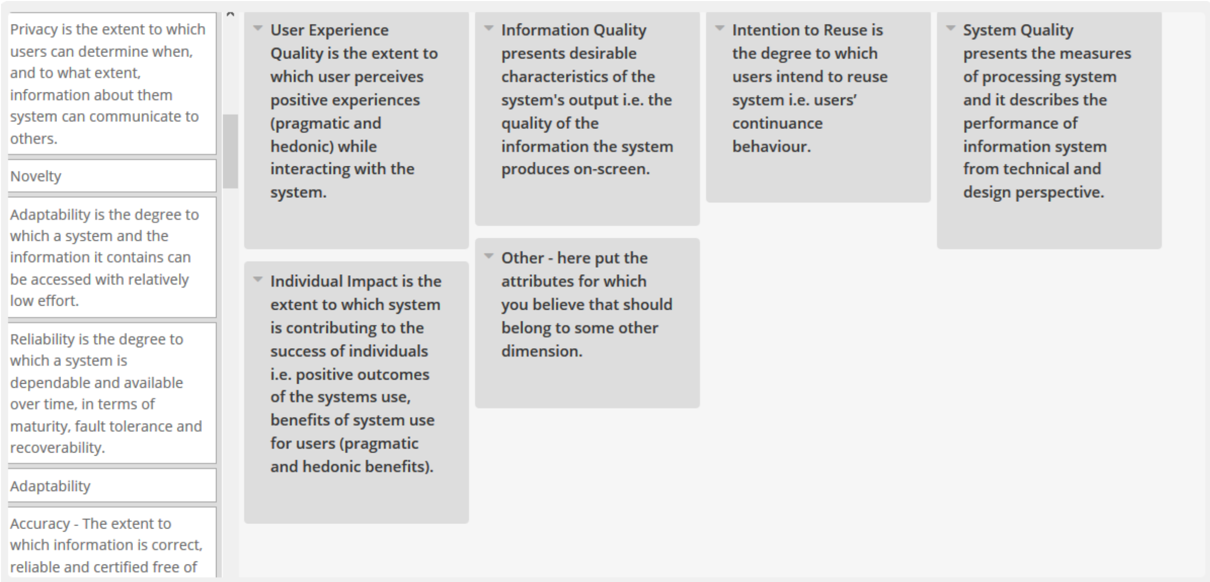
Appendix D: Experts involved in Q-sorting phase

No	Country	Education level	Level of expertise (1-basic knowledge to 3 advanced knowledge) in HCI	Level of expertise (1-basic knowledge to 3 advanced knowledge) (mobile)IS	Number of research projects in (mobile) IS as key leader	Number of research projects in HCI as key leader
1	Austria	PhD	3	3	5	10
2	Austria	PhD	2	3	5	6
3	Brazil	MSc	2	3	8	6
4	Denmark	PhD	2	3	3	5
5	Finland	PhD	2	3	20	5
6	USA	PhD	3	3	7	8
Mean			**2.33**	**3.0**	**8**	**6.7**

There were 5 male experts and 1 female expert. All of the experts reported their self-evaluated expertise on the scale from 1 to 3 (*1-basic knowledge with HCI and/or mobile IS; 2-intermediate knowledge with HCI and/or mobile IS; and 3-advanced knowledge with HCI and/or mobile IS*). The average score of HCI knowledge was 2.33, which shows a respectable level of expertise. The average score of (mobile) IS knowledge was 3.0, which shows excellent level of expertise. In average experts were key leader of 8 (mobile) IS projects, and 6.7 HCI projects.

Appendix E: Screenshot of the Card-Sorting instrument



Appendix F: Invitation letters to the users of the systems

Ingress Invitation letter:

“Dear Ingress players,

My name is Ana Coric Samardzija and I am working as a young researcher (PhD student) at the University of Zagreb, Croatia. Currently I am in the final stage of work on my PhD thesis that is focused on the research of the information system success of mobile interactive augmented reality applications.

The aim of my research is to develop an instrument that will assess interactive mobile information system success at the individual level of usage. The results of the instrument development will serve as a basis for building an *interactive mobile information system success model*.

In order to achieve the validity of the proposed model the mobile game Ingress is chosen as one of the cases studies. And as you are the active Ingress players and this is currently the most popular augmented reality game I would appreciate if you could provide me with your feedback and experience about this game, by filling this online survey.

Once you start the survey you are expected to fill in the whole questionnaire in one session. It is not possible to save partially filled form and continue later, however you can go backward and forward between pages without losing the data you filled in during the same session.

I would like to stress that you are not required to participate and you can quit the survey at any time. If you decide not to take the survey after you’ve seen the questions, just close the survey and the data won’t be used for the analysis. If you are interested in the results, I can share those with you upon your request.

Please be assured that your responses to this survey will be completely anonymous.

To fill in the survey it will take you approximately 15 minutes. Please accept this invitation to participate in this survey to help me in my PhD pursuit.

Thank you for your valuable contribution to this research!

Sincerely,
Ana Coric Samardzija
acoric@foi.hr
University of Zagreb, Croatia”

VarazdinAR Invitation letter:

“Dear VarazdinAR user(s),

My name is Ana Coric Samardzija and I am working as a young researcher (PhD student) at the University of Zagreb, Croatia. Currently I am in the final stage of my PhD research that is focused on the research of the interactive augmented reality mobile information system success characteristics.

The aim of my research is to develop an instrument that will assess interactive mobile information system success at the individual level of usage. Instrument results will serve as a basis for building the interactive mobile information system success model.

In order to achieve the validity of the proposed model the mobile system VarazdinAR is chosen as one of the cases studies. And as you have used the system for your city tour, it would mean a lot to hear your feedback and experience about this system.

Once you start the survey you are expected to fill in the whole questionnaire in one session. It is not possible to save partially filled form and continue later, however you can go backward and forward between pages without losing the data you filled in during the same session.

I would like to stress that you are not required to participate and you can quit survey at any time. If you decide not to take the survey after you've seen the questions, just close the survey and the data diff be used for the analysis. If you are interested in the results, I can share those with you upon your request.

Please be assured that your responses to this survey will be completely anonymous.

To fill out questionnaire it will take you approximately 20 minutes. Please accept this invitation to participate in this survey to help me in my PhD pursuit.

Thank you for your valuable contribution to this research!

Sincerely,
Ana Coric Samardzija
acoric@foi.hr
University of Zagreb, Croatia"

Appendix G: Field-test instrument statements for the mobile AR game Ingress & mobile AR City tour guide *VarazdinAR*

Field-test Questionnaire Items
Completeness
Information from the mobile game Ingress/mobile city tour system VarazdinAR is sufficient for the game/city tour.
The amount of information from the mobile game Ingress/mobile city tour system VarazdinAR is appropriate for the game/city tour.
Understandability
Information from the mobile game Ingress/mobile city tour system VarazdinAR is easy to understand.
Information from the mobile game Ingress/mobile city tour system VarazdinAR is clear in meaning.
Relevance
Information from the mobile game Ingress/mobile city tour system VarazdinAR is relevant for the game/city tour.
Information from the mobile game Ingress/mobile city tour system VarazdinAR is important for the game/city tour.
Accuracy
Information from the mobile game Ingress/mobile city tour system VarazdinAR is accurate.
Information from the mobile game Ingress/mobile city tour system VarazdinAR is precise.
Currency
Information from the mobile game Ingress/mobile city tour system VarazdinAR is timely.
Information from the mobile game Ingress/mobile city tour system VarazdinAR is up to date.
Adaptability
The mobile game Ingress/mobile city tour system VarazdinAR is adaptable to meet my gaming/city tour needs.
The mobile game Ingress/mobile city tour system VarazdinAR offers flexibility as to time and place of use.
Availability
The mobile game Ingress/mobile city tour system VarazdinAR launches and runs right away.
The mobile game Ingress/mobile city tour system VarazdinAR is always available for usage.
Reliability
The mobile game Ingress/mobile city tour system VarazdinAR performs reliably.
The mobile game Ingress/mobile city tour system VarazdinAR always does what it should.
Response Time
When I use the mobile game Ingress/mobile city tour system VarazdinAR, system would give me immediate feedback.
I can obtain the information from the mobile game Ingress/mobile city tour system VarazdinAR without any delay.
Accessibility
Mobile game Ingress/mobile city tour system VarazdinAR allows information readily accessible to me.
Interactive mobile information system enables information to be accessed conveniently.
Personalization
The mobile game Ingress/mobile city tour system VarazdinAR enables me to customize the presentation of information according to my personal needs.
The mobile game Ingress/mobile city tour system VarazdinAR enables me to filter the content according to my personal needs.
Security
The use of the interactive mobile game Ingress/mobile city tour system VarazdinAR feels secure.

Field-test Questionnaire Items
The mobile game Ingress/mobile city tour system VarazdinAR keeps the data secure from unauthorized access.
Efficiency
The mobile game Ingress/mobile city tour system VarazdinAR increases my efficiency.
The mobile game Ingress/mobile city tour system VarazdinAR helps me to optimize my activity.
Enjoyment
It was entertaining to use the mobile game Ingress/mobile city tour system VarazdinAR system.
I enjoyed using the use of the mobile game Ingress/mobile city tour system VarazdinAR.
Satisfaction
I am satisfied with the use of the mobile game Ingress/mobile city tour system VarazdinAR.
I am delighted with the use of the mobile game Ingress/mobile city tour system VarazdinAR.
Aesthetics
The mobile game Ingress/mobile city tour system VarazdinAR has aesthetically pleasing design
I like the visual look of the mobile game Ingress/mobile city tour system VarazdinAR.
The mobile game Ingress/mobile city tour system VarazdinAR looks impressive.
Stimulation
The use of mobile game Ingress/mobile city tour system VarazdinAR is motivating.
It is fun to use the mobile game Ingress/mobile city tour system VarazdinAR.
The use of the mobile game Ingress/mobile city tour system VarazdinAR is original/innovative.
Use
I have used the mobile game Ingress/mobile city tour system VarazdinAR for uses that it is intended.
I have used the mobile game Ingress/mobile city tour system VarazdinAR very intensively.
The mobile game Ingress/mobile city tour system VarazdinAR has good navigation options.
Privacy
I have control over what personal information the mobile game Ingress/mobile city tour system VarazdinAR is using.
My privacy rights are adequately protected while using the mobile game Ingress/mobile city tour system VarazdinAR.
The mobile game Ingress/mobile city tour system VarazdinAR doesn't use personal information without my knowledge.
Usability
The mobile game Ingress/mobile city tour system VarazdinAR is easy to use.
The mobile game Ingress/mobile city tour system VarazdinAR is easy to learn.
Usefulness
The mobile game Ingress/mobile city tour system VarazdinAR is useful for having game experience/city tour experience.
The mobile game Ingress/mobile city tour system VarazdinAR supports me in my game/tour activity.
Intention to reuse
I plan to reuse the mobile game Ingress/mobile city tour system VarazdinAR.
I will continue to use this or similar interactive mobile information system.

Curriculum Vitae

Ana Ćorić Samardžija was born on the 25th of October 1984 in Imotski. She graduated at the Faculty of Organization and Informatics in Varaždin 2008. During her studies she was receiving the state scholarship of category A. She graduated in the top 10% of students. She worked as software engineer for two years in company Igea d.o.o. After that she worked as young researcher/teaching assistant at Faculty of Organization and Informatics, University of Zagreb for six years where she besides teaching, and mentoring student projects and bachelor thesis has participated on several scientific and industry projects. Currently she works at University Computing Centre (SRCE) as IT advisor for e-learning. She has published several scientific journal papers, scientific articles on international scientific conferences and several practical papers. Hers research interests are e-learning systems, interactive systems, project management, mobile and web development. She is married.

List of Publications

Book chapters:

Poglavlje u knjigama:

1. Bubaš, Goran; Orehovački, Tihomir; Balaban, Igor; **Ćorić, Ana**. Evaluation of Web 2.0 Tools in the e-Learning Context: Case Studies Related to Pedagogy and Usability, University Information Systems - Selected Problems, Varšava : Difin SA, 2010. Str. 259-277.

Journal paper:

- **Ćorić Samardžija**, Ana; Balaban Igor. From Classroom to Career Development Planning: Eportfolio Use Examples, International Journal of Emerging Technologies in Learning. 9 (2014), 6; 26-31.
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